2008

REVISED

The Ontario Curriculum
Grades 9 and 10

# Science

reach every student

Ontario

# CONTENTS


**INTRODUCTION** 3

Secondary Schools for the Twenty-first Century ... 3
The Place of Science in the Curriculum ... 3
The Goals of the Science Program ... 4
The Nature of Science ... 4
Roles and Responsibilities in the Science Program ... 7

**THE PROGRAM IN SCIENCE** 11

Overview of the Program ... 11
Curriculum Expectations ... 14
Strands in the Grade 9 and 10 Science Curriculum ... 17
Skills of Scientific Investigation (Inquiry and Research) ... 19

**ASSESSMENT AND EVALUATION OF STUDENT ACHIEVEMENT** 22

Basic Considerations ... 22
The Achievement Chart for Science ... 23
Evaluation and Reporting of Student Achievement ... 28
Reporting on Demonstrated Learning Skills ... 28

**SOME CONSIDERATIONS FOR PROGRAM PLANNING** 29

Instructional Approaches ... 29
Health and Safety in Science ... 30
Planning Science Programs for Students With Special Education Needs ... 31
Program Considerations for English Language Learners ... 34
Environmental Education ... 36
Antidiscrimination Education ... 37
Critical Thinking and Critical Literacy in Science ... 38
Literacy, Mathematical Literacy, and Investigation (Inquiry/Research) Skills ... 39
The Role of Information and Communications Technology in Science ... 40
The Ontario Skills Passport and Essential Skills ... 41
Career Education ... 41
Cooperative Education and Other Forms of Experiential Learning ... 42
Planning Program Pathways and Programs Leading to a Specialist High Skills Major ... 43



Une publication équivalente est disponible en français sous le titre suivant : *Le curriculum de l'Ontario, 9e et 10e année – Sciences, 2008*.

This publication is available on the Ministry of Education's website, at www.edu.gov.on.ca.

## COURSES 45

Science, Grade 9, Academic (SNC1D) ........ 47
Science, Grade 9, Applied (SNC1P) ........ 59
Science, Grade 10, Academic (SNC2D) ........ 71
Science, Grade 10, Applied (SNC2P) ........ 83

## GLOSSARY 95

# INTRODUCTION

This document replaces *The Ontario Curriculum, Grades 9 and 10: Science, 1999*. Beginning in September 2009, all science programs for Grades 9 and 10 will be based on the expectations outlined in this document.

## SECONDARY SCHOOLS FOR THE TWENTY-FIRST CENTURY

The goal of Ontario secondary schools is to support high-quality learning while giving individual students the opportunity to choose programs that suit their skills and interests. The updated Ontario curriculum, in combination with a broader range of learning options outside traditional classroom instruction, will enable students to better customize their high school education and improve their prospects for success in school and in life.

## THE PLACE OF SCIENCE IN THE CURRICULUM

During the twentieth century, science played an increasingly important role in the lives of all Canadians. It underpins much of what we now take for granted, from life-saving pharmaceuticals to clean water, the places we live and work in, computers and other information technologies, and how we communicate with others. The impact of science on our lives will continue to grow as the twenty-first century unfolds. Consequently, scientific literacy for all has become a goal of science education throughout the world and has been given expression in Canada in the *Common Framework of Science Learning Outcomes, K to 12: Pan-Canadian Protocol for Collaboration on School Curriculum* (Council of Ministers of Education, Canada, 1997). Scientific literacy can be defined as possession of the scientific knowledge, skills, and habits of mind required to thrive in the science-based world of the twenty-first century.

> *A scientifically and technologically literate person is one who can read and understand common media reports about science and technology, critically evaluate the information presented, and confidently engage in discussions and decision-making activities regarding issues that involve science and technology.*
>
> Science Co-ordinators' and Consultants' Association of Ontario (SCCAO)
> and Science Teachers' Association of Ontario (STAO/APSO),
> "Position Paper: The Nature of Science" (2006), p. 1

Achieving a high level of scientific literacy is not the same as becoming a scientist. The notion of thriving in a science-based world applies as much to a small-business person, a lawyer, a construction worker, a car mechanic, or a travel agent as it does to a doctor, an engineer, or a research scientist. While the specific knowledge and skills required for each of these occupations vary, the basic goal of thriving in a science-based world remains the same. Science courses have been designed for a wide variety of students, taking into account their interests and possible postsecondary destinations. Some courses have been designed to serve as preparation for specialist studies in science-related fields; others have been designed for students intending to go on to postsecondary education but not to study science; yet others have been designed with the needs of the workplace in mind. The overall intention is that all graduates of Ontario secondary schools will achieve excellence and a high degree of scientific literacy while maintaining a sense of wonder about the world around them. Accordingly, the curriculum reflects new developments on the international science scene and is intended to position science education in Ontario at the forefront of science education around the world.

## THE GOALS OF THE SCIENCE PROGRAM

Achievement of both excellence and equity underlies the three major goals of the secondary science program. *The Ontario Curriculum, Grades 9 and 10: Science, 2008* therefore outlines not only the skills and knowledge that students are expected to develop but also the attitudes that they will need to develop in order to use their knowledge and skills responsibly. The three goals of the science program are as follows:

1. to relate science to technology, society, and the environment
2. to develop the skills, strategies, and habits of mind required for scientific inquiry
3. to understand the basic concepts of science

Every course in the secondary science program focuses on these three goals. The goals are reflected within each strand of every course in the three overall expectations, which in turn are developed in corresponding sets of related specific expectations. The same three goals also underlie assessment of student achievement in science.

## THE NATURE OF SCIENCE

> *The primary goal of science is to understand the natural and human-designed worlds. Science refers to certain processes used by humans for obtaining knowledge about nature, and to an organized body of knowledge about nature obtained by these processes. Science is a dynamic and creative activity with a long and interesting history. Many societies have contributed to the development of scientific knowledge and understanding. . . . Scientists continuously assess and judge the soundness of scientific knowledge claims by testing laws and theories, and modifying them in light of compelling new evidence or a re-conceptualization of existing evidence.*
>
> SCCAO and STAO/APSO, "Position Paper: The Nature of Science" (2006), pp. 1–2

Science is a way of knowing that seeks to describe and explain the natural and physical world. An important part of scientific literacy is an understanding of the nature of science, which includes an understanding of the following:

- what scientists, engineers, and technologists do as individuals and as a community
- how scientific knowledge is generated and validated, and what benefits, costs, and risks are involved in using this knowledge
- how science interacts with technology, society, and the environment

Occasionally, theories and concepts undergo change, but for the most part, the fundamental concepts of science – to do with phenomena such as the cellular basis of life, the laws of energy, the particle theory of matter – have proved stable.

## Fundamental Concepts

> *Change the focus of the curriculum and instruction from teaching topics to "using" topics to teach and assess deeper, conceptual understanding.*
>
> Lynn Erickson, *Concept-Based Curriculum and Instruction* (2006), p. 7

Fundamental concepts are concepts about phenomena that have not changed fundamentally over time and that are common to all cultures. The fundamental concepts in science provide a framework for the deeper understanding of all scientific knowledge – a structure that facilitates integrated thinking as students draw from the knowledge base of science and see patterns and connections within the subdisciplines of science, and between science and other disciplines. The fundamental concepts addressed in the curricula for science and technology in Grades 1 to 8 and for science in Grades 9 to 12 are similar to concepts found in science curricula around the world.

As students progress through the curriculum from Grades 1 to 12, they extend and deepen their understanding of these fundamental concepts and learn to apply their understanding with increasing sophistication. The fundamental concepts are listed and described in the following chart.

| FUNDAMENTAL CONCEPTS | |
|---|---|
| ***Matter*** | Matter is anything that has mass and occupies space. Matter has particular structural and behavioural characteristics. |
| ***Energy*** | Energy comes in many forms, and can change forms. It is required to make things happen (to do work). Work is done when a force causes movement. |
| ***Systems and Interactions*** | A system is a collection of living and/or non-living things and processes that interact to perform some function. A system includes inputs, outputs, and relationships among system components. Natural and human systems develop in response to, and are limited by, a variety of environmental factors. |
| ***Structure and Function*** | This concept focuses on the interrelationship between the function or use of a natural or human-made object and the form that the object takes. |
| ***Sustainability and Stewardship*** | Sustainability is the concept of meeting the needs of the present without compromising the ability of future generations to meet their needs.<br>Stewardship involves understanding that we need to use and care for the natural environment in a responsible way and making the effort to pass on to future generations no less than what we have access to ourselves. Values that are central to responsible stewardship are: using non-renewable resources with care; reusing and recycling what we can; switching to renewable resources where possible. |
| ***Change and Continuity*** | Change is the process of becoming different over time, and can be quantified.<br>Continuity represents consistency and connectedness within and among systems over time. Interactions within and among systems result in change and variations in consistency. |

## “Big Ideas”

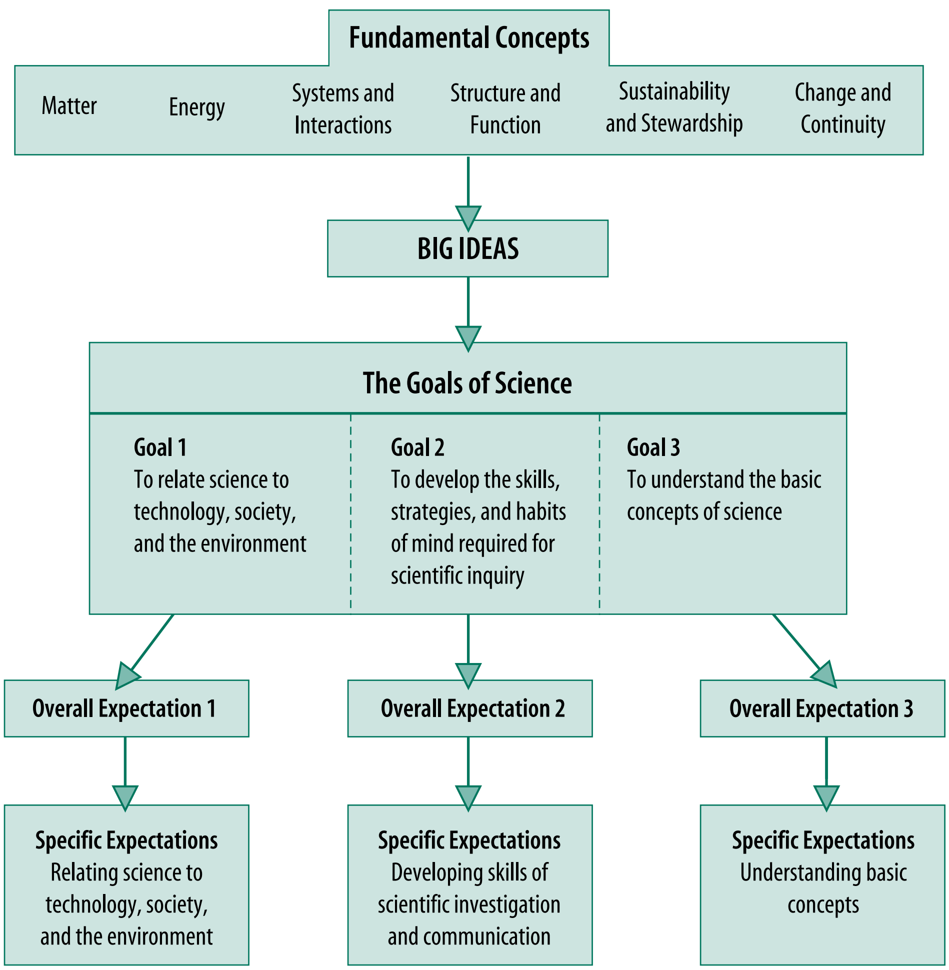
*Big ideas “go beyond discrete facts or skills to focus on larger concepts, principles, or processes.”*

Grant Wiggins and Jay McTighe, *Understanding by Design* (1998), p. 10

“Big ideas” are the broad, important understandings that students should retain long after they have forgotten many of the details of what they have studied in the classroom. They are the understandings that contribute to scientific literacy. The big ideas that students can take away from each course in this curriculum relate to some aspect of the fundamental concepts described in the preceding section. A list of the big ideas students need to understand appears at the start of every course in this document.

Developing a deeper understanding of the big ideas requires students to understand basic concepts, develop inquiry and problem-solving skills, and connect these concepts and skills to the world beyond the classroom. Teachers can help students gain such understanding by connecting learning based on the overall and specific expectations and the criteria in the achievement chart to the big ideas that relate to each course.

The relationship between the fundamental concepts, big ideas, the goals of the science program, and the overall and specific expectations is outlined in the chart that follows.



## ROLES AND RESPONSIBILITIES IN THE SCIENCE PROGRAM

### Students

Students have many responsibilities with regard to their learning, and these increase as they advance through secondary school. Students who are willing to make the effort required and who are able to monitor their thinking and learning strategies and apply themselves will soon discover that there is a direct relationship between this effort and their achievement, and will therefore be more motivated to work. Students who develop mental attitudes and ways of behaving that contribute to success in life will benefit as learners.

Successful mastery of scientific concepts and investigation skills requires students to have a sincere commitment to work and to the development of appropriate learning skills. Furthermore, students should actively pursue opportunities outside the classroom to extend and enrich their scientific understanding and skills. For example, students can make an effort to keep up with current events related to local, national, and international scientific discoveries and innovations.

### Parents

Studies show that students perform better in school if their parents[1] are involved in their education. Parents who are familiar with the curriculum expectations know what is being taught in the courses their children are taking and what their children are expected to learn. This awareness enhances parents' ability to discuss school work with their children, to communicate with teachers, and to ask relevant questions about their children's progress. Knowledge of the expectations in the various courses also helps parents to interpret teachers' comments on student progress and to work with teachers to improve their children's learning.

Effective ways in which parents can support their children's learning include the following: attending parent-teacher interviews, participating in parent workshops and school council activities (including becoming a school council member), and encouraging their children to complete their assignments at home.

The science curriculum has the potential to stimulate interest in lifelong learning not only for students but also for their parents and all those with an interest in education. In addition to supporting regular school activities, parents may want to take an active interest in current events and issues in the field of science, and to provide their children with opportunities to question and reflect on the impact of these developments on their immediate lives, the environment, and society. Parents can also provide valuable support by encouraging children to take part in activities that develop responsible citizenship (such as participating in an environmental clean-up program in their neighbourhood) or that further their interest in science (such as volunteering at local science centres or children's museums).

Throughout the secondary science program, students will have opportunities to interact with living things and to work with a variety of equipment and materials. To help ensure students' safety, parents should inform teachers of any allergies that their children may have. Parents should also encourage their children to arrive at school prepared to participate safely in activities. Simple precautions such as wearing closed-toe shoes, tying back long hair, and removing loose jewellery (or taping it down in the case of Medic Alert bracelets) contribute to a safe environment when working within science classrooms.

1. In this document, *parent(s)* is used to refer to parents and guardians.

## Teachers

Teachers are responsible for developing appropriate instructional strategies to help students achieve the curriculum expectations, as well as appropriate methods for assessing and evaluating student learning. Teachers bring enthusiasm and varied teaching and assessment approaches to the classroom, addressing individual students' needs and ensuring sound learning opportunities for every student.

Using a variety of instructional, assessment, and evaluation strategies, teachers provide numerous hands-on opportunities for students to develop and refine their investigation skills, including their problem-solving skills, critical and creative thinking skills, and communication skills, while discovering fundamental concepts through inquiry, exploration, observation, and research. The activities offered should enable students to relate and apply these concepts to the social, environmental, and economic conditions and concerns of the world in which they live. Opportunities to relate knowledge and skills to these wider contexts will motivate students to learn in a meaningful way and to become lifelong learners.

Teachers need to help students understand that problem solving of any kind often requires a considerable expenditure of time and energy and a good deal of perseverance. Teachers also need to encourage students to investigate, to reason, to explore alternative solutions, and to take the risks necessary to become successful problem solvers.

Science can play a key role in shaping students' views about life and learning. Science exists in a broader social and economic context. It is affected by the values and choices of individuals, businesses, and governments and, in turn, has a significant impact on society and the environment. Teachers must provide opportunities for students to develop habits of mind appropriate for meaningful work in science, including a commitment to accuracy, precision, and integrity in observation; respect for evidence; adherence to safety procedures; and respect for living things and the environment.

Teachers are also responsible for ensuring the safety of students during classroom activities and for encouraging and motivating students to assume responsibility for their own safety and the safety of others. They must also ensure that students acquire the knowledge and skills needed for safe participation in science activities.

## Principals

The principal works in partnership with teachers and parents to ensure that each student has access to the best possible educational experience. The principal is also a community builder who creates an environment that is welcoming to all, and who ensures that all members of the school community are kept well informed.

To support student learning, principals ensure that the Ontario curriculum is being properly implemented in all classrooms through the use of a variety of instructional approaches and that appropriate resources are made available for teachers and students. To enhance teaching and student learning in all subjects, including science, principals promote learning teams and work with teachers to facilitate teacher participation in professional development activities. Principals are responsible for ensuring that every student who has an Individual Education Plan (IEP) is receiving the modifications and/or accommodations described in his or her plan – in other words, that the IEP is properly developed, implemented, and monitored.

## Community Partners

Community partners in areas related to science can be an important resource for schools and students. They can provide support for students in the classroom and can be models of how the knowledge and skills acquired through the study of the curriculum relate to life beyond school. As mentors, they can enrich not only the educational experience of students but also the life of the community. For example, schools can make use of community groups that recruit practising scientists (e.g., engineers, optometrists, veterinarians, geologists, lab technicians) to provide in-class workshops for students that are based on topics, concepts, and skills from the curriculum.

Schools and school boards can play a role by coordinating efforts with community partners. They can involve community volunteers in supporting science instruction and in promoting a focus on scientific literacy in and outside the school. Community partners can be included in events held in the school (such as parent education nights and science fairs), and school boards can collaborate with leaders of existing community science programs for students, including programs offered in community centres, libraries, and local museums and science centres.

# THE PROGRAM IN SCIENCE

## OVERVIEW OF THE PROGRAM

The overall aim of the secondary science program is to ensure scientific literacy for every secondary school graduate. To better achieve this aim, all courses in the program are designed to focus on science not only as an intellectual pursuit but also as an activity-based enterprise within a social context.

Courses in the Grade 9 and 10 secondary science curriculum are organized into five strands (see page 17). The first strand focuses on the essential skills of scientific investigation, and on career exploration. The remaining four strands cover the content areas of science, each focusing on one of the scientific subdisciplines – biology, chemistry, earth and space science, and physics. The content of the Grade 7 and 8 program creates a strong foundation for students entering secondary school science programs. The transition from Grade 8 to Grade 9 is a smooth one because the content strands of the elementary science and technology program are closely aligned with those of the Grade 9 and 10 science program, as shown in the following chart.

| Elementary Science and Technology | Secondary Science |
|---|---|
| Understanding Life Systems → | Biology |
| Understanding Matter and Energy → | Chemistry |
| Understanding Earth and Space Systems → | Earth and Space Science |
| Understanding Structures and Mechanisms → | Physics |

### Courses in Grades 9 and 10

The science courses in the Grade 9 and 10 curriculum are offered in two course types: *academic* and *applied*. The course types are defined as follows:

*Academic courses develop students' knowledge and skills through the study of theory and abstract problems. These courses focus on the essential concepts of a subject and explore related concepts as well. They incorporate practical applications as appropriate.*

*Applied courses focus on the essential concepts of a subject, and develop students' knowledge and skills through practical applications and concrete examples. Familiar situations are used to illustrate ideas, and students are given more opportunities to experience hands-on applications of the concepts and theories they study.*

Students who successfully complete the academic or applied course in Grade 9 may proceed to either the academic or the applied course in Grade 10.

The Grade 10 academic and applied courses prepare students for particular destination-related courses in Grade 11, for which prerequisites are specified in the Grade 11 and 12 curriculum policy document. The Grade 11 and 12 science curriculum offers university preparation, university/college preparation, college preparation, and workplace preparation courses. When choosing courses in Grades 9 and 10, students, with the help of parents and educators, should carefully consider their strengths, interests, and needs, as well as their postsecondary goals and the course pathways that will enable them to reach those goals.

It should be noted that successful completion of either the academic or the applied Grade 9 course allows students to proceed directly to the Grade 11 workplace preparation course, and successful completion of the Grade 10 applied course allows them to proceed directly to the Grade 12 workplace preparation course.

#### Locally Developed Compulsory Credit Courses (LDCCs)

School boards may offer up to two locally developed compulsory credit courses in science – a Grade 9 course and/or a Grade 10 course[2] – that may be used to meet the compulsory credit requirement in science for one or both of these grades.[3] The locally developed Grade 9 and/or 10 compulsory credit courses prepare students for success in the Grade 11 workplace preparation course, and the Grade 10 course prepares them for success in the Grade 12 workplace preparation course.

**Courses in Science, Grades 9 and 10***

| Grade | Course Name | Course Type | Course Code | Credit Value | Prerequisite |
|---|---|---|---|---|---|
| 9 | Science | Academic | SNC1D | 1 | None |
| 9 | Science | Applied | SNC1P | 1 | None |
| 10 | Science | Academic | SNC2D | 1 | Grade 9 Science, Academic or Applied |
| 10 | Science | Applied | SNC2P | 1 | Grade 9 Science, Academic or Applied |

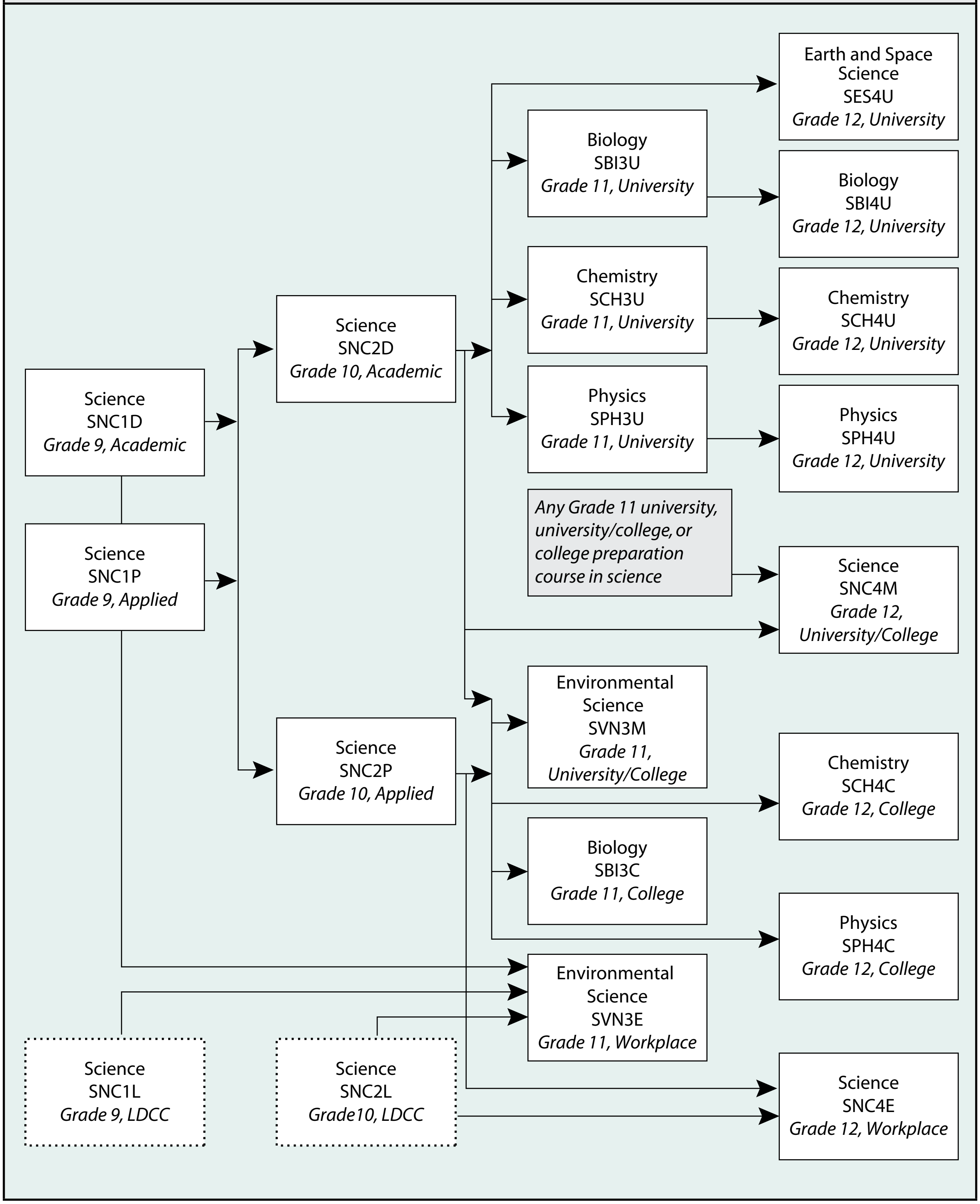
* See preceding text for information about Grade 9 and 10 locally developed compulsory credit science courses.

2. Policy/Program Memorandum No. 134, issued September 13, 2004, states that boards may offer "one Grade 9 course in English, in mathematics, and in science and one Grade 10 course in English, in mathematics, and either in science or in Canadian history that can be counted as a compulsory credit in that discipline".

3. If a student successfully completes both an LDCC course in Grade 9 or Grade 10 science and a curriculum course in science in the same grade, the principal may grant a credit for each course. The two credits may be used to meet the compulsory credit requirement for science.

## Prerequisite Chart for Science, Grades 9–12

This chart maps out all the courses in the discipline and shows the links between courses and the prerequisites for them. It does not attempt to depict all possible movements from course to course.




*Note:* Dotted lines represent locally developed compulsory credit courses (LDCCs), which are not outlined in this curriculum document.

## Half-Credit Courses

The courses outlined in the Grade 9 and 10 and Grade 11 and 12 science curriculum documents are designed as full-credit courses. However, *with the exception of the Grade 12 university preparation and university/college preparation courses*, they may also be delivered as half-credit courses.

Half-credit courses, which require a minimum of fifty-five hours of scheduled instructional time, adhere to the following conditions:

- The two half-credit courses created from a full course must together contain all of the expectations of the full course. The expectations for each half-credit course must be drawn from all strands of the full course and must be divided in a manner that best enables students to achieve the required knowledge and skills in the allotted time.
- A course that is a prerequisite for another course in the secondary curriculum may be offered as two half-credit courses, but students must successfully complete both parts of the course to fulfil the prerequisite. (Students are not required to complete both parts unless the course is a prerequisite for another course they may wish to take.)
- The title of each half-credit course must include the designation *Part 1* or *Part 2*. A half credit (0.5) will be recorded in the credit-value column of both the report card and the Ontario Student Transcript.

Boards will ensure that all half-credit courses comply with the conditions described above, and will report all half-credit courses to the ministry annually in the School October Report.

# CURRICULUM EXPECTATIONS

*The Ontario Curriculum, Grades 9 and 10: Science, 2008* identifies the curriculum expectations for each course. The expectations describe the knowledge and skills that students are expected to develop and demonstrate in their class work and investigations, on tests, and in various other activities on which their achievement is assessed and evaluated.

Two sets of expectations – overall expectations and specific expectations – are listed for each *strand*, or broad area of the curriculum. (The strands are numbered A, B, C, D, and E.) Taken together, the overall expectations and specific expectations represent the mandated curriculum.

The *overall expectations* describe in general terms the knowledge and skills that students are expected to demonstrate by the end of each course. There are three overall expectations for each content strand in each course in science.

The *specific expectations* describe the expected knowledge and skills in greater detail. The specific expectations are grouped under numbered subheadings, each of which indicates the strand and the overall expectation to which the group of specific expectations corresponds (e.g., "B2" indicates that the group relates to overall expectation 2 in strand B). The organization of expectations into groups is not meant to imply that the expectations in any one group are achieved independently of the expectations in the other groups. The subheadings are used merely to help teachers focus on particular aspects of knowledge and skills as they develop and present various lessons and learning activities for their students.

Each Grade 9 and 10 science course is organized into five ***strands***, numbered A, B, C, D, and E.

The ***overall expectations*** describe in general terms the knowledge and skills students are expected to demonstrate by the end of each course. Two or three overall expectations are provided for each strand in every course. The numbering of overall expectations indicates the strand to which they belong (e.g., D1 through D3 are the overall expectations for strand D).

Grade 10, Applied

# D. EARTH AND SPACE SCIENCE: EARTH'S DYNAMIC CLIMATE

## OVERALL EXPECTATIONS

By the end of this course, students will:

**D1.** analyse effects of human activity on climate change, and effects of climate change on living things and natural systems;

**D2.** investigate various natural and human factors that have an impact on climate change and global warming;

**D3.** demonstrate an understanding of various natural and human factors that contribute to climate change and global warming.

## SPECIFIC EXPECTATIONS

### D1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

**D1.1** analyse, on the basis of research, various ways in which living things and natural systems have been affected by climate change (e.g., the effect of loss of permafrost on northern roads and housing; the effect of longer growing seasons in some regions on farmers; the effect of warming oceans on coral reefs), and communicate their findings [IP, PR, AI, C]

*Sample issue:* Some areas of Canada have been experiencing hotter and drier summers, resulting in poor harvests, loss of wetland habitat, and increased incidence of forest fires. However, in other areas, an increase in the number of frost-free days has extended the agricultural growing season.

*Sample questions:* What effect does climate change have on air quality and extreme weather phenomena? How does global warming increase the vulnerability of Canadian forests to fire and pests? How does the destruction of forests affect animals and humans?

**D1.2** analyse ways in which human actions (e.g., burning fossil fuels, implementing tree-planting programs) have increased or decreased the production of greenhouse gases [AI, C]

*Sample issue:* Motor vehicle emissions are a major contributor to greenhouse gases. People can reduce such emissions by walking, biking, or using public transportation instead of driving; by keeping their vehicle in good operating condition; or by driving a hybrid vehicle.

*Sample questions:* Why do government and/or industry offer rebates to consumers buying programmable thermostats and compact fluorescent light bulbs? How does the production of oil from the Alberta oil sands contribute to greenhouse gas emissions? What is the difference in greenhouse gas emissions between a traditional SUV and a hybrid vehicle? What is "clean coal", and what is its impact on greenhouse gas emissions? How does large-scale livestock farming increase the production of greenhouse gases? What actions have you and/or your community taken to help reduce levels of greenhouse gases?

### D2. Developing Skills of Investigation and Communication

By the end of this course, students will:

**D2.1** use appropriate terminology related to Earth's dynamic climate, including, but not limited to: *anthropogenic*, *atmosphere*, *carbon footprint*, *carbon sink*, *climate*, *greenhouse gases*, *hydrosphere*, and *weather* [C]

**D2.2** investigate the principles of the natural greenhouse effect, using simulations, diagrams, and/or models, and compare these principles to those of an actual greenhouse [PR, AI]

**D2.3** use a research process to investigate a source of greenhouse gases (e.g., decaying garbage, animal digestive processes, burning biomass)

THE O

88

A ***numbered subheading*** identifies each group of specific expectations and relates to one particular overall expectation (e.g., "D1. Relating Science to Technology, Society, and the Environment" relates to overall expectation D1).

The ***sample issues*** provide a broader context for expectations in the Relating Science to Technology, Society, and the Environment strand. They are examples of current, relevant, open-ended issues related to the topic of the expectation that students can explore and debate, forming and justifying their own conclusions.

The ***specific expectations*** describe the expected knowledge and skills in greater detail. The expectation number identifies the strand to which the expectation belongs and the overall expectation to which it relates (e.g., D2.1, D2.2, and D2.3 relate to the second overall expectation in strand D).

The ***examples*** are meant to illustrate the kind of knowledge or skills, the specific area of learning, the depth of learning, and/or the level of complexity that the expectation entails. The examples are illustrations only, not requirements. They appear in parentheses within specific expectations.

The ***sample questions*** are intended to help teachers initiate open discussions on a range of current issues related to the topic of the expectation. They can also provide students with a focus for inquiry and/or research.

The ***abbreviations in square brackets*** following many specific expectations link the expectation to one or more of the *four broad areas of scientific investigation skills* (see p. 19). In achieving the expectation, students are expected to apply skills from the area(s) specified by the abbreviation(s).

Many of the specific expectations are accompanied by examples, given in parentheses, as well as "sample issues" and "sample questions". The examples, sample issues, and sample questions are meant to illustrate the kind of knowledge or skill, the specific area of learning, the depth of learning, and/or the level of complexity that the expectation entails. They have been developed to model appropriate practice for the grade and are meant to serve as a guide for teachers rather than an exhaustive or mandatory list. Teachers can choose to use the examples and sample issues and questions that are appropriate for their classrooms, or they may develop their own approaches that reflect a similar level of complexity. Whatever the specific ways in which the requirements outlined in the expectations are implemented in the classroom, they must, wherever possible, be inclusive and reflect the diversity of the student population and the population of the province.

## The Expectations and the Goals of the Science Program

The three overall expectations in the content strands of every course, and their corresponding groups of specific expectations, are closely connected with the three goals of the science program (see page 4). The relationship between the goals and the expectations is briefly described below:

**Goal 1.** ***To relate science to technology, society, and the environment***
The first overall expectation in each content strand focuses on relating science to technology, society, and the environment (STSE). These expectations and their related clusters of specific expectations are positioned at the beginning of the strands to better align the curriculum with the optimal approach to teaching and learning science, and to emphasize the importance of scientific, technological, and environmental literacy for all students. The STSE expectations provide the context for developing the related skills and conceptual knowledge necessary for making connections between scientific, technological, social, and environmental issues. The STSE expectations often focus on aspects of environmental education.

**Goal 2.** ***To develop the skills, strategies, and habits of mind required for scientific investigation***
The skills needed for developing scientific literacy are described in the second overall expectation in each strand and elaborated in its corresponding group of specific expectations, found under the heading "Developing Skills of Investigation and Communication".

**Goal 3.** ***To understand the basic concepts of science***
The conceptual knowledge that students are expected to acquire in the strand is described in the third overall expectation and elaborated in its corresponding group of specific expectations, found under the heading "Understanding Basic Concepts".

The incorporation of the three goals and their interrelationships in the curriculum expectations reinforces the idea that learning in science cannot be viewed as merely the learning of facts. Rather, it involves students' making connections and acquiring, in age-appropriate ways, the knowledge and skills that will help them to understand and consider critically the role of science in their daily lives, and the impact of scientific developments on society and the environment.

## STRANDS IN THE GRADE 9 AND 10 SCIENCE CURRICULUM

The expectations in all Grade 9 and 10 courses are organized in five strands, the first focusing on scientific investigation skills and the remaining four representing the major content areas in the science curriculum. The five strands are as follows:

- **A.** Scientific Investigation Skills and Career Exploration
- **B.** Biology
- **C.** Chemistry
- **D.** Earth and Space Science
- **E.** Physics

### Strand A: Scientific Investigation Skills

The first strand outlines required learning related to scientific investigation skills (SIS). The expectations in this strand describe the skills that are considered to be essential for all types of scientific investigation (see page 19). These skills apply to all areas of course content and must be developed in conjunction with learning in all four content strands of the course. (Scientific investigation skills were also a focus of the elementary science and technology curriculum, but they were embedded in expectations within the content strands.)

The scientific investigation skills are organized under subheadings related to the four broad areas of investigation – initiating and planning; performing and recording; analysing and interpreting; and communicating. To highlight the connection between skills in these broad areas of investigation and the expectations in the other four strands of a course, abbreviations in square brackets are given after each specific expectation in the first two groups of specifics in every strand (under the headings "Relating Science to Technology, Society, and the Environment" and "Developing Skills of Investigation and Communication"). These abbreviations link a specific expectation to the applicable area(s) of investigation skills. For example, "[IP]" indicates that, with achievement of the specific expectation, a student will have developed skills relating to initiating and planning. Teachers should ensure that students develop the scientific investigation skills in appropriate ways as they work to achieve the curriculum expectations in the content strands. Students' mastery of these skills must be assessed and evaluated as part of students' achievement of the overall expectations for the course.

### Strands B through E: Topics in Science

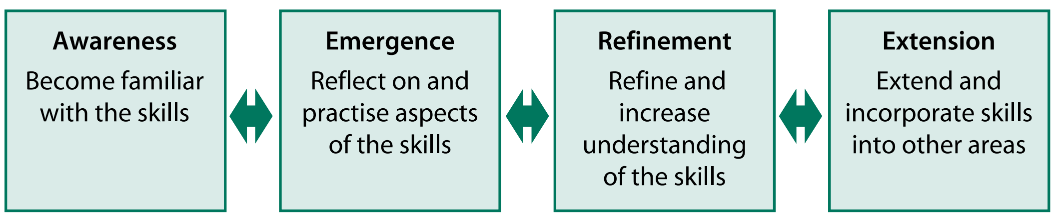
Strands B through E in the Grade 9 and 10 courses cover the four major scientific sub-disciplines – biology, chemistry, earth and space science, and physics. They are designed to build on the required knowledge and skills of the elementary science and technology curriculum, especially the curriculum for Grades 6, 7, and 8, while at the same time expanding and deepening students' understanding of the fundamental concepts. The chart on page 18 provides an outline of the topics in science in Grades 9 and 10, and also shows their broad connections to the science and technology curriculum for Grades 6 to 8.

| Topics in Science, Grades 6–8 and Grades 9 and 10 | | | | |
|---|---|---|---|---|
| ***Grades 6, 7, and 8*** | | | | |
| | **Understanding Life Systems** | **Understanding Matter and Energy** | **Understanding Earth and Space Sytems** | **Understanding Structures and Mechanisms** |
| **Grade 6** | Biodiversity | Electricity and Electrical Devices | Space | Flight |
| **Grade 7** | Interactions in the Environment | Pure Substances and Mixtures | Heat in the Environment | Form and Function |
| **Grade 8** | Cells | Fluids | Water Systems | Systems in Action |
| ***Grades 9 and 10 (Strands B through E)*** | | | | |
| | **B. Biology** | **C. Chemistry** | **D. Earth and Space Science** | **E. Physics** |
| **Grade 9 Academic** | Sustainable Ecosystems | Atoms, Elements, and Compounds | The Study of the Universe | The Characteristics of Electricity |
| **Grade 9 Applied** | Sustainable Ecosystems and Human Activity | Exploring Matter | Space Exploration | Electrical Applications |
| **Grade 10 Academic** | Tissues, Organs, and Systems of Living Things | Chemical Reactions | Climate Change | Light and Geometric Optics |
| **Grade 10 Applied** | Tissues, Organs, and Systems | Chemical Reactions and Their Practical Applications | Earth's Dynamic Climate | Light and Applications of Optics |

## SKILLS OF SCIENTIFIC INVESTIGATION (INQUIRY AND RESEARCH)

The goal of science education is more than just providing students with a knowledge of facts. Mastery of the subject can no longer be evaluated solely in terms of students' ability to recall specialized terminology, memorize isolated facts, or repeat a theory. Rather, students must be given opportunities to learn through investigation. In doing so, they can practise and become proficient in various scientific investigation skills. These skills not only develop critical thinking and allow students to extend their understanding of science; they are also useful in students' everyday lives and will help them in pursuing their post-secondary goals, whether in science or some other area of endeavour.

As students advance from grade to grade, they practise these skills more fully and independently and in increasingly demanding contexts. Initially, students become aware of and familiar with each new skill. With emerging understanding, students reflect on and practise aspects of these skills when conducting investigations. As their knowledge and confidence grow, students begin to implement the skills more fully. Through repeated use, they are able to increase and refine their understanding of and proficiency in each skill. Finally, once they become proficient, they can extend skills, incorporating them into other areas of study as well as everyday activities.




### Four Broad Areas of Scientific Investigation

Students learn to apply scientific investigation skills in four broad areas: *initiating and planning; performing and recording; analysing and interpreting*; and *communicating*.

- *Initiating and planning* skills include formulating questions or hypotheses or making predictions about ideas, issues, problems, or the relationships between observable variables, and planing investigations to answer those questions or test those hypotheses.
- *Performing and recording* skills include conducting research by gathering, organizing, and recording information, and safely conducting inquiries to make observations and to collect, organize, and record data.
- *Analysing and interpreting* skills include evaluating the adequacy of the data from inquiries or the information from research sources, and analysing the data or information in order to draw and justify conclusions.
- *Communication* skills include using appropriate linguistic, numeric, symbolic, and graphic modes of representation, and a variety of forms, to communicate ideas, procedures, and results.

Skills in these four areas are not necessarily performed sequentially. As the figure on page 20 illustrates, investigation may begin in any one of the areas, and students will tend to move back and forth among the areas as they practise and refine their skills. Students should

# Interactions Among the Four Broad Areas of Skills

## Initiating and Planning

Formulate questions or hypotheses or make predictions about issues, problems, or the relationships between observable variables, and plan investigations to answer the questions or test the hypotheses/predictions

- Think and brainstorm
- Identify problems/issues to explore
- Formulate questions
- Identify variables
- Make predictions, develop hypotheses
- Define and clarify the inquiry or research problem
- Identify and locate research sources
- Select instruments and materials
- Plan for safe practices in investigations

## Communicating

Use appropriate linguistic, numeric, symbolic, and graphic modes to communicate ideas, procedures, results, and conclusions in a variety of ways

- Communicate ideas, procedures, and results in a variety of forms (e.g., orally, in writing, using electronic presentations)
- Use appropriate formats to communicate results (e.g., reports, data tables, scientific models)
- Use numeric, symbolic, and graphic modes of representation
- Express results accurately and precisely
- Use correct terminology and appropriate units of measurement

## Performing and Recording

Conduct research by gathering, organizing, and recording information from appropriate sources; and conduct inquiries, making observations and collecting, organizing, and recording qualitative and quantitative data

- Conduct inquiries safely
- Observe, and record observations
- Use equipment, materials, and technology accurately and safely
- Control variables, as appropriate
- Adapt or extend procedures
- Gather, organize, and record relevant information from research, and data from inquiries
- Acknowledge sources, using an accepted form of documentation

## Analysing and Interpreting

Evaluate the reliability of data from inquiries, and of information from research sources, and analyse the data or information to identify patterns and relationships and draw and justify conclusions

- Think critically and logically
- Evaluate reliability of data and information
- Process and synthesize data
- Evaluate whether data supports or refutes hypotheses/predictions
- Interpret data/information to identify patterns and relationships
- Draw conclusions
- Justify conclusions
- Identify sources of error or bias

reflect on their questions, procedures, and findings, and should be prepared to modify them as they proceed through an investigation. In addition, each investigation is unique and will require a particular mix and sequence of skills.

Individual students may develop specific skills earlier or later than their peers, and some students may need to revisit particular skills at different points within the science curriculum. Skills in different areas may be practised and refined in the context of tasks and activities that are not necessarily part of a single, complete investigation that involves all four areas.

> *The purpose of inquiry and research is to encourage high levels of critical thinking so that processes and resources are appropriate, conclusions are based on supporting evidence, and problems are solved and decisions made that will extend learning for a lifetime.*
>
> Ontario School Library Association, *Information Studies: Kindergarten to Grade 12* (1999), p. 16

# ASSESSMENT AND EVALUATION OF STUDENT ACHIEVEMENT

## BASIC CONSIDERATIONS

The primary purpose of assessment and evaluation is to improve student learning. Information gathered through assessment helps teachers to determine students' strengths and weaknesses in their achievement of the curriculum expectations in each course. This information also serves to guide teachers in adapting curriculum and instructional approaches to students' needs and in assessing the overall effectiveness of programs and classroom practices.

Assessment is the process of gathering information from a variety of sources (including assignments, day-to-day observations, conversations or conferences, demonstrations, projects, performances, and tests) that accurately reflects how well a student is achieving the curriculum expectations in a course. As part of assessment, teachers provide students with descriptive feedback that guides their efforts towards improvement. Evaluation refers to the process of judging the quality of student work on the basis of established criteria, and assigning a value to represent that quality.

Assessment and evaluation will be based on the provincial curriculum expectations and the achievement levels outlined in this document.

In order to ensure that assessment and evaluation are valid and reliable, and that they lead to the improvement of student learning, teachers must use assessment and evaluation strategies that:

- address both what students learn and how well they learn;
- are based both on the categories of knowledge and skills and on the achievement level descriptions given in the achievement chart on pages 26–27;
- are varied in nature, administered over a period of time, and designed to provide opportunities for students to demonstrate the full range of their learning;
- are appropriate for the learning activities used, the purposes of instruction, and the needs and experiences of the students;
- are fair to all students;

- accommodate students with special education needs, consistent with the strategies outlined in their Individual Education Plan;
- accommodate the needs of students who are learning the language of instruction;
- ensure that each student is given clear directions for improvement;
- promote students' ability to assess their own learning and to set specific goals;
- include the use of samples of students' work that provide evidence of their achievement;
- are communicated clearly to students and parents at the beginning of the school year and at other appropriate points throughout the school year.

### Evaluation of Achievement of Overall Expectations

All curriculum expectations must be accounted for in instruction, but evaluation focuses on students' achievement of the overall expectations. A student's achievement of the overall expectations is evaluated on the basis of his or her achievement of related specific expectations. The overall expectations are broad in nature, and the specific expectations define the particular content or scope of the knowledge and skills referred to in the overall expectations. Teachers will use their professional judgement to determine which specific expectations should be used to evaluate achievement of the overall expectations, and which ones will be covered in instruction and assessment (e.g., through direct observation) but not necessarily evaluated.

### Levels of Achievement

The characteristics given in the achievement chart (pages 26–27) for level 3 represent the "provincial standard" for achievement of the expectations. A complete picture of achievement at level 3 in a science course can be constructed by reading from top to bottom in the shaded column of the achievement chart, headed "70–79% (Level 3)". Parents of students achieving at level 3 can be confident that their children will be prepared for work in subsequent courses.

Level 1 identifies achievement that falls much below the provincial standard, while still reflecting a passing grade. Level 2 identifies achievement that approaches the standard. Level 4 identifies achievement that surpasses the standard. It should be noted that achievement at level 4 does not mean that the student has achieved expectations beyond those specified for a particular course. It indicates that the student has achieved all or almost all of the expectations for that course, and that he or she demonstrates the ability to use the knowledge and skills specified for that course in more sophisticated ways than a student achieving at level 3.

## THE ACHIEVEMENT CHART FOR SCIENCE

The achievement chart that follows identifies four categories of knowledge and skills in science. The achievement chart is a standard province-wide guide to be used by teachers. It enables teachers to make judgements about student work that are based on clear performance standards and on a body of evidence collected over time.

The purpose of the achievement chart is to:

- provide a common framework that encompasses all curriculum expectations for all courses outlined in this document;

- guide the development of high-quality assessment tasks and tools (including rubrics);
- help teachers to plan instruction for learning;
- assist teachers in providing meaningful feedback to students;
- provide various categories and criteria with which to assess and evaluate students' learning.

## Categories of Knowledge and Skills

The categories, defined by clear criteria, represent four broad areas of knowledge and skills within which the subject expectations for any given course are organized. The four categories should be considered as interrelated, reflecting the wholeness and interconnectedness of learning.

The categories of knowledge and skills are described as follows:

***Knowledge and Understanding.*** Subject-specific content acquired in each course (knowledge), and the comprehension of its meaning and significance (understanding).

***Thinking and Investigation.*** The use of critical and creative thinking skills and inquiry, research, and problem-solving skills and/or processes.

***Communication.*** The conveying of meaning through various forms.

***Application.*** The use of knowledge and skills to make connections within and between various contexts.

Teachers will ensure that student work is assessed and/or evaluated in a balanced manner with respect to the four categories, and that achievement of particular expectations is considered within the appropriate categories.

## Criteria

Within each category in the achievement chart, criteria are provided that are subsets of the knowledge and skills that define each category. The criteria for each category are listed below:

**Knowledge and Understanding**

- knowledge of content (e.g., facts, terminology, definitions, safe use of equipment and materials)
- understanding of content (e.g., concepts, ideas, theories, principles, procedures, processes)

**Thinking and Investigation**

- use of initiating and planning skills and strategies (e.g., formulating questions, identifying the problem, developing hypotheses, selecting strategies and resources, developing plans)
- use of processing skills and strategies (e.g., performing and recording, gathering evidence and data, observing, manipulating materials and using equipment safely, solving equations, proving)
- use of critical/creative thinking processes, skills, and strategies (e.g., analysing, interpreting, problem solving, evaluating, forming and justifying conclusions on the basis of evidence)

**Communication**

- expression and organization of ideas and information (e.g., clear expression, logical organization) in oral, visual, and/or written forms (e.g., diagrams, models)
- communication for different audiences (e.g., peers, adults) and purposes (e.g., to inform, to persuade) in oral, visual, and/or written forms
- use of conventions, vocabulary, and terminology of the discipline in oral, visual, and written forms (e.g., symbols, formulae, scientific notation, SI units)

**Application**

- application of knowledge and skills (e.g., concepts and processes, safe use of equipment, scientific investigation skills) in familiar contexts
- transfer of knowledge and skills (e.g., concepts and processes, safe use of equipment, scientific investigation skills) to unfamiliar contexts
- making connections between science, technology, society, and the environment (e.g., assessing the impact of science on technology, people and other living things, and the environment)
- proposing courses of practical action to deal with problems relating to science, technology, society, and the environment

## Descriptors

A "descriptor" indicates the characteristic of the student's performance, with respect to a particular criterion, on which assessment or evaluation is focused. In the achievement chart, *effectiveness* is the descriptor used for each criterion in the Thinking and Investigation, Communication, and Application categories. What constitutes effectiveness in any given performance task will vary with the particular criterion being considered. Assessment of effectiveness may therefore focus on a quality such as appropriateness, clarity, accuracy, precision, logic, relevance, significance, fluency, flexibility, depth, or breadth, as appropriate for the particular criterion. For example, in the Thinking and Investigation category, assessment of effectiveness might focus on the degree of relevance or depth apparent in an analysis; in the Communication category, on clarity of expression or logical organization of information and ideas; or in the Application category, on appropriateness or breadth in the making of connections. Similarly, in the Knowledge and Understanding category, assessment of knowledge might focus on accuracy, and assessment of understanding might focus on the depth of an explanation. Descriptors help teachers to focus their assessment and evaluation on specific knowledge and skills for each category and criterion, and help students to better understand exactly what is being assessed and evaluated.

## Qualifiers

A specific "qualifier" is used to define each of the four levels of achievement – that is, *limited* for level 1, *some* for level 2, *considerable* for level 3, and *a high degree* or *thorough* for level 4. A qualifier is used along with a descriptor to produce a description of performance at a particular level. For example, the description of a student's performance at level 3 with respect to the first criterion in the Thinking and Investigation category would be: "The student uses initiating and planning skills and strategies with considerable effectiveness".

The descriptions of the levels of achievement given in the chart should be used to identify the level at which the student has achieved the expectations. Students should be provided with numerous and varied opportunities to demonstrate the full extent of their achievement of the curriculum expectations across all four categories of knowledge and skills.

## ACHIEVEMENT CHART: SCIENCE, GRADES 9–12

| Categories | 50–59% (Level 1) | 60–69% (Level 2) | 70–79% (Level 3) | 80–100% (Level 4) |
|---|---|---|---|---|
| **Knowledge and Understanding** – Subject-specific content acquired in each course (knowledge), and the comprehension of its meaning and significance (understanding) | | | | |
| | The student: | | | |
| **Knowledge of content** *(e.g., facts, terminology, definitions, safe use of equipment and materials)* | demonstrates limited knowledge of content | demonstrates some knowledge of content | demonstrates considerable knowledge of content | demonstrates thorough knowledge of content |
| **Understanding of content** *(e.g., concepts, ideas, theories, principles, procedures, processes)* | demonstrates limited understanding of content | demonstrates some understanding of content | demonstrates considerable understanding of content | demonstrates thorough understanding of content |
| **Thinking and Investigation** – The use of critical and creative thinking skills and inquiry, research, and problem-solving skills and/or processes | | | | |
| | The student: | | | |
| **Use of initiating and planning skills and strategies** *(e.g., formulating questions, identifying the problem, developing hypotheses, selecting strategies and resources, developing plans)* | uses initiating and planning skills and strategies with limited effectiveness | uses initiating and planning skills and strategies with some effectiveness | uses initiating and planning skills and strategies with considerable effectiveness | uses initiating and planning skills and strategies with a high degree of effectiveness |
| **Use of processing skills and strategies** *(e.g., performing and recording, gathering evidence and data, observing, manipulating materials and using equipment safely, solving equations, proving)* | uses processing skills and strategies with limited effectiveness | uses processing skills and strategies with some effectiveness | uses processing skills and strategies with considerable effectiveness | uses processing skills and strategies with a high degree of effectiveness |
| **Use of critical/creative thinking processes, skills, and strategies** *(e.g., analysing, interpreting, problem solving, evaluating, forming and justifying conclusions on the basis of evidence )* | uses critical/ creative thinking processes, skills, and strategies with limited effectiveness | uses critical/ creative thinking processes, skills, and strategies with some effectiveness | uses critical/ creative thinking processes, skills, and strategies with considerable effectiveness | uses critical/ creative thinking processes, skills, and strategies with a high degree of effectiveness |
| **Communication** – The conveying of meaning through various forms | | | | |
| | The student: | | | |
| **Expression and organization of ideas and information** *(e.g., clear expression, logical organization)* **in oral, visual, and/or written forms** *(e.g., diagrams, models)* | expresses and organizes ideas and information with limited effectiveness | expresses and organizes ideas and information with some effectiveness | expresses and organizes ideas and information with considerable effectiveness | expresses and organizes ideas and information with a high degree of effectiveness |

| Categories | 50–59% (Level 1) | 60–69% (Level 2) | 70–79% (Level 3) | 80–100% (Level 4) |
|---|---|---|---|---|
| **Communication** (*continued*) | | | | |
| | The student: | | | |
| **Communication for different audiences** *(e.g., peers, adults)* **and purposes** *(e.g., to inform, to persuade)* **in oral, visual, and/or written forms** | communicates for different audiences and purposes with limited effectiveness | communicates for different audiences and purposes with some effectiveness | communicates for different audiences and purposes with considerable effectiveness | communicates for different audiences and purposes with a high degree of effectiveness |
| **Use of conventions, vocabulary, and terminology of the discipline in oral, visual, and/or written forms** *(e.g., symbols, formulae, scientific notation, SI units)* | uses conventions, vocabulary, and terminology of the discipline with limited effectiveness | uses conventions, vocabulary, and terminology of the discipline with some effectiveness | uses conventions, vocabulary, and terminology of the discipline with considerable effectiveness | uses conventions, vocabulary, and terminology of the discipline with a high degree of effectiveness |
| **Application** – The use of knowledge and skills to make connections within and between various contexts | | | | |
| | The student: | | | |
| **Application of knowledge and skills** *(e.g., concepts and processes, safe use of equipment, scientific investigation skills)* **in familiar contexts** | applies knowledge and skills in familiar contexts with limited effectiveness | applies knowledge and skills in familiar contexts with some effectiveness | applies knowledge and skills in familiar contexts with considerable effectiveness | applies knowledge and skills in familiar contexts with a high degree of effectiveness |
| **Transfer of knowledge and skills** *(e.g., concepts and processes, safe use of equipment, scientific investigation skills)* **to unfamiliar contexts** | transfers knowledge and skills to unfamiliar contexts with limited effectiveness | transfers knowledge and skills to unfamiliar contexts with some effectiveness | transfers knowledge and skills to unfamiliar contexts with considerable effectiveness | transfers knowledge and skills to unfamiliar contexts with a high degree of effectiveness |
| **Making connections between science, technology, society, and the environment** *(e.g., assessing the impact of science on technology, people and other living things, and the environment)* | makes connections between science, technology, society, and the environment with limited effectiveness | makes connections between science, technology, society, and the environment with some effectiveness | makes connections between science, technology, society, and the environment with considerable effectiveness | makes connections between science, technology, society, and the environment with a high degree of effectiveness |
| **Proposing courses of practical action to deal with problems relating to science, technology, society, and the environment** | proposes courses of practical action of limited effectiveness | proposes courses of practical action of some effectiveness | proposes courses of practical action of considerable effectiveness | proposes highly effective courses of practical action |

*Note:* A student whose achievement is below 50% at the end of a course will not obtain a credit for the course.

## EVALUATION AND REPORTING OF STUDENT ACHIEVEMENT

Student achievement must be communicated formally to students and parents by means of the Provincial Report Card, Grades 9–12. The report card provides a record of the student's achievement of the curriculum expectations in every course, at particular points in the school year or semester, in the form of a percentage grade. The percentage grade represents the quality of the student's overall achievement of the expectations for the course and reflects the corresponding level of achievement as described in the achievement chart for the discipline.

A final grade is recorded for every course, and a credit is granted and recorded for every course in which the student's grade is 50% or higher. The final grade for each course will be determined as follows:

- Seventy per cent of the grade will be based on evaluations conducted throughout the course. This portion of the grade should reflect the student's most consistent level of achievement throughout the course, although special consideration should be given to more recent evidence of achievement.
- Thirty per cent of the grade will be based on a final evaluation in the form of an examination, performance, essay, and/or other method of evaluation suitable to the course content and administered towards the end of the course.

## REPORTING ON DEMONSTRATED LEARNING SKILLS

The report card provides a record of the learning skills demonstrated by the student in every course, in the following five categories: Works Independently, Teamwork, Organization, Work Habits, and Initiative. The learning skills are evaluated using a four-point scale (E–Excellent, G–Good, S–Satisfactory, N–Needs Improvement). The separate evaluation and reporting of the learning skills in these five areas reflects their critical role in students' achievement of the curriculum expectations. To the extent possible, the evaluation of learning skills, apart from any that may be included as part of a curriculum expectation in a course, should not be considered in the determination of percentage grades.

# SOME CONSIDERATIONS FOR PROGRAM PLANNING

When planning a program in science, teachers must take into account considerations in a number of important areas, including those discussed below.

## INSTRUCTIONAL APPROACHES

> *A much more effective way to learn is for students to be actively involved in thinking and discussing during both class and investigation activities, with the goal of having the students develop a deep understanding of scientific concepts.*
>
> Kathleen Falconer et al., *Effect of Reformed Courses in Physics and Physical Science on Student Conceptual Understanding* (American Educational Research Association, April 2001), p. 1

Students come to secondary school with a natural curiosity developed throughout the elementary grades. They also bring with them individual interests and abilities as well as diverse personal and cultural experiences, all of which have an impact on their prior knowledge about science, technology, the environment, and the world they live in. Effective instructional approaches and learning activities draw on students' prior knowledge, capture their interest, and encourage meaningful practice both inside and outside the classroom. Students will be engaged when they are able to see the connection between the scientific concepts they are learning and their application in the world around them and in real-life situations.

Students in a science class typically demonstrate diversity in the ways they learn best. It is important, therefore, that students have opportunities to learn in a variety of ways – individually, cooperatively, independently, with teacher direction, through hands-on experiences, and through examples followed by practice. In science, students are required to learn concepts and procedures, acquire skills, and learn and apply scientific processes, and they become competent in these various areas with the aid of instructional and learning strategies that are suited to the particular type of learning. The approaches and strategies teachers use will vary according to both the object of the learning and the needs of the students.

*Differentiated Instruction is responsive instruction. It occurs as teachers become increasingly proficient in understanding their students as individuals, increasingly comfortable with the meaning and structure of the disciplines they teach, and increasingly expert at teaching flexibly in order to match instruction to student need with the goal of maximizing the potential of each learner in a given area.*

Carol Ann Tomlinson, *Fulfilling the Promise of the Differentiated Classroom* (ASCD, 2003), pp. 2–3

In order to learn science and to apply their knowledge and skills effectively, students must develop a solid understanding of scientific concepts. Research and successful classroom practice have shown that an inquiry approach, with emphasis on learning through concrete, hands-on experiences, best enables students to develop the conceptual foundation they need. When planning science programs, teachers will provide activities and challenges that actively engage students in inquiries that honour the ideas and skills students bring to them, while further deepening their conceptual understandings and essential skills.

Students will investigate scientific concepts using a variety of equipment, materials, and strategies. Activities are necessary for supporting the effective learning of science by all students. These active learning opportunities invite students to explore and investigate abstract scientific ideas in rich, varied, and hands-on ways. Moreover, the use of a variety of equipment and materials helps deepen and extend students' understanding of scientific concepts and further extends their development of scientific investigation skills.

All learning, especially new learning, should be embedded in well-chosen contexts for learning – that is, contexts that are broad enough to allow students to investigate initial understandings, identify and develop relevant supporting skills, and gain experience with varied and interesting applications of the new knowledge. In the secondary science curriculum, many of these contexts come from the Relating Science to Technology, Society, and the Environment (STSE) expectations. Such rich contexts for learning enable students to see the "big ideas" of science. This understanding of "big ideas" will enable and encourage students to use scientific thinking throughout their lives. As well, contextualized teaching and learning provides teachers with useful insights into their students' thinking, their understanding of concepts, and their ability to reflect on what they have done. This insight allows teachers to provide supports to help enhance students' learning.

## HEALTH AND SAFETY IN SCIENCE

Teachers must model safe practices at all times and communicate safety expectations to students in accordance with school board and Ministry of Education policies and Ministry of Labour regulations. Teachers are responsible for ensuring the safety of students during classroom activities and also for encouraging and motivating students to assume responsibility for their own safety and the safety of others. Teachers must also ensure that students have the knowledge and skills needed for safe participation in science activities.

To carry out their responsibilities with regard to safety, it is important for teachers to have:

- concern for their own safety and that of their students;
- the knowledge necessary to use the materials, equipment, and procedures involved in science safely;
- knowledge concerning the care of living things – plants and animals – that are brought into the classroom;
- the skills needed to perform tasks efficiently and safely.

Students demonstrate that they have the knowledge, skills, and habits of mind required for safe participation in science activities when they:

- maintain a well-organized and uncluttered work space;
- follow established safety procedures;
- identify possible safety concerns;
- suggest and implement appropriate safety procedures;
- carefully follow the instructions and example of the teacher;
- consistently show care and concern for their own safety and that of others.

Various kinds of health and safety issues can arise when learning involves field trips. Out-of-school field trips can provide an exciting and authentic dimension to students' learning experiences. They also take the teacher and students out of the predictable classroom environment and into unfamiliar settings. Teachers must preview and plan these activities carefully to protect students' health and safety.

## PLANNING SCIENCE PROGRAMS FOR STUDENTS WITH SPECIAL EDUCATION NEEDS

Classroom teachers are the key educators of students who have special education needs. They have a responsibility to help all students learn, and they work collaboratively with special education resource teachers, where appropriate, to achieve this goal. *Special Education Transformation: The Report of the Co-Chairs with the Recommendations of the Working Table on Special Education, 2006* endorses a set of beliefs that should guide program planning for students with special education needs *in all disciplines*. These beliefs are as follows:

- All students can succeed.
- Universal design[4] and differentiated instruction[5] are effective and interconnected means of meeting the learning or productivity needs of any group of students.
- Successful instructional practices are founded on evidence-based research, tempered by experience.
- Classroom teachers are key educators for a student's literacy and numeracy development.
- Each student has his or her own unique patterns of learning.
- Classroom teachers need the support of the larger community to create a learning environment that supports students with special education needs.
- Fairness is not sameness.

In any given classroom, students may demonstrate a wide range of strengths and needs. Teachers plan programs that recognize this diversity and give students performance tasks that respect their particular abilities so that all students can derive the greatest possible benefit from the teaching and learning process. The use of flexible groupings for instruction and the provision of ongoing assessment are important elements of programs that accommodate a diversity of learning needs.

4. The goal of Universal Design for Learning (UDL) is to create a learning environment that is open and accessible to all students, regardless of age, skills, or situation. Instruction based on principles of universal design is flexible and supportive, can be adjusted to meet different student needs, and enables all students to access the curriculum as fully as possible.

5. Differentiated instruction is effective instruction that shapes each student's learning experience in response to his or her particular learning preferences, interests, and readiness to learn.

In planning science courses for students with special education needs, teachers should begin by examining the current achievement level of the individual student, the strengths and learning needs of the student, and the knowledge and skills that all students are expected to demonstrate at the end of the course, in order to determine which of the following options is appropriate for the student:

- no accommodations[6] or modifications; or
- accommodations only; or
- modified expectations, with the possibility of accommodations; or
- alternative expectations, which are not derived from the curriculum expectations for a course and which constitute alternative programs and/or courses.

If the student requires either accommodations or modified expectations, or both, the relevant information, as described in the following paragraphs, must be recorded in his or her Individual Education Plan (IEP). More detailed information about planning programs for students with special education needs, including students who require alternative programs and/or courses,[7] can be found in *The Individual Education Plan (IEP): A Resource Guide, 2004* (referred to hereafter as the *IEP Resource Guide, 2004*). For a detailed discussion of the ministry's requirements for IEPs, see *Individual Education Plans: Standards for Development, Program Planning, and Implementation, 2000* (referred to hereafter as *IEP Standards, 2000*). (Both documents are available at www.edu.gov.on.ca.)

## Students Requiring Accommodations Only

Some students are able, with certain accommodations, to participate in the regular course curriculum and to demonstrate learning independently. Accommodations allow access to the course without any changes to the knowledge and skills the student is expected to demonstrate. The accommodations required to facilitate the student's learning must be identified in his or her IEP (see *IEP Standards, 2000,* page 11). A student's IEP is likely to reflect the same accommodations for many, or all, subjects or courses.

Providing accommodations to students with special education needs should be the first option considered in program planning. Instruction based on principles of universal design and differentiated instruction focuses on the provision of accommodations to meet the diverse needs of learners.

There are three types of accommodations:

- *Instructional accommodations* are changes in teaching strategies, including styles of presentation, methods of organization, or use of technology and multimedia.
- *Environmental accommodations* are changes that the student may require in the classroom and/or school environment, such as preferential seating or special lighting.
- *Assessment accommodations* are changes in assessment procedures that enable the student to demonstrate his or her learning, such as allowing additional time to complete tests or assignments or permitting oral responses to test questions (see page 29 of the *IEP Resource Guide, 2004,* for more examples).

If a student requires "accommodations only" in science courses, assessment and evaluation of his or her achievement will be based on the appropriate course curriculum expectations and the achievement levels outlined in this document. The IEP box on the

---

6. *Accommodations* refers to individualized teaching and assessment strategies, human supports, and/or individualized equipment.

7. Alternative programs are identified on the IEP form by the term "alternative (ALT)".

student's Provincial Report Card will not be checked, and no information on the provision of accommodations will be included.

## Students Requiring Modified Expectations

Some students will require modified expectations, which differ from the regular course expectations. For most students, modified expectations will be based on the regular course curriculum, with changes in the number and/or complexity of the expectations. Modified expectations represent specific, realistic, observable, and measurable achievements and describe specific knowledge and/or skills that the student can demonstrate independently, given the appropriate assessment accommodations.

It is important to monitor, and to reflect clearly in the student's IEP, the extent to which expectations have been modified. As noted in section 7.12 of the ministry's policy document *Ontario Secondary Schools, Grades 9 to 12: Program and Diploma Requirements, 1999*, the principal will determine whether achievement of the modified expectations constitutes successful completion of the course, and will decide whether the student is eligible to receive a credit for the course. This decision must be communicated to the parents and the student.

When a student is expected to achieve most of the curriculum expectations for the course, the modified expectations should identify *how the required knowledge and skills differ from those identified in the course expectations*. When modifications are so extensive that achievement of the learning expectations (knowledge, skills, and performance tasks) is not likely to result in a credit, the expectations should *specify the precise requirements or tasks on which the student's performance will be evaluated* and which will be used to generate the course mark recorded on the Provincial Report Card.

Modified expectations indicate the knowledge and/or skills the student is expected to demonstrate and have assessed in each reporting period (see *IEP Standards, 2000*, pages 10 and 11). The student's learning expectations must be reviewed in relation to the student's progress at least once every reporting period, and must be updated as necessary (see *IEP Standards, 2000*, page 11).

If a student requires modified expectations in science courses, assessment and evaluation of his or her achievement will be based on the learning expectations identified in the IEP and on the achievement levels outlined in this document. If some of the student's learning expectations for a course are modified but the student is working towards a credit for the course, it is sufficient simply to check the IEP box on the Provincial Report Card. If, however, the student's learning expectations are modified to such an extent that the principal deems that a credit will not be granted for the course, the IEP box must be checked and the appropriate statement from the *Guide to the Provincial Report Card, Grades 9–12, 1999* (page 8) must be inserted. The teacher's comments should include relevant information on the student's demonstrated learning of the modified expectations, as well as next steps for the student's learning in the course.

## PROGRAM CONSIDERATIONS FOR ENGLISH LANGUAGE LEARNERS

Ontario schools have some of the most multilingual student populations in the world. The first language of approximately 20 per cent of the students in Ontario's English-language schools is a language other than English. Ontario's linguistic heritage includes several Aboriginal languages and many African, Asian, and European languages. It also includes some varieties of English – also referred to as dialects – that differ significantly from the English required for success in Ontario schools. Many English language learners were born in Canada and have been raised in families and communities in which languages other than English, or varieties of English that differ from the language used in the classroom, are spoken. Other English language learners arrive in Ontario as newcomers from other countries; they may have experience of highly sophisticated educational systems, or they may have come from regions where access to formal schooling was limited.

When they start school in Ontario, many of these students are entering a new linguistic and cultural environment. All teachers share in the responsibility for these students' English language development.

English language learners (students who are learning English as a second or additional language in English-language schools) bring a rich diversity of background knowledge and experience to the classroom. These students' linguistic and cultural backgrounds not only support their learning in their new environment but also become a cultural asset in the classroom community. Teachers will find positive ways to incorporate this diversity into their instructional programs and into the classroom environment.

Most English language learners in Ontario schools have an age-appropriate proficiency in their first language. Although they need frequent opportunities to use English at school, there are important educational and social benefits associated with continued development of their first language while they are learning English. Teachers need to encourage parents to continue to use their own language at home in rich and varied ways as a foundation for language and literacy development in English. It is also important for teachers to find opportunities to bring students' languages into the classroom, using parents and community members as a resource.

During their first few years in Ontario schools, English language learners may receive support through one of two distinct programs from teachers who specialize in meeting their language-learning needs:

***English as a Second Language (ESL)*** programs are for students born in Canada or newcomers whose first language is a language other than English or is a variety of English significantly different from that used for instruction in Ontario schools.

***English Literacy Development (ELD)*** programs are primarily for newcomers whose first language is a language other than English, or is a variety of English significantly different from that used for instruction in Ontario schools, and who arrive with significant gaps in their education. These students generally come from countries where access to education is limited or where there are limited opportunities to develop language and literacy skills in any language. Some Aboriginal students from remote communities in Ontario may also have had limited opportunities for formal schooling, and they also may benefit from ELD instruction.

In planning programs for students with linguistic backgrounds other than English, teachers need to recognize the importance of the orientation process, understanding that every learner needs to adjust to the new social environment and language in a unique way and at an individual pace. For example, students who are in an early stage of English-language acquisition may go through a "silent period" during which they closely observe the interactions and physical surroundings of their new learning environment. They may use body language rather than speech or they may use their first language until they have gained enough proficiency in English to feel confident of their interpretations and responses. Students thrive in a safe, supportive, and welcoming environment that nurtures their self-confidence while they are receiving focused literacy instruction. When they are ready to participate in paired, small-group, or whole-class activities, some students will begin by using a single word or phrase to communicate a thought, while others will speak quite fluently.

With exposure to the English language in a supportive learning environment, most young children will develop oral fluency quite quickly, making connections between concepts and skills acquired in their first language and similar concepts and skills presented in English. However, oral fluency is not a good indicator of a student's knowledge of vocabulary or sentence structure, reading comprehension, or other aspects of language proficiency that play an important role in literacy development and academic success. Research has shown that it takes five to seven years for most English language learners to catch up to their English-speaking peers in their ability to use English for academic purposes. Moreover, the older the children are when they arrive, the more language knowledge and skills they have to catch up on, and the more direct support they require from their teachers.

Responsibility for students' English-language development is shared by the classroom teacher, the ESL/ELD teacher (where available), and other school staff. Volunteers and peers may also be helpful in supporting English language learners in the language classroom. Teachers must adapt the instructional program in order to facilitate the success of these students in their classrooms. Appropriate adaptations include:

- modification of some or all of the subject expectations so that they are challenging but attainable for the learner at his or her present level of English proficiency, given the necessary support from the teacher;
- use of a variety of instructional strategies (e.g., extensive use of visual cues, graphic organizers, and scaffolding; previewing of textbooks; pre-teaching of key vocabulary; peer tutoring; strategic use of students' first languages);
- use of a variety of learning resources (e.g., visual material, simplified text, bilingual dictionaries, and materials that reflect cultural diversity);
- use of assessment accommodations (e.g., granting of extra time; use of oral interviews, demonstrations or visual representations, or tasks requiring completion of graphic organizers or cloze sentences instead of essay questions and other assessment tasks that depend heavily on proficiency in English).

When learning expectations in any course are modified for an English language learner (whether the student is enrolled in an ESL or ELD course or not), this information must be clearly indicated on the student's report card.

Although the degree of program adaptation required will decrease over time, students who are no longer receiving ESL or ELD support may still need some program adaptations to be successful.

For further information on supporting English language learners, refer to *The Ontario Curriculum, Grades 9 to 12: English as a Second Language and English Literacy Development, 2007; English Language Learners – ESL and ELD Programs and Services: Policies and Procedures for Ontario Elementary and Secondary Schools, Kindergarten to Grade 12, 2007*; and the resource guide *Many Roots, Many Voices: Supporting English Language Learners in Every Classroom, 2005*.

## ENVIRONMENTAL EDUCATION

> *Environmental education is education about the environment, for the environment, and in the environment that promotes an understanding of, rich and active experience in, and an appreciation for the dynamic interactions of:*
>
> - *The earth's physical and biological systems*
> - *The dependency of our social and economic systems on these natural systems*
> - *The scientific and human dimensions of environmental issues*
> - *The positive and negative consequences, both intended and unintended, of the interactions between human-created and natural systems.*
>
> *Shaping Our Schools, Shaping Our Future: Environmental Education in Ontario Schools* (June 2007), p. 6

As noted in *Shaping Our Schools, Shaping Our Future: Environmental Education in Ontario Schools*, environmental education "is the responsibility of the entire education community. It is a content area and can be taught. It is an approach to critical thinking, citizenship, and personal responsibility, and can be modelled. It is a context that can enrich and enliven education in all subject areas, and offer students the opportunity to develop a deeper connection with themselves, their role in society, and their interdependence on one another and the earth's natural systems" (p. 10).

The increased emphasis on relating science to technology, society, and the environment (STSE) within this curriculum document provides numerous opportunities for teachers to integrate environmental education effectively into the curriculum. The STSE expectations provide meaningful contexts for applying what has been learned about the environment, for thinking critically about issues related to the environment, and for considering personal action that can be taken to protect the environment. Throughout the courses and strands, teachers have opportunities to take students out of the classroom and into the world beyond the school, to observe, explore, and investigate. One effective way to approach environmental literacy is through examining critical inquiry questions related to students' sense of place, to the impact of human activity on the environment, and/or to systems thinking. This can be done at numerous points within the science curriculum.

The following are some examples:

- A sense of place can be developed as students investigate natural and human factors that influence Earth's climate.
- An understanding of the effects of human activity on the environment can develop as students consider the impact of their actions (e.g., taking part in tree planting at a local park, walking or biking to school instead of riding in the car, packing a litterless lunch) on their local environment.
- Systems thinking can be developed as students understand what a system is and how changing one part of it (e.g., introducing zebra mussels into a local lake or non-native invasive plants into a wetland) can affect the whole system.

## ANTIDISCRIMINATION EDUCATION

### Overview

The implementation of antidiscrimination principles in education influences all aspects of school life. It promotes a school climate that encourages all students to work to attain high standards, affirms the worth of all students, and helps students strengthen their sense of identity and develop a positive self-image. It encourages staff and students alike to value and show respect for diversity in the school and the wider society. It requires schools to adopt measures to provide a safe environment for learning, free from harassment, violence, and expressions of hate.

Antidiscrimination education encourages students to think critically about themselves and others in the world around them in order to promote fairness, healthy relationships, and active, responsible citizenship.

Schools have the responsibility to ensure that school–community interaction reflects the diversity in the local community and wider society. Consideration should be given to a variety of strategies for communicating and working with parents and community members from diverse groups, in order to ensure their participation in such school activities as plays, concerts, and teacher interviews. Families new to Canada, who may be unfamiliar with the Ontario school system, or parents of Aboriginal students may need special outreach and encouragement in order to feel comfortable in their interactions with the school.

### Antidiscrimination Education and Science

The science program provides students with access to materials that reflect diversity with respect to gender, race, culture, and ability. Diverse groups of people involved in scientific activities and careers should be prominently featured. In planning the science program, teachers should consider issues such as access to laboratory experiences and equipment. Laboratory benches and lighting should be adjustable and appropriate for students with physical disabilities. Equipment and materials can also be adapted in ways that make them accessible to all students.

The examples used to illustrate knowledge and skills, and the practical applications and topics that students explore as part of the learning process, should vary so that they appeal to both boys and girls and relate to students' diverse backgrounds, interests, and experiences.

In many instances, variations in culture and location (whether rural, urban, or suburban) can be found in a single classroom. Students living in apartment buildings will have different access to plants and animals than students living in a rural setting or on a First Nation reserve. There may be cultural sensitivities for some students in areas such as the use of biological specimens. For example, a number of religions have prohibitions regarding pigs. Although it is impossible to anticipate every contingency, teachers should be open to adjusting their instruction, if feasible, when concerns are brought to their attention.

It is important that learning activities include opportunities for students to describe, study, or research how women and men from a variety of backgrounds, including Aboriginal peoples, have contributed to science, used science to solve problems in their daily life and work, or been affected by scientific processes or phenomena. The calendar systems of various cultures or the use that Aboriginal peoples have made of medicinal plants might be considered. Students might examine the impact of climate change on different regions and cultures around the world, as well as the impact of technologies or technological processes in use in different countries in relation to the food chain, the environment, or the ozone layer. Expectations in the curriculum encourage students to look at the perspectives and world views of various cultures, including Aboriginal cultures, as they relate to scientific issues.

Access to computers should be monitored and a range of software applications provided. A problem-solving approach can benefit students who are having difficulties with materials or equipment. Because access to equipment at home will vary, it is important to offer challenges for or support to students whose levels of prior knowledge differ.

## CRITICAL THINKING AND CRITICAL LITERACY IN SCIENCE

Critical thinking is the process of thinking about ideas or situations in order to understand them fully, identify their implications, and/or make a judgement about what is sensible or reasonable to believe or do. Critical thinking includes skills such as questioning, predicting, hypothesizing, analysing, synthesizing, examining opinions, identifying values and issues, detecting bias, and distinguishing between alternatives.

Students use critical thinking skills in science when they assess, analyse, and/or evaluate the impact of something on society and the environment; when they form an opinion about something and support that opinion with logical reasons; or when they create personal plans of action with regard to making a difference. In order to do these things, students need to examine the opinions and values of others, detect bias, look for implied meaning in their readings, and use the information gathered to form a personal opinion or stance.

As they work to achieve the STSE expectations, students are frequently asked to identify the implications of an action, activity, or process. As they gather information from a variety of sources, they need to be able to interpret what they are reading, to look for instances of bias, and to determine why that source might express that particular bias.

In developing the skills of scientific investigation (inquiry/research skills), students must ask appropriate questions to frame their research, interpret information, and detect bias. Depending on the topic, they may be required to consider the values and perspectives of a variety of groups and individuals.

Critical literacy is the capacity for a particular type of critical thinking that involves looking beyond the literal meaning of a text to determine what is present and what is missing, in order to analyse and evaluate the text's complete meaning and the author's intent. Critical literacy goes beyond conventional critical thinking by focusing on issues related to fairness, equity, and social justice. Critically literate students adopt a critical stance, asking what view of the world the text advances and whether they find this view acceptable.

In science, students who are critically literate are able, for example, to read or view reports from a variety of sources on a common issue. They are able to assess how fairly the facts have been reported, what biases might be contained in each report and why that might be, how the content of the report was determined and by whom, and what might have been left out of the report and why. These students would then be equipped to produce their own interpretation of the issue.

## LITERACY, MATHEMATICAL LITERACY, AND INVESTIGATION (INQUIRY/RESEARCH) SKILLS

Literacy, mathematical literacy, and investigation skills are critical to students' success in all subjects of the curriculum and in all areas of their lives. Many of the activities and tasks that students undertake in the science curriculum involve the literacy skills related to oral, written, and visual communication. Communication skills are fundamental to the development of scientific literacy, and fostering students' communication skills is an important part of the teacher's role in the science curriculum.

When reading in science, students use a different set of skills than they do when reading fiction or general non-fiction. They need to understand vocabulary and terminology that are unique to science, and must be able to interpret symbols, charts, diagrams, and graphs. In addition, as they progress through secondary school, it becomes critically important for them to have the ability to make sense of the organization of science textbooks, scientific journals, and research papers. To help students construct meaning from scientific texts, it is essential that teachers of science model and teach the strategies that support learning to read while students are reading to learn in science.

Writing in science employs special forms and therefore also requires specific and focused learning opportunities. Students use writing skills to describe and explain their observations, to support the process of critically analysing information in both informal and formal contexts, and to present their findings in written, graphic, and multimedia forms.

> *Scientists … take meticulous notes to form hypotheses, document observations, conduct experiments, and solve problems. Writing for them is much more than data collection; it is exploring, revising, and thinking on paper. Writing helps them learn facts, work out what the facts mean, and use facts to make new discoveries and refine old theories.*
>
> Laura Robb, *Teaching Reading in Social Studies, Science and Math* (2003), p. 59

Oral communication skills are fundamental to the development of scientific literacy and are essential for thinking and learning. Through purposeful talk, students not only learn to communicate information but also explore and come to understand ideas and concepts; identify and solve problems; organize their experience and knowledge; and express and clarify their thoughts, feelings, and opinions.

To develop their oral communication skills, students need numerous opportunities to listen to information and talk about a range of subjects in science. The science program provides opportunities for students to engage in various oral activities in connection with expectations in all the strands, such as brainstorming to identify what they know about the new topic they are studying, discussing strategies for solving a problem, presenting and defending ideas or debating issues, and offering critiques of models and results produced by their peers.

Students' understanding is revealed through both oral and written communication. It is not always necessary for science learning to involve a written communication component. Whether students are talking or writing about their scientific learning, teachers can ask questions that prompt students to explain their thinking and reasoning behind a particular solution, design, or strategy, or to reflect on what they have done.

Understanding science also requires the use and understanding of specialized terminology. In all science courses, students are expected to use appropriate and correct terminology, and are encouraged to use language with care and precision in order to communicate effectively.

The Ministry of Education has facilitated the development of materials to support literacy instruction across the curriculum. Helpful advice for integrating literacy instruction in science courses may be found in the following resource documents:

- *Think Literacy: Cross-Curricular Approaches, Grades 7–12, 2003*
- *Think Literacy: Cross-Curricular Approaches – Subject-Specific Examples: Science, Grade 9 Applied, 2004*
- *Think Literacy: Cross-Curricular Approaches – Subject-Specific Examples: Science, Grades 9–10 – Oral Communication, 2005*
- *Think Literacy: Cross-Curricular Approaches – Subject-Specific Examples: Science, Grades 9–10 – Writing Strategies, 2005*
- *Think Literacy: Cross-Curricular Approaches – Subject-Specific Examples: Science, Grade 10 – Reading Strategies, 2005*
- *Think Literacy: Cross-Curricular Approaches – Subject-Specific Examples: Locally Developed Compulsory Credit Course – Grade 9 Science, 2005*

The science program also builds on, reinforces, and enhances mathematical literacy. For example, clear, concise communication in science often involves using diagrams, tables, graphs, calculations, and equations to represent quantitative data. Many components of the science curriculum emphasize students' ability to interpret data and information presented in a variety of forms (e.g., symbols, graphs, tables). In addition, physics, chemistry, earth and space science, and biology provide rich problem-solving situations that require students to apply, and help them develop and extend, mathematical knowledge and thinking.

Investigations are at the heart of learning in science. In science courses, students will have multiple opportunities to develop their ability to ask questions and conduct inquiries and research as they plan and carry out investigations. They will practise using a variety of inquiry and research skills that they need to carry out their investigations, and will learn how to determine the most appropriate methods to use in a particular inquiry or research activity. Students will also learn how to locate relevant information in a variety of print and electronic sources, including books and articles, scientific periodicals, manuals, newspapers, websites, databases, tables, diagrams, and charts. As they advance through the courses, students will be expected to distinguish between primary and secondary sources, to use these sources in appropriate ways and with increasing sophistication, and to assess their validity and relevance.

## THE ROLE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY IN SCIENCE

Information and communications technology (ICT) provides a range of tools that can significantly extend and enrich teachers' instructional strategies and support students' learning in science. Computer programs can help students collect, organize, and sort the data they gather and to write, edit, and present multimedia reports on their findings. ICT can also be used to connect students to other schools, at home and abroad, and to bring the global community into the local classroom. Technology also makes it possible to use simulations – for instance, when field studies on a particular topic are not feasible or dissections are not acceptable.

Whenever appropriate, therefore, students should be encouraged to use ICT to support and communicate their learning. For example, students working individually or in groups can use computers and portable storage devices, CD-ROM and DVD technologies, and/or Internet websites to gain access to science institutions in Canada and around the world. Students can also use digital or video cameras to record laboratory inquiries or findings on field trips, or for multimedia presentations on scientific issues.

Although the Internet is a powerful learning tool, all students must be made aware of issues of privacy, safety, and responsible use, as well as of the potential for abuse of this technology, particularly when it is used to promote hatred.

ICT tools are also useful for teachers in their teaching practice, both for whole class instruction and for the design of curriculum units that contain varied approaches to learning to meet diverse student needs. A number of educational software programs to support science are licensed through the ministry and are listed at www.osapac.org/software.asp.

## THE ONTARIO SKILLS PASSPORT AND ESSENTIAL SKILLS

Teachers planning programs in science need to be aware of the purpose and benefits of the Ontario Skills Passport (OSP). The OSP is a bilingual, web-based resource that enhances the relevance of classroom learning for students and strengthens school–work connections. The OSP provides clear descriptions of Essential Skills such as Reading Text, Writing, Computer Use, Measurement and Calculation, and Problem Solving and includes an extensive database of occupation-specific workplace tasks that illustrate how workers use these skills on the job. The Essential Skills are transferable, in that they are used in virtually all occupations. The OSP also includes descriptions of important work habits, such as working safely, being reliable, and providing excellent customer service. The OSP is designed to help employers assess and record students' demonstration of these skills and work habits during their cooperative education placements. Students can use the OSP to assess, practise, and build their Essential Skills and work habits and transfer them to a job or further education or training.

The skills described in the OSP are the Essential Skills that the Government of Canada and other national and international agencies have identified and validated, through extensive research, as the skills needed for work, learning, and life. These Essential Skills provide the foundation for learning all other skills and enable people to evolve with their jobs and adapt to workplace change. For further information on the OSP and the Essential Skills, visit http://skills.edu.gov.on.ca.

## CAREER EDUCATION

Ongoing scientific discoveries and innovations coupled with rapidly evolving technologies have resulted in an exciting environment in which creativity and innovation thrive, bringing about new career opportunities. Today's employers seek candidates with strong critical-thinking and problem-solving skills and the ability to work cooperatively in a team – traits that are developed through participation in the science program. Through science courses, students will develop a variety of important capabilities, including the ability to identify issues, conduct research, carry out experiments, solve problems, present results, and work on projects both independently and as a team. Students are also given opportunities to explore various careers related to the areas of science under study and to research the education and training required for these careers (see the expectations in the first strand of every course in the program, "Scientific Investigation Skills and Career Exploration").

## COOPERATIVE EDUCATION AND OTHER FORMS OF EXPERIENTIAL LEARNING

Cooperative education and other forms of experiential learning, such as job shadowing, field trips, and work experience, enable students to apply the skills they have developed in the classroom to real-life activities in the world of science and innovation. Cooperative education and other workplace experiences also help to broaden students' knowledge of employment opportunities in a wide range of fields, including laboratory technology and research, health care, veterinary science, and horticulture. In addition, students develop their understanding of workplace practices, certifications, and the nature of employer–employee relationships. Teachers of science can support their students' learning by maintaining links with community-based organizations to ensure that students have access to hands-on experiences that will reinforce the knowledge and skills they have gained in school.

Students who choose a science course as the related course for two cooperative education credits are able, through this packaged program, to meet the OSSD compulsory credit requirements for groups 1, 2, and 3.

Health and safety issues must be addressed when learning involves cooperative education and other workplace experiences. Teachers who provide support for students in workplace learning placements need to assess placements for safety and ensure that students understand the importance of issues relating to health and safety in the workplace. Before taking part in workplace learning experiences, students must acquire the knowledge and skills needed for safe participation. Students must understand their rights to privacy and confidentiality as outlined in the Freedom of Information and Protection of Privacy Act. They have the right to function in an environment free from abuse and harassment, and they need to be aware of harassment and abuse issues in establishing boundaries for their own personal safety. They should be informed about school and community resources and school policies and reporting procedures with respect to all forms of abuse and harassment.

Policy/Program Memorandum No. 76A,"Workplace Safety and Insurance Coverage for Students in Work Education Programs" (September 2000), outlines procedures for ensuring the provision of Health and Safety Insurance Board coverage for students who are at least 14 years of age and are on placements of more than one day. (A one-day job shadowing or job twinning experience is treated as a field trip.) Teachers should also be aware of the minimum age requirements outlined in the Occupational Health and Safety Act for persons to be in or to be working in specific workplace settings. All cooperative education and other workplace experiences will be provided in accordance with the ministry's policy document *Cooperative Education and Other Forms of Experiential Learning: Policies and Procedures for Ontario Secondary Schools, 2000*.

## PLANNING PROGRAM PATHWAYS AND PROGRAMS LEADING TO A SPECIALIST HIGH SKILLS MAJOR

Science courses are well suited for inclusion in some programs leading to a Specialist High Skills Major (SHSM) or in programs designed to provide pathways to particular apprenticeship or workplace destinations. In some SHSM programs, science courses can be bundled with other courses to provide the academic knowledge and skills important to particular industry sectors and required for success in the workplace and postsecondary education, including apprenticeship. Science courses may also be combined with cooperative education credits to provide the workplace experience required for some SHSM programs and for various program pathways to apprenticeship and workplace destinations. (SHSM programs would also include sector-specific learning opportunities offered by employers, skills-training centres, colleges, and community organizations.)

# COURSES

# Science, Grade 9

## Academic SNC1D

This course enables students to develop their understanding of basic concepts in biology, chemistry, earth and space science, and physics, and to relate science to technology, society, and the environment. Throughout the course, students will develop their skills in the processes of scientific investigation. Students will acquire an understanding of scientific theories and conduct investigations related to sustainable ecosystems; atomic and molecular structures and the properties of elements and compounds; the study of the universe and its properties and components; and the principles of electricity.

**Prerequisite:** None

### Big Ideas

***Biology***

- Ecosystems are dynamic and have the ability to respond to change, within limits, while maintaining their ecological balance.
- People have the responsibility to regulate their impact on the sustainability of ecosystems in order to preserve them for future generations.

***Chemistry***

- Elements and compounds have specific physical and chemical properties that determine their practical uses.
- The use of elements and compounds has both positive and negative effects on society and the environment.

***Earth and Space Science***

- Different types of celestial objects in the solar system and universe have distinct properties that can be investigated and quantified.
- People use observational evidence of the properties of the solar system and the universe to develop theories to explain their formation and evolution.
- Space exploration has generated valuable knowledge but at enormous cost.

***Physics***

- Electricity is a form of energy produced from a variety of non-renewable and renewable sources.
- The production and consumption of electrical energy has social, economic, and environmental implications.
- Static and current electricity have distinct properties that determine how they are used.

### Fundamental Concepts Covered in This Course (see also page 5)

| Fundamental Concepts | Biology | Chemistry | Earth and Space Science | Physics |
|---|---|---|---|---|
| Matter | | ✓ | ✓ | |
| Energy | | | ✓ | ✓ |
| Systems and Interactions | ✓ | | ✓ | ✓ |
| Structure and Function | | ✓ | ✓ | ✓ |
| Sustainability and Stewardship | ✓ | ✓ | | |
| Change and Continuity | ✓ | | ✓ | |

# A. SCIENTIFIC INVESTIGATION SKILLS AND CAREER EXPLORATION

## OVERALL EXPECTATIONS

Throughout this course, students will:

**A1.** demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analysing and interpreting, and communicating);

**A2.** identify and describe a variety of careers related to the fields of science under study, and identify scientists, including Canadians, who have made contributions to those fields.

## SPECIFIC EXPECTATIONS

### A1. Scientific Investigation Skills

Throughout this course, students will:

#### Initiating and Planning [IP]*

**A1.1** formulate scientific questions about observed relationships, ideas, problems, and/or issues, make predictions, and/or formulate hypotheses to focus inquiries or research

**A1.2** select appropriate instruments (e.g., sampling instruments, laboratory glassware, magnifying lenses, an electroscope) and materials (e.g., ebonite rods, star charts, a ball and spring apparatus, pH paper) for particular inquiries

**A1.3** identify and locate print, electronic, and human sources that are relevant to research questions

**A1.4** apply knowledge and understanding of safe practices and procedures when planning investigations (e.g., appropriate techniques for handling, storing, and disposing of laboratory materials [following the Workplace Hazardous Materials Information System–WHMIS]; safe operation of electrical equipment; safe handling of biological materials), with the aid of appropriate support materials (e.g., the Reference Manual on the WHMIS website; the Live Safe! Work Smart! website)

#### Performing and Recording [PR]*

**A1.5** conduct inquiries, controlling some variables, adapting or extending procedures as required, and using standard equipment and materials safely, accurately, and effectively, to collect observations and data

**A1.6** gather data from laboratory and other sources, and organize and record the data using appropriate formats, including tables, flow charts, graphs, and/or diagrams

**A1.7** select, organize, and record relevant information on research topics from various sources, including electronic, print, and/or human sources (e.g., Statistics Canada publications, NASA or EnerGuide websites, personal interviews), using recommended formats and an accepted form of academic documentation

#### Analysing and Interpreting [AI]*

**A1.8** analyse and interpret qualitative and/or quantitative data to determine whether the evidence supports or refutes the initial prediction or hypothesis, identifying possible sources of error, bias, or uncertainty

**A1.9** analyse the information gathered from research sources for reliability and bias

**A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions

* The abbreviation(s) for the broad area(s) of investigation skills – IP, PR, AI, and/or C – are provided in square brackets at the end of the expectations in strands B–E to which the particular area(s) relate (see pp. 19–21 for information on scientific investigation skills).

**Communicating [C]***

**A1.11** communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g., data tables, laboratory reports, presentations, debates, simulations, models)

**A1.12** use appropriate numeric, symbolic, and graphic modes of representation, and appropriate units of measurement (e.g., SI and imperial units)

**A1.13** express the results of any calculations involving data accurately and precisely

## A2. Career Exploration

Throughout this course, students will:

**A2.1** identify and describe a variety of careers related to the fields of science under study (e.g., astrophysicist, geophysicist, conservation officer, park warden, fire protection engineer, hydrologist, electrician) and the education and training necessary for these careers

**A2.2** identify scientists, including Canadians (e.g., David Suzuki, Howard Alper, Roberta Bondar, Kenneth Hill), who have made a contribution to the fields of science under study

# B. BIOLOGY: SUSTAINABLE ECOSYSTEMS

## OVERALL EXPECTATIONS

By the end of this course, students will:

**B1.** assess the impact of human activities on the sustainability of terrestrial and/or aquatic ecosystems, and evaluate the effectiveness of courses of action intended to remedy or mitigate negative impacts;

**B2.** investigate factors related to human activity that affect terrestrial and aquatic ecosystems, and explain how they affect the sustainability of these ecosystems;

**B3.** demonstrate an understanding of the dynamic nature of ecosystems, particularly in terms of ecological balance and the impact of human activity on the sustainability of terrestrial and aquatic ecosystems.

## SPECIFIC EXPECTATIONS

### B1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

**B1.1** assess, on the basis of research, the impact of a factor related to human activity (e.g., urban sprawl, introduction of invasive species, overhunting/overfishing) that threatens the sustainability of a terrestrial or aquatic ecosystem [IP, PR, AI, C]

*Sample issue:* The Great Lakes constitute an important shipping route. Foreign ships often empty their ballast water, which can contain invasive species, directly into the lakes. The goby, which was likely imported in ballast water, is an aggressive fish that has taken over the spawning grounds of some native species, threatening the balance of the ecosystem.

*Sample questions:* How has suburban development on the Niagara Escarpment or the Oak Ridges Moraine affected local ecosystems? How has the zebra mussel population in Lake Erie affected aquatic species and water quality? How has commercial logging affected the sustainability of forests in Northern Ontario?

**B1.2** evaluate the effectiveness of government initiatives in Canada (federal, provincial, municipal), and/or the efforts of societal groups or non-governmental organizations, such as Aboriginal communities, environmental groups, or student organizations, with respect to an environmental issue that affects the sustainability of terrestrial or aquatic ecosystems (e.g., wetland restoration, recycling programs, Canada–Ontario Environmental Farm Plans, stewardship of national and provincial parks) [AI, C]

*Sample issue:* Landfill sites can have negative effects on adjacent ecosystems, attracting pests, leaching toxic chemicals, and producing greenhouse gases. Municipal recycling and composting programs divert garbage, reducing the need for new landfill sites. However, many people, particularly rural residents and those in apartment buildings, may not be included in these programs.

*Sample questions:* What provincial or federal legislation attempts to protect special features or sensitive elements of terrestrial or freshwater ecosystems? How could such legislation be more effective? How have the actions of local wetland-reclamation, municipal tree-planting, Aboriginal fisheries-management, Great Lakes–rehabilitation, organic farming, or other groups helped to ensure ecological sustainability? What further action could such groups take?

## B2. Developing Skills of Investigation and Communication

By the end of this course, students will:

**B2.1** use appropriate terminology related to sustainable ecosystems, including, but not limited to: *bioaccumulation, biosphere, diversity, ecosystem, equilibrium, sustainability, sustainable use, protection,* and *watershed* [C]

**B2.2** interpret qualitative and quantitative data from undisturbed and disturbed ecosystems (terrestrial and/or aquatic), communicate the results graphically, and, extrapolating from the data, explain the importance of biodiversity for all sustainable ecosystems [PR, AI, C]

**B2.3** plan and conduct an investigation, involving both inquiry and research, into how a human activity affects soil composition or soil fertility (e.g., changes to soil composition resulting from the use of different compostable materials, organic or inorganic fertilizers, or pesticides), and, extrapolating from the data and information gathered, explain the impact of this activity on the sustainability of terrestrial ecosystems [IP, PR, AI, C]

**B2.4** plan and conduct an investigation, involving both inquiry and research, into how a human activity affects water quality (e.g., leaching of organic or inorganic fertilizers or pesticides into water systems, changes to watersheds resulting from deforestation or land development, diversion of ground water for industrial uses), and, extrapolating from the data and information gathered, explain the impact of this activity on the sustainability of aquatic ecosystems [IP, PR, AI, C]

**B2.5** analyse the effect of human activity on the populations of terrestrial and aquatic ecosystems by interpreting data and generating graphs (e.g., data from Statistics Canada, Parks Canada, and other websites on: the concentration in water of chemicals from fertilizer run-off and their effect on the growth of algae; stressors associated with human use of natural areas, such as trampled vegetation, wildlife mortality from motor vehicles, and the removal of plants, animals, and/or natural objects; suburban developments and their impact on the food supply for animals such as foxes and racoons) [PR, AI, C]

## B3. Understanding Basic Concepts

By the end of this course, students will:

**B3.1** compare and contrast biotic and abiotic characteristics of sustainable and unsustainable terrestrial and aquatic ecosystems

**B3.2** describe the complementary processes of cellular respiration and photosynthesis with respect to the flow of energy and the cycling of matter within ecosystems (i.e., carbon dioxide is a by-product of cellular respiration and is used for photosynthesis, which produces oxygen needed for cellular respiration), and explain how human activities can disrupt the balance achieved by these processes (e.g., automobile use increases the amount of carbon dioxide in the atmosphere; planting more trees decreases the amount of carbon dioxide in the atmosphere)

**B3.3** describe the limiting factors of ecosystems (e.g., nutrients, space, water, energy, predators), and explain how these factors affect the carrying capacity of an ecosystem (e.g., the effect of an increase in the moose population on the wolf population in the same ecosystem)

**B3.4** identify the earth's four spheres (biosphere, hydrosphere, lithosphere, atmosphere), and describe the relationship that must exist between these spheres if diversity and sustainability are to be maintained

**B3.5** identify various factors related to human activity that have an impact on ecosystems (e.g., the introduction of invasive species; shoreline development; industrial emissions that result in acid rain), and explain how these factors affect the equilibrium and survival of ecosystems (e.g., invasive species push out native species and upset the equilibrium in an ecosystem; shoreline development affects the types of terrestrial and aquatic life that can live near lake shores or river banks; acid rain changes the pH of water, which affects the type of aquatic life that can survive in a lake)

# C. CHEMISTRY: ATOMS, ELEMENTS, AND COMPOUNDS

## OVERALL EXPECTATIONS

By the end of this course, students will:

**C1.** assess social, environmental, and economic impacts of the use of common elements and compounds, with reference to their physical and chemical properties;

**C2.** investigate, through inquiry, the physical and chemical properties of common elements and compounds;

**C3.** demonstrate an understanding of the properties of common elements and compounds, and of the organization of elements in the periodic table.

## SPECIFIC EXPECTATIONS

### C1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

**C1.1** assess the usefulness of and/or the hazards associated with common elements or compounds in terms of their physical and chemical properties [AI, C]

*Sample issue:* Polyethylene is a versatile, flexible, and durable compound that is used in a range of products, including toys, plastic bottles, bullet-proof vests, and plastic bags. However, its durability poses problems for the environment because products made from polyethylene are not biodegradable.

*Sample questions:* What properties of diamonds make them useful in a variety of applications? What property of DDT allows it to continue to accumulate in the fatty tissue of mammals despite its ban by the Canadian government in the 1980s? How do the chemical properties of peroxide make it suitable for use in hair dye? What are the hazards associated with this use?

**C1.2** assess social, environmental, and economic impacts of the use of common elements or compounds [AI, C]

*Sample issue:* By reducing the accumulation of ice on roads, road salt makes winter driving safer, decreasing medical and insurance costs associated with motor vehicle accidents. But the compounds in road salt damage roads and vehicles, pollute water systems, and harm animals and vegetation.

*Sample questions:* How has the presence of mercury in water bodies in Northern Ontario affected the environment and the lives of Aboriginal people? How does the widespread use of agricultural chemicals in Canada or elsewhere affect the economy, society, and the environment? What are the economic benefits and environmental costs of diamond mining for Northern Canadian communities?

### C2. Developing Skills of Investigation and Communication

By the end of this course, students will:

**C2.1** use appropriate terminology related to atoms, elements, and compounds, including, but not limited to: *boiling point, mixtures, particle theory, pure substances,* and *viscosity* [C]

**C2.2** conduct an inquiry to identify the physical and chemical properties of common elements and compounds (e.g., magnesium sulfate, water, carbon, copper II) [PR]

**C2.3** plan and conduct an inquiry into the properties of common substances found in the laboratory or used in everyday life (e.g., starch, table salt, wax, toothpaste), and distinguish the substances by their physical and chemical properties (e.g., *physical properties:* hardness, conductivity, colour, melting point, solubility, density; *chemical properties:* combustibility, reaction with water) [IP, PR, AI]

**C2.4** conduct appropriate chemical tests to identify some common gases (e.g., oxygen, hydrogen, carbon dioxide) on the basis of their chemical properties, and record their observations [PR, C]

**C2.5** construct molecular models to represent simple molecules (e.g., $O_2$, $CO_2$, $H_2O$, $NH_3$, $CH_4$) [PR]

## C3. Understanding Basic Concepts

By the end of this course, students will:

**C3.1** explain how different atomic models evolved as a result of experimental evidence (e.g., how the Thomson model of the atom changed as a result of the Rutherford gold-foil experiment)

**C3.2** describe the characteristics of neutrons, protons, and electrons, including charge, location, and relative mass

**C3.3** distinguish between elements and compounds (e.g., compounds are pure substances that can be broken down into elements by chemical means)

**C3.4** describe the characteristic physical and chemical properties of common elements and compounds (e.g., aluminum is a good conductor of heat; copper reacts to moist air by developing a greenish surface of copper carbonate; sodium carbonate is a white, odourless powder that dissolves in water; water has unique physical properties that allow it to support life)

**C3.5** describe patterns in the arrangements of electrons in the first 20 elements of the periodic table, using the Bohr-Rutherford model

**C3.6** explain the relationship between the atomic structure of an element and the position of that element in the periodic table

**C3.7** compare and contrast the physical properties of elements within a group (e.g., alkali metals) and between groups (e.g., the carbon group and noble gases) in the periodic table

**C3.8** identify and use the symbols for common elements (e.g., C, Cl, S, N) and the formulae for common compounds (e.g., $H_2O$, $CO_2$, NaCl, $O_2$)

# D. EARTH AND SPACE SCIENCE: THE STUDY OF THE UNIVERSE

## OVERALL EXPECTATIONS

By the end of this course, students will:

**D1.** assess some of the costs, hazards, and benefits of space exploration and the contributions of Canadians to space research and technology;

**D2.** investigate the characteristics and properties of a variety of celestial objects visible from Earth in the night sky;

**D3.** demonstrate an understanding of the major scientific theories about the structure, formation, and evolution of the universe and its components and of the evidence that supports these theories.

## SPECIFIC EXPECTATIONS

### D1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

**D1.1** assess, on the basis of research, and report on the contributions of Canadian governments, organizations, businesses, and/or individuals to space technology, research, and/or exploration (e.g., as part of the International Space Station mission; in the fields of telecommunications and satellite technology) [IP, PR, AI, C]

*Sample issue:* The Canadarm was developed by a Canadian company with financial support from the federal government to offset its high costs. It is an important component of the International Space Station, a unique facility that provides many innovative opportunities for space exploration and research.

*Sample questions:* What contributions have Canadian researchers made to space exploration? How have Canadians contributed to the development and use of satellite technology? How have partnerships between the public and private sectors in Canada contributed to the development of technology used in space research and exploration?

**D1.2** assess some of the costs, hazards, and benefits of space exploration (e.g., the expense of developing new technologies, accidents resulting in loss of life, contributions to our knowledge of the universe), taking into account the benefits of technologies that were developed for the space program but that can be used to address environmental and other practical challenges on Earth (e.g., radiation monitors and barriers, sensors to monitor air and water quality, remote sensing technology, fire-resistant materials) [AI, C]

*Sample issue:* Technologies that were originally developed for space exploration now have a range of environmental, medical, business, and domestic uses. However, these technologies were developed at great cost, using funds that might have been directed to other types of research and development.

*Sample questions:* What hazards do humans face when they are in space? What technologies have been developed in response to these hazards? How have these technologies been adapted for use on Earth? How much money was spent to develop the Canadarm? How is Canadarm technology now used in other sectors such as medicine and the environment?

### D2. Developing Skills of Investigation and Communication

By the end of this course, students will:

**D2.1** use appropriate terminology related to the study of the universe, including, but not limited to: *celestial objects*, *orbital radius*, *retrograde motion*, and *satellite* [C]

**D2.2** use direct observation, computer simulation, or star charts to determine the location, appearance, and motion of well-known stars and other celestial objects that are visible in the night sky (e.g., the stars Polaris, Sirius, Betelgeuse; the planet Venus) [PR, AI]

**D2.3** plan and conduct a simulation that illustrates the interrelationships between various properties of celestial objects visible in the night sky (e.g., set up flashlights of various intensities at different distances from an observation point to help illustrate why the brightness of a star viewed from Earth is a function of both its actual brightness and its distance from Earth) [IP, PR, AI]

**D2.4** gather and record data, using an inquiry or research process, on the properties of specific celestial objects within the solar system (e.g., the composition of their atmosphere, if any; the composition of their surface; the strength of their gravitational pull) [IP, PR, C]

**D2.5** compare and contrast properties of celestial objects visible in the night sky, drawing on information gathered through research and using an appropriate format (e.g., compare the size of planets; represent the distance of stars from Earth using scientific notation; compare star temperatures and colour) [PR, AI, C]

## D3. Understanding Basic Concepts

By the end of this course, students will:

**D3.1** describe observational and theoretical evidence relating to the origin and evolution of the universe (e.g., evidence supporting the big bang theory)

**D3.2** describe observational and theoretical evidence relating to the formation of the solar system (e.g., evidence that supports the theory that the solar system was formed from a contracting, spinning disc of dust and gas)

**D3.3** describe the major components of the solar system and the universe (e.g., planets, stars, galaxies), using appropriate scientific terminology and units (e.g., astronomical units, scientific notation, light years)

**D3.4** describe the sun's composition and energy source, and explain how its energy warms Earth and supports life on the planet (e.g., with reference to the types of radiation the sun emits and the interaction of the sun's energy with Earth's atmosphere)

**D3.5** explain the causes of astronomical phenomena (e.g., the aurora borealis, solar eclipses, phases of the moon, comets) and how various phenomena can best be observed from Earth (e.g., solar eclipses should be viewed through a suitable solar filter or by projection, not with the naked eye)

**D3.6** describe various reasons that humankind has had for studying space (e.g., to develop calendars for agricultural purposes, to forecast weather, for celestial navigation, for religious inspiration) and the conceptions of the universe held by various cultures and civilizations (e.g., Aboriginal peoples; ancient Greek, Mayan civilizations)

# E. PHYSICS: THE CHARACTERISTICS OF ELECTRICITY

## OVERALL EXPECTATIONS

By the end of this course, students will:

**E1.** assess some of the costs and benefits associated with the production of electrical energy from renewable and non-renewable sources, and analyse how electrical efficiencies and savings can be achieved, through both the design of technological devices and practices in the home;

**E2.** investigate, through inquiry, various aspects of electricity, including the properties of static and current electricity, and the quantitative relationships between potential difference, current, and resistance in electrical circuits;

**E3.** demonstrate an understanding of the principles of static and current electricity.

## SPECIFIC EXPECTATIONS

### E1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

**E1.1** analyse the design of a technological device that improves its electrical efficiency or protects other devices by using or controlling static electricity (e.g., paint sprayers, photocopiers, lightning rods, grounding wires) [AI, C]

*Sample questions:* How does eliminating static electricity help or hinder the performance of a device? How have static electricity controls helped in developing new technologies?

**E1.2** assess some of the social, economic, and environmental implications of the production of electrical energy in Canada from renewable and non-renewable sources (e.g., wind, solar, hydro, coal, oil, natural gas, nuclear) [AI, C]

*Sample issue:* The operation of wind farms along Lake Huron produces electricity from a renewable source, reducing dependence on non-renewable sources of electricity. However, the wind farms produce noise and visual pollution, affect local animal life, and reduce the amount of land available for agriculture.

*Sample questions:* What is the price difference between electricity produced from solar power and by coal-burning plants? What effects do coal mining, oil production, wind farms, and hydroelectric dams have on surrounding ecosystems? What types of hazardous substances are used or created in the production of solar power and nuclear power? What types of emissions are produced by coal-burning and hydroelectric power plants? What are the effects of these emissions on human health and the environment?

**E1.3** produce a plan of action to reduce electrical energy consumption at home (e.g., using EnerGuide information when purchasing appliances), and outline the roles and responsibilities of various groups (e.g., government, business, family members) in this endeavour [IP, AI, C]

*Sample issue:* Replacing incandescent light bulbs with compact fluorescent bulbs can reduce the energy needed to light a home by 75%. Although the bulbs are more expensive than incandescent bulbs, electrical companies sometimes provide coupons to reduce the price. Also, the Ontario government is phasing out incandescent bulbs, which will further reduce energy consumption.

*Sample questions:* What are EnerGuide and ENERGY STAR, and how can they be used when purchasing appliances or electronics? What is the difference in energy consumption between a conventional and a front-loading washing machine? What appliances consume electrical energy even when they are not in use?

## E2. Developing Skills of Investigation and Communication

By the end of this course, students will:

**E2.1** use appropriate terminology related to electricity, including, but not limited to: *ammeter, amperes, battery, current, fuse, kilowatt hours, load, ohms, potential difference, resistance, switch, voltmeter,* and *volts* [C]

**E2.2** conduct investigations into the transfer of static electric charges by friction, contact, and induction, and produce labelled diagrams to explain the results [PR, AI, C]

**E2.3** predict the ability of different materials to hold or transfer electric charges (i.e., to act as insulators or conductors), and test their predictions through inquiry [IP, PR]

**E2.4** plan and carry out inquiries to determine and compare the conductivity of various materials (e.g., metals, plastics, glass, water) [IP, PR, AI, C]

**E2.5** design, draw circuit diagrams of, and construct series and parallel circuits (e.g., a circuit where all light bulbs go out when one light bulb is removed; a circuit that allows one of several light bulbs to be switched on and off independently of the others), and measure electric current $I$, potential difference $V$, and resistance $R$ at various points in the circuits, using appropriate instruments and SI units [IP, PR, AI, C]

**E2.6** analyse and interpret the effects of adding an identical load in series and in parallel in a simple circuit [AI, C]

**E2.7** investigate the quantitative relationships between current, potential difference, and resistance in a simple series circuit [PR, AI]

**E2.8** solve simple problems involving potential difference $V$, electric current $I$, and resistance $R$, using the quantitative relationship $V = IR$ [AI, C]

**E2.9** determine the energy consumption of various appliances, and calculate their operating costs (e.g., using the kilowatt hour rate from a utility bill) [AI, C]

**E2.10** calculate the efficiency of an energy converter, using the following equation: percent efficiency = $(E_{out}/E_{in}) \times 100\%$ [AI, C]

## E3. Understanding Basic Concepts

By the end of this course, students will:

**E3.1** identify electrical quantities (i.e., current, potential difference, resistance, and electrical energy), and list their symbols and their corresponding SI units (e.g., electric current: $I$, ampere)

**E3.2** explain the characteristics of conductors and insulators and how materials allow static charge to build up or be discharged

**E3.3** compare and contrast static electricity with alternating current (AC) and direct current (DC) (e.g., the charge on a charged electroscope, the charge in a functioning circuit)

**E3.4** identify the components of a simple DC circuit (e.g., electrical source, load, connecting wires, switch, fuse), and explain their functions

**E3.5** explain the characteristics of electric current, potential difference, and resistance in simple series and parallel circuits, noting how the quantities differ in the two circuits

**E3.6** describe, qualitatively, the interrelationships between resistance, potential difference, and electric current (e.g., the effect on current when potential difference is changed and resistance is constant)

**E3.7** explain what different meters (e.g., ammeters, voltmeters, multimeters) measure and how they are connected within an electrical circuit to measure electrical quantities

**E3.8** explain how various factors (e.g., wire length, wire material, cross-sectional area of wire) influence the resistance of an electrical circuit

# Science, Grade 9

## Applied SNC1P

This course enables students to develop their understanding of basic concepts in biology, chemistry, earth and space science, and physics, and to apply their knowledge of science to everyday situations. They are also given opportunities to develop practical skills related to scientific investigation. Students will plan and conduct investigations into practical problems and issues related to the impact of human activity on ecosystems; the structure and properties of elements and compounds; space exploration and the components of the universe; and static and current electricity.

**Prerequisite:** None

### Big Ideas

***Biology***
- Ecosystems consist of a variety of components, including, in many cases, humans.
- The sustainability of ecosystems depends on balanced interactions between their components.
- Human activity can affect the sustainability of aquatic and terrestrial ecosystems.

***Chemistry***
- Elements and compounds have specific properties that determine their uses.
- The use of elements and compounds has both positive and negative effects on society and the environment.

***Earth and Space Science***
- Celestial objects in the solar system and universe have specific properties that can be investigated and understood.
- Technologies developed for space exploration have practical applications on Earth.

***Physics***
- Electricity is a form of energy produced from a variety of non-renewable and renewable sources.
- The production and consumption of electrical energy has social, economic, and environmental implications.
- Static and current electricity have distinct properties that determine how they are used.

### Fundamental Concepts Covered in This Course (see also page 5)

| Fundamental Concepts | Biology | Chemistry | Earth and Space Science | Physics |
|---|---|---|---|---|
| Matter | | ✓ | ✓ | |
| Energy | | | ✓ | ✓ |
| Systems and Interactions | ✓ | | ✓ | ✓ |
| Structure and Function | | ✓ | ✓ | ✓ |
| Sustainability and Stewardship | ✓ | ✓ | | |
| Change and Continuity | ✓ | | | |

# A. SCIENTIFIC INVESTIGATION SKILLS AND CAREER EXPLORATION

## OVERALL EXPECTATIONS

Throughout this course, students will:

**A1.** demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analysing and interpreting, and communicating);

**A2.** identify and describe a variety of careers related to the fields of science under study, and identify scientists, including Canadians, who have made contributions to those fields.

## SPECIFIC EXPECTATIONS

### A1. Scientific Investigation Skills

Throughout this course, students will:

#### Initiating and Planning [IP]*

**A1.1** formulate scientific questions about observed relationships, ideas, problems, and/or issues, make predictions, and/or formulate hypotheses to focus inquiries or research

**A1.2** select appropriate instruments (e.g., soil sampling instruments, a pneumatic trough and test tubes, magnifying lenses, an electroscope) and materials (e.g., ebonite rods, star charts, oxygen testing splints, pH paper) for particular inquiries

**A1.3** identify and locate print, electronic, and human sources that are relevant to research questions

**A1.4** apply knowledge and understanding of safe practices and procedures when planning investigations (e.g., appropriate techniques for handling, storing, and disposing of laboratory materials [following the Workplace Hazardous Materials Information System–WHMIS]; safe operation of electrical equipment; safe handling of biological materials), with the aid of appropriate support materials (e.g., the Reference Manual on the WHMIS website; the Live Safe! Work Smart! website)

#### Performing and Recording [PR]*

**A1.5** conduct inquiries, controlling some variables, adapting or extending procedures as required, and using standard equipment and materials safely, accurately, and effectively, to collect observations and data

**A1.6** gather data from laboratory and other sources, and organize and record the data using appropriate formats, including tables, flow charts, graphs, and/or diagrams

**A1.7** select, organize, and record relevant information on research topics from various sources, including electronic, print, and/or human sources (e.g., Statistics Canada publications, NASA or EnerGuide websites, personal interviews), using recommended formats and an accepted form of academic documentation

#### Analysing and Interpreting [AI]*

**A1.8** analyse and interpret qualitative and/or quantitative data to determine whether the evidence supports or refutes the initial prediction or hypothesis, identifying possible sources of error, bias, or uncertainty

**A1.9** analyse the information gathered from research sources for reliability and bias

**A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions

* The abbreviation(s) for the broad area(s) of investigation skills – IP, PR, AI, and/or C – are provided in square brackets at the end of the expectations in strands B–E to which the particular area(s) relate (see pp. 19–21 for information on scientific investigation skills).

### Communicating [C]*

**A1.11** communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g., data tables, laboratory reports, presentations, debates, simulations, models)

**A1.12** use appropriate numeric, symbolic, and graphic modes of representation, and appropriate units of measurement (e.g., SI and imperial units)

**A1.13** express the results of any calculations involving data accurately and precisely

## A2. Career Exploration

Throughout this course, students will:

**A2.1** identify and describe a variety of careers related to the fields of science under study (e.g., radar satellite technician, fish and wildlife technologist, ceramicist, electrician) and the education and training necessary for these careers

**A2.2** identify scientists, including Canadians (e.g., Kim Fernie, Robert Ackman, Helen Hogg, Kenneth Hill), who have made a contribution to the fields of science under study

# B. BIOLOGY: SUSTAINABLE ECOSYSTEMS AND HUMAN ACTIVITY

## OVERALL EXPECTATIONS

By the end of this course, students will:

**B1.** analyse the impact of human activity on terrestrial or aquatic ecosystems, and assess the effectiveness of selected initiatives related to environmental sustainability;

**B2.** investigate some factors related to human activity that affect terrestrial or aquatic ecosystems, and describe the consequences that these factors have for the sustainability of these ecosystems;

**B3.** demonstrate an understanding of characteristics of terrestrial and aquatic ecosystems, the interdependence within and between ecosystems, and the impact humans have on the sustainability of these ecosystems.

## SPECIFIC EXPECTATIONS

### B1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

**B1.1** analyse, on the basis of research, how a human activity (e.g., urban sprawl, use of pesticides and fertilizers, creation of pollution, human interaction with wildlife) threatens the sustainability of a terrestrial or aquatic ecosystem [IP, PR, AI, C]

*Sample issue:* Pesticides and fertilizers are used to increase the productivity of land. However, run-off flows into water bodies and leaches into groundwater, poisoning the water or altering its chemical balance and affecting aquatic ecosystems.

*Sample questions:* How does the draining of wetlands for new subdivisions affect local waterbirds and plants that thrive in marshes? How does untreated waste released into rivers or lakes affect fish and animals that eat the fish? How does the introduction of Atlantic salmon or other sport fish affect indigenous lake trout and brook trout?

**B1.2** assess the effectiveness of a local initiative of personal interest that seeks to ensure the sustainability of a terrestrial or aquatic ecosystem (e.g., greening their school grounds; conservation efforts of local Aboriginal communities; naturalizing banks of local rivers or ponds with native vegetation; adoption of an integrated pest management strategy to combat pests in a local garden), and explain why the initiative is important to the sustainability of the ecosystem [AI, C]

*Sample issue:* Municipal composting initiatives divert garbage from landfill sites and make compost available to gardeners. The use of compost reduces the need for chemical fertilizers, helping to ensure the sustainability of aquatic ecosystems by reducing fertilizer run-off. However, many people, such as those living in apartment buildings, are not included in composting programs.

*Sample questions:* What action has been taken to green the grounds of your school? What effect has such action had on the local ecosystem? What additional action could be taken? What local initiatives have been developed to reduce the amount of pollution released into nearby rivers or lakes? What additional initiatives could be taken to enhance the sustainability of these ecosystems? How has the implementation of an Environmental Farm Plan (EFP) changed practices at a local farm? What are the benefits of the plan with regard to the sustainability of the ecosystem?

## B2. Developing Skills of Investigation and Communication

By the end of this course, students will:

**B2.1** use appropriate terminology related to sustainable ecosystems and human activity, including, but not limited to: *biodiversity, biotic, ecosystem, equilibrium, species diversity, sustainability*, and *watershed* [C]

**B2.2** investigate the characteristics and interactions of biotic and abiotic components of a terrestrial or aquatic ecosystem, and describe the importance of these components in a sustainable ecosystem [PR, AI, C]

**B2.3** compile and graph qualitative and quantitative data on organisms within an undisturbed or disturbed ecosystem (terrestrial or aquatic) (e.g., nematode and earthworm populations in soil or compost; bird populations during migration or winter feeding; tadpole and mosquito larvae populations in a local pond) [PR, AI, C]

**B2.4** plan and conduct an inquiry into how a factor related to human activity affects a terrestrial or aquatic ecosystem (e.g., how changes to soil composition from the use of different compostable materials or organic or inorganic fertilizers affect the types of plants that can be grown; how lower water levels resulting from water diversion affect waterfowl nesting areas and fish reproduction), and describe the consequences that this factor has for the sustainability of the ecosystem [IP, PR, AI, C]

**B2.5** analyse the effect of factors related to human activity on terrestrial or aquatic ecosystems by interpreting data and generating graphs (e.g., data on the concentration in water of chemicals from fertilizer run-off and their effect on the growth of algae) [AI, C]

## B3. Understanding Basic Concepts

By the end of this course, students will:

**B3.1** identify similarities and differences between terrestrial and aquatic ecosystems, and describe these similarities and differences using diagrams

**B3.2** describe the interdependence of the components within a terrestrial and an aquatic ecosystem, and explain how the components of both systems work together to ensure the sustainability of a larger ecosystem

**B3.3** describe the complementary processes of cellular respiration and photosynthesis with respect to the flow of energy and the cycling of matter within ecosystems (e.g., carbon dioxide is a by-product of cellular respiration and is used for photosynthesis, which produces oxygen needed for cellular respiration), and explain how human activities can disrupt the balance achieved by these processes (e.g., automobile use increases the amount of carbon dioxide in the atmosphere; planting trees reduces the amount of carbon dioxide in the atmosphere)

**B3.4** identify the major limiting factors of ecosystems (e.g., nutrients, space, water, predators), and explain how these factors are related to the carrying capacity of an ecosystem (e.g., how an increase in the moose population in an ecosystem affects the wolf population in the same ecosystem)

**B3.5** identify some factors related to human activity that have an impact on ecosystems (e.g., the use of fertilizers and pesticides; altered shorelines; organic and conventional farming; urban sprawl), and explain how these factors affect the equilibrium and survival of populations in terrestrial and aquatic ecosystems (e.g., fertilizers change the fertility of soil, affecting what types of plants can grow in it; pesticides leach into water systems, affecting water quality and aquatic life; shoreline development affects the types of aquatic life and terrestrial vegetation that can live by lake shores or river banks; urban sprawl wipes out fields and woods, destroying wildlife habitats)

# C. CHEMISTRY: EXPLORING MATTER

## OVERALL EXPECTATIONS

By the end of this course, students will:

**C1.** analyse how properties of common elements and/or simple compounds affect their use, and assess the social and environmental impact associated with their production or use;

**C2.** investigate, through inquiry, physical and chemical properties of common elements and simple compounds;

**C3.** demonstrate an understanding of the properties of common elements and simple compounds, and general features of the organization of the periodic table.

## SPECIFIC EXPECTATIONS

### C1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

**C1.1** analyse how the chemical and physical properties of common elements and/or simple compounds affect the use of everyday materials that contain those elements and/or compounds [AI, C]

*Sample issue:* Chlorine compounds have strong disinfectant properties and are used in bleach and to purify water. However, these compounds can be highly toxic and must be used with care.

*Sample questions:* How do the compounds in road salt reduce ice accumulation? Why are fire extinguishers that contain compressed carbon dioxide not suitable for fighting a magnesium fire? Why do some types of sports equipment use titanium? Why should gasoline not be used as a degreasing solvent?

**C1.2** assess the social and environmental impact of the production or use of a common element or simple compound [AI, C]

*Sample issue:* The use of road salt makes winter driving safer, reducing the social costs of motor vehicle accidents, including loss of human life. But the compounds in road salt damage roads and vehicles, pollute water systems, and harm animals and vegetation.

*Sample questions:* What are the social benefits and environmental costs of mining or refining metals such as nickel, iron, or gold? What is the environmental impact of using fertilizers rich in nitrogen on lawns and gardens? What is the environmental impact of the widespread use of plastics?

### C2. Developing Skills of Investigation and Communication

By the end of this course, students will:

**C2.1** use appropriate terminology related to the exploration of matter, including, but not limited to: *combustion, conductor, decomposition, lustrous, precipitate, reaction,* and *soluble* [C]

**C2.2** use an inquiry process to identify the physical and chemical properties of common elements and simple common compounds, including gaseous substances (e.g., sulfur is a yellow solid; sodium chloride is water soluble; nitrogen gas is colourless, odourless, and very unreactive) [PR, AI]

**C2.3** plan and conduct an investigation to compare and contrast characteristic physical properties of metals with those of non-metals (e.g., most metals are lustrous or shiny and are good conductors of heat; most non-metals in solid form are brittle and are not good conductors of heat) [IP, PR, AI]

**C2.4** investigate and distinguish between the physical and chemical properties of household substances (e.g., starch, table salt, wax, toothpaste) [PR, AI]

**C2.5** investigate and compare the chemical properties (e.g., combustibility, reaction with water) of representative elements within groups in the periodic table families of elements (e.g., Mg and Ca; N and P) [PR, AI]

**C2.6** construct and draw models of simple molecules (e.g., $H_2$, $NH_3$, $CO_2$, $CH_4$) [PR, C]

**C2.7** conduct chemical tests to identify common gases (e.g., oxygen, hydrogen, carbon dioxide) on the basis of their chemical properties, and record their observations [PR, AI, C]

## C3. Understanding Basic Concepts

By the end of this course, students will:

**C3.1** identify the characteristics of neutrons, protons, and electrons, including charge, location, and relative mass

**C3.2** describe the characteristics that distinguish elements from compounds (e.g., elements are pure substances made up of only one kind of atom; compounds are pure substances made up of more than one kind of element)

**C3.3** identify general features of the periodic table (e.g., metals appear on the left of the periodic table; non-metals appear on the right; elements within the same group have similar properties)

**C3.4** explain the relationships between the properties of elements and their position in the periodic table (e.g., with reference to atomic structure, group, and period)

**C3.5** describe the characteristic physical and chemical properties of common elements (e.g., density, texture, odour, combustibility, solubility, ability to conduct or absorb heat)

**C3.6** use symbols and chemical formulae to represent common elements and simple compounds (e.g., C, O, H, $H_2O$, $CO_2$)

**C3.7** identify the elements and compounds in common household products (e.g., hydrogen peroxide, lye, salt)

# D. EARTH AND SPACE SCIENCE: SPACE EXPLORATION

## OVERALL EXPECTATIONS

By the end of this course, students will:

**D1.** analyse the major challenges and benefits of space exploration, and assess the contributions of Canadians to space exploration;

**D2.** investigate the properties of different types of celestial objects in the solar system and the universe;

**D3.** demonstrate an understanding of major astronomical phenomena and of the principal components of the solar system and the universe.

## SPECIFIC EXPECTATIONS

### D1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

**D1.1** research the challenges associated with space exploration, and explain the purpose of materials and technologies that were developed to address these challenges and how these materials and technologies are now used in other fields of endeavour (e.g., robotic arm technology developed for the space program is used in industry to handle hazardous chemicals; synthetic materials developed to protect astronauts are used in fire-fighting equipment) [IP, PR, AI, C]

*Sample questions:* Why is radiation a particular hazard for astronauts? What sorts of instruments are used to monitor radiation levels? What sorts of materials have been developed to protect astronauts from radiation? What uses would such instruments and materials have on Earth?

**D1.2** assess the contributions of Canadians to space exploration (e.g., as astronauts; in research and development) [AI, C]

*Sample issue:* Canadian companies committed major financial and human resources to develop specialized technologies such as the Special Purpose Dexterous Manipulator ("Dextre"). Although the required investment was great, such projects result in a positive reputation and other benefits for Canada in the field of space exploration.

*Sample questions:* What contributions have Canadian researchers made to space exploration? How have Canadian governments, universities and colleges, or Canadian-owned companies contributed to space exploration?

### D2. Developing Skills of Investigation and Communication

By the end of this course, students will:

**D2.1** use appropriate terminology related to space exploration, including, but not limited to: *astronomical units, gravitational pull,* and *universe* [C]

**D2.2** investigate patterns in the night sky (e.g., constellations) and the motion of celestial objects (e.g., the sun, our moon, planets, stars, galaxies), using direct observation, computer simulations, and/or star charts, and record the information using a graphic organizer or other format [PR, AI, C]

**D2.3** use a research process to compile and analyse information on the characteristics of various objects in the universe (e.g., planets, stars, constellations, galaxies) [PR, AI]

**D2.4** investigate a technological challenge related to the exploration of celestial objects that arises from the objects' specific properties, and identify the solution that has been devised (e.g., multiple booster rockets power spacecraft travelling to distant planets; heat shields protect the space shuttle from extreme temperatures when re-entering Earth's atmosphere) [PR, AI]

## D3. Understanding Basic Concepts

By the end of this course, students will:

**D3.1** describe the major components of the universe (e.g., planets, moons, stars, galaxies), the motion of the different types of celestial objects, and the distances between certain objects, using appropriate scientific terminology and units (e.g., astronomical units, light years)

**D3.2** compare the characteristics and properties of celestial objects that constitute the solar system, including their motion and their distance from other celestial objects in the solar system (e.g., composition, size, rotation, presence and composition of atmosphere, gravitational pull, magnetic field)

**D3.3** identify the factors that make Earth well suited for the existence of life (e.g., a magnetosphere that protects the planet from solar wind; Earth's distance from the sun; the ability of Earth's atmosphere to trap heat, preventing extreme fluctuations in temperature)

**D3.4** describe the characteristics of the sun and the effects of its energy on Earth and Earth's atmosphere

**D3.5** describe the causes of major astronomical phenomena (e.g., the aurora borealis, solar/lunar eclipses) and how various phenomena can best be observed from Earth (e.g., solar eclipses should be viewed through a telescope equipped with a solar filter, not with the naked eye)

**D3.6** describe the role of celestial objects in the traditions and beliefs of selected cultures and civilizations (e.g., Aboriginal peoples; ancient Greek, Mayan civilizations)

# E. PHYSICS: ELECTRICAL APPLICATIONS

## OVERALL EXPECTATIONS

By the end of this course, students will:

**E1.** assess the major social, economic, and environmental costs and benefits of using electrical energy, distinguishing between renewable and non-renewable sources, and propose a plan of action to reduce energy costs;

**E2.** investigate, through inquiry, the properties of static and current electricity and the cost of the consumption of electrical energy;

**E3.** demonstrate an understanding of the concepts and principles of static and current electricity.

## SPECIFIC EXPECTATIONS

### E1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

**E1.1** assess social, economic, and environmental costs and benefits of using a renewable and a non-renewable source of electrical energy (e.g., solar, wind, hydro, nuclear, coal, oil, natural gas), taking the issue of sustainability into account [AI, C]

*Sample issue:* The production of electricity at nuclear power plants generates very low levels of greenhouse gases. However, the construction and maintenance of nuclear power plants is expensive and the long-term storage of nuclear waste may have an impact on the environment.

*Sample questions:* Which method of production of electrical energy generates the greatest amount of greenhouse gases? Which generates the smallest amount? What are the economic and long-term environmental costs of producing nuclear energy? Of using solar energy? What are some of the social and environmental effects of oil production?

**E1.2** propose a plan of action to decrease household energy costs by applying their knowledge of the energy consumption of different types of appliances (e.g., front-load and top-load washing machines; cathode ray tube [CRT] and liquid crystal display [LCD] computer monitors) [PR, AI, C]

*Sample questions:* Which appliances in the home consume the greatest amount of energy? What are some options for reducing the amount of energy they consume? How cost-efficient is it to purchase a new energy-efficient appliance when a less efficient appliance is still in good working condition?

### E2. Developing Skills of Investigation and Communication

By the end of this course, students will:

**E2.1** use appropriate terminology related to static and current electricity, including, but not limited to: *ammeter, ampere, battery, conductivity, current, energy consumption, fuse, kilowatt hours, load, ohm, potential difference, resistance, switch, voltmeter,* and *volts* [C]

**E2.2** use an inquiry process to determine and compare the conductivity of various materials (e.g., metals, plastic, glass, water) [PR, AI]

**E2.3** conduct inquiries involving conduction and induction to investigate the law of electric charges [PR, AI]

**E2.4** design, draw circuit diagrams of, and construct simple series and parallel circuits (e.g., circuits with: one light bulb; two light bulbs of the same brightness; one light bulb on and the other light bulb off) [IP, PR, C]

**E2.5** compare, on the basis of observation, the differences between series and parallel circuits [PR, AI]

**E2.6** use an inquiry process to investigate the effects that changing resistance and changing potential difference have on current in a simple series circuit [PR, AI]

**E2.7** calculate the costs of running common household electrical devices, and compare their efficiency (e.g., using EnerGuide information) [AI, C]

**E2.8** graph and interpret electricity consumption data collected over a period of time from electrical meters at home or in the community (e.g., their school, a local community centre) [PR, AI, C]

## E3. Understanding Basic Concepts

By the end of this course, students will:

**E3.1** compare conductors and insulators, and explain how materials allow static charge to build up or be discharged

**E3.2** explain the law of electric charges with reference to common electrostatic phenomena (e.g., charging by contact or by induction)

**E3.3** identify the components of a simple direct current (DC) electrical circuit (e.g., electrical source, electrical load, switch, fuse), and describe their functions

**E3.4** identify electrical quantities and their symbols (e.g., electric current $I$, potential difference $V$, resistance $R$), and explain how they are measured using an ammeter, a voltmeter, and a multimeter

**E3.5** explain the characteristics of electric current, potential difference, and resistance, in simple series and parallel circuits

**E3.6** describe, qualitatively, the interrelationships between resistance, potential difference, and electric current, in a series circuit (e.g., the effect on current when potential difference is changed)

**E3.7** explain the practical use of resistance in a common household product (e.g., a toaster or hair dryer)

# Science, Grade 10

## Academic SNC2D

This course enables students to enhance their understanding of concepts in biology, chemistry, earth and space science, and physics, and of the interrelationships between science, technology, society, and the environment. Students are also given opportunities to further develop their scientific investigation skills. Students will plan and conduct investigations and develop their understanding of scientific theories related to the connections between cells and systems in animals and plants; chemical reactions, with a particular focus on acid–base reactions; forces that affect climate and climate change; and the interaction of light and matter.

**Prerequisite:** Science, Grade 9, Academic or Applied

### Big Ideas

***Biology***

- Plants and animals, including humans, are made of specialized cells, tissues, and organs that are organized into systems.
- Developments in medicine and medical technology can have social and ethical implications.

***Chemistry***

- Chemicals react with each other in predictable ways.
- Chemical reactions may have a negative impact on the environment, but they can also be used to address environmental challenges.

***Earth and Space Science***

- Earth's climate is dynamic and is the result of interacting systems and processes.
- Global climate change is influenced by both natural and human factors.
- Climate change affects living things and natural systems in a variety of ways.
- People have the responsibility to assess their impact on climate change and to identify effective courses of action to reduce this impact.

***Physics***

- Light has characteristics and properties that can be manipulated with mirrors and lenses for a range of uses.
- Society has benefited from the development of a range of optical devices and technologies.

### Fundamental Concepts Covered in This Course (see also page 5)

| Fundamental Concepts | Biology | Chemistry | Earth and Space Science | Physics |
|---|---|---|---|---|
| Matter | | ✓ | | |
| Energy | | ✓ | ✓ | ✓ |
| Systems and Interactions | ✓ | | ✓ | |
| Structure and Function | ✓ | | | ✓ |
| Sustainability and Stewardship | ✓ | ✓ | ✓ | ✓ |
| Change and Continuity | ✓ | | ✓ | |

# A. SCIENTIFIC INVESTIGATION SKILLS AND CAREER EXPLORATION

## OVERALL EXPECTATIONS

Throughout this course, students will:

**A1.** demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analysing and interpreting, and communicating);

**A2.** identify and describe a variety of careers related to the fields of science under study, and identify scientists, including Canadians, who have made contributions to those fields.

## SPECIFIC EXPECTATIONS

### A1. Scientific Investigation Skills

Throughout this course, students will:

#### Initiating and Planning [IP]*

**A1.1** formulate scientific questions about observed relationships, ideas, problems, and/or issues, make predictions, and/or formulate hypotheses to focus inquiries or research

**A1.2** select appropriate instruments (e.g., a microscope, laboratory glassware, an optical bench) and materials (e.g., prepared slides, an aquarium, lenses, pH paper) for particular inquiries

**A1.3** identify and locate print, electronic, and human sources that are relevant to research questions

**A1.4** apply knowledge and understanding of safe practices and procedures when planning investigations (e.g., appropriate techniques for handling, storing, and disposing of laboratory materials [following the Workplace Hazardous Materials Information System–WHMIS]; safe operation of optical equipment; safe handling and disposal of biological materials), with the aid of appropriate support materials (e.g., the Reference Manual on the WHMIS website; the Live Safe! Work Smart! website)

#### Performing and Recording [PR]*

**A1.5** conduct inquiries, controlling some variables, adapting or extending procedures as required, and using standard equipment and materials safely, accurately, and effectively, to collect observations and data

**A1.6** gather data from laboratory and other sources, and organize and record the data using appropriate formats, including tables, flow charts, graphs, and/or diagrams

**A1.7** select, organize, and record relevant information on research topics from various sources, including electronic, print, and/or human sources (e.g., websites for public health organizations, federal and provincial government publications, reference books, personal interviews), using recommended formats and an accepted form of academic documentation

#### Analysing and Interpreting [AI]*

**A1.8** analyse and interpret qualitative and/or quantitative data to determine whether the evidence supports or refutes the initial prediction or hypothesis, identifying possible sources of error, bias, or uncertainty

**A1.9** analyse the information gathered from research sources for reliability and bias

**A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions

* The abbreviation(s) for the broad area(s) of investigation skills – IP, PR, AI, and/or C – are provided in square brackets at the end of the expectations in strands B–E to which the particular area(s) relate (see pp. 19–21 for information on scientific investigation skills).

**Communicating [C]***

**A1.11** communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g., data tables, laboratory reports, presentations, debates, simulations, models)

**A1.12** use appropriate numeric, symbolic, and graphic modes of representation, and appropriate units of measurement (e.g., SI and imperial units)

**A1.13** express the results of any calculations involving data accurately and precisely

## A2. Career Exploration

Throughout this course, students will:

**A2.1** identify and describe a variety of careers related to the fields of science under study (e.g., meteorologist, medical illustrator, geochemist, optical physicist) and the education and training necessary for these careers

**A2.2** identify scientists, including Canadians (e.g., Sheela Basrur, William Richard Peltier, Alice Wilson, Willard Doyle), who have made a contribution to the fields of science under study

# B. BIOLOGY: TISSUES, ORGANS, AND SYSTEMS OF LIVING THINGS

## OVERALL EXPECTATIONS

By the end of this course, students will:

**B1.** evaluate the importance of medical and other technological developments related to systems biology, and analyse their societal and ethical implications;

**B2.** investigate cell division, cell specialization, organs, and systems in animals and plants, using research and inquiry skills, including various laboratory techniques;

**B3.** demonstrate an understanding of the hierarchical organization of cells, from tissues, to organs, to systems in animals and plants.

## SPECIFIC EXPECTATIONS

### B1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

**B1.1** analyse, on the basis of research, ethical issues related to a technological development in the field of systems biology (e.g., cloning, stem-cell research, live organ transplants, transgenic transplants), and communicate their findings [IP, PR, AI, C]

*Sample issue:* DNA screening is a valuable tool for determining whether a person is genetically predisposed to certain diseases. However, it raises ethical issues related to privacy, choice, access, treatment, and discrimination. It also raises questions about how far society should go in using available technologies, who funds research, and who owns or manages the resulting product or technology.

*Sample questions:* What are the ethical arguments for and against stem-cell research? What ethical issues might arise when a drug company funds trials of a new drug it has developed to treat a genetic disorder? Who should determine how the results of transgenic research in plants and animals will be applied?

**B1.2** assess the importance to human health and/or society of medical imaging technologies (e.g., ultrasound, X-rays, computerized axial tomography [CT or CAT] scan, magnetic resonance imaging [MRI], microscopy, biophotonics) used in Canada in diagnosing or treating abnormalities in tissues, organs, and/or systems [AI, C]

*Sample issue:* Ultrasound is routinely used during pregnancy to monitor the development of the fetus. It is also used to perform amniocentesis, which screens for genetic disorders, and allows doctors to perform surgery on the fetus before birth to correct some abnormalities. However, there have been few studies on the long-term effects of the use of ultrasound.

*Sample questions:* How are medical imaging technologies used in the diagnosis and treatment of heart disease and stroke? What types of imaging technologies are used in ophthalmology? How have they benefited people who have eye disease? How have developments in biophotonics advanced a range of surgical procedures?

**B1.3** describe public health strategies related to systems biology (e.g., cancer screening and prevention programs; vaccines against the human papillomavirus [HPV] and measles, mumps, and rubella [MMR]; AIDS education), and assess their impact on society [AI, C]

*Sample issue:* Early-childhood vaccination programs have greatly reduced the incidence of certain diseases and the social and medical costs associated with them. Influenced by controversial studies arguing that there may be health risks associated with such vaccines, some parents have chosen not to vaccinate their children, which could lead to a resurgence of these potentially deadly diseases.

*Sample questions:* What strategies are included in public health initiatives aimed at reducing the incidence of smoking-related diseases? What impact have these initiatives had on smoking rates and associated medical costs? How have health authorities responded to the threat of West Nile virus? What effect does this response have on people's lifestyles? How did various cultures attempt to prevent disease before vaccines were available? What impact have vaccines had on global health?

## B2. Developing Skills of Investigation and Communication

By the end of this course, students will:

**B2.1** use appropriate terminology related to cells, tissues, organs, and systems of living things, including, but not limited to: *absorption, anaphase, capillaries, concentration, differentiation, diffusion, meristematic, mesophyll, phloem, prophase, red blood cells, regeneration, stomate,* and *xylem* [C]

**B2.2** examine cells under a microscope or similar instrument to identify the various stages of mitosis in plants and animals [PR, AI]

**B2.3** examine different plant and animal cells (e.g., cheek cells, onion cells) under a microscope or similar instrument, and draw labelled biological diagrams to show how the cells' organelles differ [PR, C]

**B2.4** investigate, using a microscope or similar instrument, specialized cells in the human body or in plants, focusing on different types of cells (e.g., bone, muscle, leaf, root cells), and draw labelled biological diagrams to show the cells' structural differences [PR, C]

**B2.5** investigate the rate of cell division in cancerous and non-cancerous cells, using pictures, videos, or images, and predict the impact of this rate of cell division on an organism [PR, AI]

**B2.6** investigate, through a laboratory or computer-simulated dissection of a plant, worm, fish, or frog, the interrelationships between organ systems of a plant or an animal (e.g., between the root system and leaf system in a plant; between the digestive system and circulatory system in an animal) [PR, AI]

**B2.7** use a research process to investigate a disease or abnormality related to tissues, organs, or systems of humans or plants (e.g., heart disease, tobacco mosaic virus, wheat rust) [IP, PR, C]

## B3. Understanding Basic Concepts

By the end of this course, students will:

**B3.1** describe the cell cycle in plants and animals, and explain the importance of mitosis for the growth of cells and repair of tissues

**B3.2** explain the importance of cell division and cell specialization in generating new tissues and organs (e.g., the division of stem cells into specialized cells such as muscle cells or nerve cells in humans; the division of meristematic cells to expand and differentiate plant tissue)

**B3.3** explain the links between specialized cells, tissues, organs, and systems in plants and animals (e.g., muscle cells and nerve cells form the tissue found in the heart, which is a component of the circulatory system; granum and thylakoid structures act as solar collectors in the chloroplast to produce carbohydrates for plant growth)

**B3.4** explain the primary functions of a variety of systems in animals (e.g., the circulatory system transports materials through the organism; the respiratory system supplies oxygen to and removes carbon dioxide from the body)

**B3.5** explain the interaction of different systems within an organism (e.g., the respiratory system brings oxygen into the body, and the circulatory system transports the oxygen to cells) and why such interactions are necessary for the organism's survival

# C. CHEMISTRY: CHEMICAL REACTIONS

## OVERALL EXPECTATIONS

By the end of this course, students will:

**C1.** analyse a variety of safety and environmental issues associated with chemical reactions, including the ways in which chemical reactions can be applied to address environmental challenges;

**C2.** investigate, through inquiry, the characteristics of chemical reactions;

**C3.** demonstrate an understanding of the general principles of chemical reactions, and various ways to represent them.

## SPECIFIC EXPECTATIONS

### C1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

**C1.1** analyse, on the basis of research, various safety and environmental issues associated with chemical reactions and their reactants and/or product(s) (e.g., chemical reactions related to the use of cyanide in gold mining, the corrosion of metal supports on bridges, the use of different antibacterial agents such as chlorine and bromine in recreational pools) [IP, PR, AI, C]

*Sample issue:* Ammonia and chlorine bleach are two common household cleaning agents. However, when these two substances are mixed, the chemical reaction produces chlorine gas, which is highly toxic.

*Sample questions:* Why is it important to understand the chemical composition of chlorinating agents used in swimming pools before using them? What chemical reactions result in acid precipitation? What impact does it have on the environment? What sources of information are available on the safety or environmental implications of chemicals and chemical reactions? Why is it important to ensure that these sources are up to date? Why is it important to understand WHMIS information, including Material Safety Data Sheets, before using any chemicals?

**C1.2** analyse how an understanding of the properties of chemical substances and their reactions can be applied to solve environmental challenges (e.g., renewing the Great Lakes, neutralizing acid spills, scrubbing smokestack emissions) [AI, C]

*Sample issue:* Spills from oil tankers damage the environment by contaminating water and shorelines, killing birds and aquatic life. Biological oil agents help break down the oil so it degrades faster and does less damage to the environment.

*Sample questions:* How does the addition of lime reduce the acidification of water? How can this reaction be applied to renew lakes that have been affected by acid precipitation? Why is acid leaching used in soil contaminated with heavy metals?

### C2. Developing Skills of Investigation and Communication

By the end of this course, students will:

**C2.1** use appropriate terminology related to chemical reactions, including, but not limited to: *compounds*, *product*, and *reactant* [C]

**C2.2** construct molecular models to illustrate the structure of molecules in simple chemical reactions (e.g., $C + O_2 \rightarrow CO_2$; $2H_2 + O_2 \rightarrow 2H_2O$), and produce diagrams of these models [PR, C]

**C2.3** investigate simple chemical reactions, including synthesis, decomposition, and displacement reactions, and represent them using a variety of formats (e.g., molecular models, word equations, balanced chemical equations) [PR, AI, C]

**C2.4** use an inquiry process to investigate the law of conservation of mass in a chemical reaction (e.g., compare the values before and after the reaction), and account for any discrepancies [PR, AI]

**C2.5** plan and conduct an inquiry to identify the evidence of chemical change (e.g., the formation of a gas or precipitate, a change in colour or odour, a change in temperature) [IP, PR, AI]

**C2.6** plan and conduct an inquiry to classify some common substances as acidic, basic, or neutral (e.g., use acid–base indicators or pH test strips to classify common household substances) [IP, PR, AI]

## C3. Understanding Basic Concepts

By the end of this course, students will:

**C3.1** describe the relationships between chemical formulae, composition, and names of binary compounds (e.g., carbon dioxide, $CO_2$, has two oxygen atoms and one carbon atom)

**C3.2** explain, using the law of conservation of mass and atomic theory, the rationale for balancing chemical equations

**C3.3** describe the types of evidence that indicate chemical change (e.g., changes in colour, the production of a gas, the formation of a precipitate, the production or absorption of heat, the production of light)

**C3.4** write word equations and balanced chemical equations for simple chemical reactions (e.g., $2H_2 + O_2 \rightarrow 2H_2O$)

**C3.5** describe, on the basis of observation, the reactants in and products of a variety of chemical reactions, including synthesis, decomposition, and displacement reactions (e.g., reactions occurring when magnesium burns or in the production of oxygen from hydrogen peroxide; the reaction of iron and copper sulphate; reactions occurring when fossil fuels burn)

**C3.6** describe the process of acid–base neutralization (i.e., an acid reacts with a base to form a salt and often water)

**C3.7** describe how the pH scale is used to classify solutions as acidic, basic, or neutral (e.g., a solution with a pH of 1 is highly acidic; a solution with a pH of 7 is neutral)

**C3.8** identify simple ionic compounds (e.g., NaCl), simple compounds involving polyatomic ions (e.g., $KNO_3$, NaOH), molecular compounds (e.g., $CO_2$, $H_2O$, $NH_3$), and acids (e.g., HCl(aq), $H_2SO_4$(aq)), using the periodic table and a list of the most common polyatomic ions (e.g., $OH^-$, $SO_4^{-2}$), and write the formulae

# D. EARTH AND SPACE SCIENCE: CLIMATE CHANGE

## OVERALL EXPECTATIONS

By the end of this course, students will:

**D1.** analyse some of the effects of climate change around the world, and assess the effectiveness of initiatives that attempt to address the issue of climate change;

**D2.** investigate various natural and human factors that influence Earth's climate and climate change;

**D3.** demonstrate an understanding of natural and human factors, including the greenhouse effect, that influence Earth's climate and contribute to climate change.

## SPECIFIC EXPECTATIONS

### D1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

**D1.1** analyse current and/or potential effects, both positive and negative, of climate change on human activity and natural systems (e.g., loss of habitat for Arctic mammals such as polar bears and loss of traditional lifestyles for Inuit as Arctic ice shrinks; famine as arable land is lost to desertification; an increase in water-borne disease and human resettlement as coastal lands are flooded; expansion of the growing season in some regions) [AI, C]

*Sample issue:* Scientists are researching changes in climate patterns as possible contributing factors to an increase in the number of smog days in Ontario and elsewhere in Canada. As the air quality worsens, people may curtail their outdoor activities, and those with respiratory problems may require medical attention, increasing health care costs.

*Sample questions:* How have recent extreme weather events such as heat waves in Europe or drought in southern Africa affected habitats in these regions? How might predicted changes to global temperature and precipitation affect agriculture in Ontario, Canada, or different areas around the world? How might the continuing reduction of the polar ice cap influence domestic and international transportation and shipping?

**D1.2** assess, on the basis of research, the effectiveness of some current individual, regional, national, or international initiatives that address the issue of climate change (e.g., Drive Clean, ENERGY STAR, federal and provincial government rebates for retrofitting older buildings to be more energy efficient, carbon offset programs, community tree-planting programs, municipal recycling programs, Intergovernmental Panel on Climate Change [IPCC]), and propose a further course of action related to one of these initiatives [PR, AI, C]

*Sample issue:* Governments and industry have created rebates or tax cuts to encourage consumers to replace their old appliances with efficient ENERGY STAR appliances. However, such initiatives do not take into account the resources used to create the new products or the problems associated with the disposal of old appliances.

*Sample questions:* What type of recycling and composting programs are in place in your community? What proportion of locally generated garbage do they divert from landfill sites? How could they be improved? What is the purpose of carbon offset credits? Do they achieve that purpose? Why or why not?

## D2. Developing Skills of Investigation and Communication

By the end of this course, students will:

**D2.1** use appropriate terminology related to climate change, including, but not limited to: *albedo*, *anthropogenic*, *atmosphere*, *cycles*, *heat sinks*, and *hydrosphere* [C]

**D2.2** design and build a model to illustrate the natural greenhouse effect, and use the model to explain the anthropogenic greenhouse effect [IP, PR, C]

**D2.3** analyse different sources of scientific data (e.g., lake cores, tree rings, fossils and preserved organisms, ice cores) for evidence of natural climate change and climate change influenced by human activity [PR, AI, C]

**D2.4** investigate a popular hypothesis on a cause-and-effect relationship having to do with climate change (e.g., the combustion of fossil fuels is responsible for rising global temperatures; the concentration of atmospheric $CO_2$ is responsible for rising global temperatures; global temperatures have been on the increase since the industrial revolution; the severity of cyclones, hurricanes, and tornadoes increases as atmospheric temperatures increase), using simulations and/or time-trend data that model climate profiles (e.g., data from Statistics Canada and Environment Canada) [PR, AI, C]

**D2.5** investigate, through laboratory inquiry or simulations, the effects of heat transfer within the hydrosphere and atmosphere [PR, AI]

**D2.6** investigate, through laboratory inquiry or simulations, how water in its various states influences climate patterns (e.g., water bodies moderate climate, water vapour is a greenhouse gas, ice increases the albedo of Earth's surface) [PR, AI]

**D2.7** investigate, through research or simulations, the influence of ocean currents on local and global heat transfer and precipitation patterns [PR, AI]

**D2.8** classify the climate of their local region using various tools or systems (e.g., Ecoregions of Canada, bioclimate profiles), and compare their region to other regions in Ontario, Canada, and the world [AI, C]

**D2.9** compare different perspectives and/or biases evident in discussions of climate change in scientific and non-scientific media (e.g., with reference to knowledge, beliefs, and values) [AI, C]

## D3. Understanding Basic Concepts

By the end of this course, students will:

**D3.1** describe the principal components of Earth's climate system (e.g., the sun, oceans, and atmosphere; the topography and configuration of land masses) and how the system works

**D3.2** describe and explain heat transfer in the hydrosphere and atmosphere and its effects on air and water currents

**D3.3** describe the natural greenhouse effect, explain its importance for life, and distinguish it from the anthropogenic greenhouse effect

**D3.4** identify natural phenomena (e.g., plate tectonics, uplift and weathering, solar radiance, cosmic ray cycles) and human activities (e.g., forest fires, deforestation, the burning of fossil fuels, industrial emissions) known to affect climate, and describe the role of both in Canada's contribution to climate change

**D3.5** describe the principal sources and sinks, both natural and/or anthropogenic, of greenhouse gases (e.g., carbon dioxide, methane, nitrous oxide, halocarbons, water vapour)

**D3.6** describe how different carbon and nitrogen compounds (e.g., carbon dioxide, methane, nitrous oxide) influence the trapping of heat in the atmosphere and hydrosphere

**D3.7** describe, in general terms, the causes and effects of the anthropogenic greenhouse effect, the depletion of stratospheric and tropospheric ozone, and the formation of ground-level ozone and smog

**D3.8** identify and describe indicators of global climate change (e.g., changes in: glacial and polar ice, sea levels, wind patterns, global carbon budget assessments)

# E. PHYSICS: LIGHT AND GEOMETRIC OPTICS

## OVERALL EXPECTATIONS

By the end of this course, students will:

**E1.** evaluate the effectiveness of technological devices and procedures designed to make use of light, and assess their social benefits;

**E2.** investigate, through inquiry, the properties of light, and predict its behaviour, particularly with respect to reflection in plane and curved mirrors and refraction in converging lenses;

**E3.** demonstrate an understanding of various characteristics and properties of light, particularly with respect to reflection in mirrors and reflection and refraction in lenses.

## SPECIFIC EXPECTATIONS

### E1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

**E1.1** analyse a technological device or procedure related to human perception of light (e.g., eyeglasses, contact lenses, infrared or low light vision sensors, laser surgery), and evaluate its effectiveness [AI, C]

*Sample issue:* Laser surgery corrects vision by surgically reshaping the cornea to correct refractive defects in the eye. While the procedure is effective in most cases, it poses risks and can in some cases lead to poor night vision.

*Sample questions:* How do anti-glare night vision glasses help people who have difficulty driving at night? How do eyeglasses with colour filters help people with dyslexia to read?

**E1.2** analyse a technological device that uses the properties of light (e.g., microscope, retroreflector, solar oven, camera), and explain how it has enhanced society [AI, C]

*Sample issue:* Cameras can produce a range of optical effects, from highly detailed and realistic to manipulated and abstract. Photographic images are used for a wide range of purposes that benefit society, including in the areas of culture, education, security, policing, entertainment, and the environment. However, the widespread use of cameras raises privacy concerns.

*Sample questions:* How do vision sensors help the Canadian Food Inspection Agency improve food safety? How are photonics used in the early diagnosis of diseases such as cancer? How have optical fibres enhanced our ability to communicate information? How do all of these technologies benefit society? How are outdoor lights such as street or stadium lights designed to limit light pollution in surrounding areas?

### E2. Developing Skills of Investigation and Communication

By the end of this course, students will:

**E2.1** use appropriate terminology related to light and optics, including, but not limited to: *angle of incidence*, *angle of reflection*, *angle of refraction*, *focal point*, *luminescence*, *magnification*, *mirage*, and *virtual image* [C]

**E2.2** use an inquiry process to investigate the laws of reflection, using plane and curved mirrors, and draw ray diagrams to summarize their findings [PR, C]

**E2.3** predict the qualitative characteristics of images formed by plane and curved mirrors (e.g., location, relative distance, orientation, and size in plane mirrors; location, orientation, size, type in curved mirrors), test their predictions through inquiry, and summarize their findings [PR, AI, C]

**E2.4** use an inquiry process to investigate the refraction of light as it passes through media of different refractive indices, compile data on their findings, and analyse the data to determine if there is a trend (e.g., the amount by which the angle of refraction changes as the angle of incidence increases varies for media of different refractive indices) [PR, AI, C]

**E2.5** predict, using ray diagrams and algebraic equations, the position and characteristics of an image produced by a converging lens, and test their predictions through inquiry [PR, AI, C]

**E2.6** calculate, using the indices of refraction, the velocity of light as it passes through a variety of media, and explain the angles of refraction with reference to the variations in velocity [PR, C]

## E3. Understanding Basic Concepts

By the end of this course, students will:

**E3.1** describe and explain various types of light emissions (e.g., chemiluminescence, bioluminescence, incandescence, fluorescence, phosphorescence, triboluminescence; from an electric discharge or light-emitting diode [LED])

**E3.2** identify and label the visible and invisible regions of the electromagnetic spectrum

**E3.3** describe, on the basis of observation, the characteristics and positions of images formed by plane and curved mirrors (e.g., location, orientation, size, type), with the aid of ray diagrams and algebraic equations, where appropriate

**E3.4** explain the conditions required for partial reflection/refraction and for total internal reflection in lenses, and describe the reflection/refraction using labelled ray diagrams

**E3.5** describe the characteristics and positions of images formed by converging lenses (e.g., orientation, size, type), with the aid of ray diagrams

**E3.6** identify ways in which the properties of mirrors and lenses (both converging and diverging) determine their use in optical instruments (e.g., cameras, telescopes, binoculars, microscopes)

**E3.7** identify the factors, in qualitative and quantitative terms, that affect the refraction of light as it passes from one medium to another

**E3.8** describe properties of light, and use them to explain naturally occurring optical phenomena (e.g., apparent depth, shimmering, a mirage, a rainbow)

# Science, Grade 10

## Applied SNC2P

This course enables students to develop a deeper understanding of concepts in biology, chemistry, earth and space science, and physics, and to apply their knowledge of science in real-world situations. Students are given opportunities to develop further practical skills in scientific investigation. Students will plan and conduct investigations into everyday problems and issues related to human cells and body systems; chemical reactions; factors affecting climate change; and the interaction of light and matter.

**Prerequisite:** Science, Grade 9, Academic or Applied

### Big Ideas

***Biology***
- All animals are made of specialized cells, tissues, and organs that are organized into systems.
- Although technology and chemicals can be used to improve human health, they can also constitute a health hazard.

***Chemistry***
- Chemicals react with one another in predictable ways.
- Chemical reactions are a necessary component of chemical products and processes used in the home and workplace.

***Earth and Space Science***
- Global climate change is affected by both natural and human factors.
- Climate change affects living things and natural systems in a variety of ways.

***Physics***
- A wide range of technologies utilize the properties of light and colour.
- The behaviour of light depends on the materials with which it interacts.
- Light is a form of energy, produced from a variety of sources, and can be transformed into other useful forms of energy.

### Fundamental Concepts Covered in This Course (see also page 5)

| Fundamental Concepts | Biology | Chemistry | Earth and Space Science | Physics |
|---|---|---|---|---|
| Matter | | ✓ | | |
| Energy | | ✓ | ✓ | ✓ |
| Systems and Interactions | ✓ | | ✓ | |
| Structure and Function | ✓ | | | ✓ |
| Sustainability and Stewardship | ✓ | ✓ | ✓ | ✓ |
| Change and Continuity | ✓ | | ✓ | |

# A. SCIENTIFIC INVESTIGATION SKILLS AND CAREER EXPLORATION

## OVERALL EXPECTATIONS

Throughout this course, students will:

**A1.** demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analysing and interpreting, and communicating);

**A2.** identify and describe a variety of careers related to the fields of science under study, and identify scientists, including Canadians, who have made contributions to those fields.

## SPECIFIC EXPECTATIONS

### A1. Scientific Investigation Skills

Throughout this course, students will:

**Initiating and Planning [IP]***

**A1.1** formulate scientific questions about observed relationships, ideas, problems, and/or issues, make predictions, and/or formulate hypotheses to focus inquiries or research

**A1.2** select appropriate instruments (e.g., a microscope, laboratory glassware, an optical bench) and materials (e.g., prepared slides, an aquarium, lenses, acid–base indicators) for particular inquiries

**A1.3** identify and locate print, electronic, and human sources that are relevant to research questions

**A1.4** apply knowledge and understanding of safe practices and procedures when planning investigations (e.g., appropriate techniques for handling, storing, and disposing of laboratory materials [following the Workplace Hazardous Materials Information System–WHMIS]; safe operation of optical equipment; safe handling and disposal of biological materials), with the aid of appropriate support materials (e.g., the Reference Manual on the WHMIS website; the Live Safe! Work Smart! website)

**Performing and Recording [PR]***

**A1.5** conduct inquiries, controlling some variables, adapting or extending procedures as required, and using standard equipment and materials safely, accurately, and effectively, to collect observations and data

**A1.6** gather data from laboratory and other sources, and organize and record the data using appropriate formats, including tables, flow charts, graphs, and/or diagrams

**A1.7** select, organize, and record relevant information on research topics from various sources, including electronic, print, and/or human sources (e.g., a website for a public health organization, federal and provincial government publications, reference books, personal interviews), using recommended formats and an accepted form of academic documentation

**Analysing and Interpreting [AI]***

**A1.8** analyse and interpret qualitative and/or quantitative data to determine whether the evidence supports or refutes the initial prediction or hypothesis, identifying possible sources of error, bias, or uncertainty

**A1.9** analyse the information gathered from research sources for reliability and bias

**A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions

* The abbreviation(s) for the broad area(s) of investigation skills – IP, PR, AI, and/or C – are provided in square brackets at the end of the expectations in strands B–E to which the particular area(s) relate (see pp. 19–21 for information on scientific investigation skills).

### Communicating [C]*

**A1.11** communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g., data tables, laboratory reports, presentations, debates, simulations, models)

**A1.12** use appropriate numeric, symbolic, and graphic modes of representation, and appropriate units of measurement (e.g., SI and imperial units)

**A1.13** express the results of any calculations involving data accurately and precisely

## A2. Career Exploration

Throughout this course, students will:

**A2.1** identify and describe a variety of careers related to the fields of science under study (e.g., veterinarian assistant, quality control technician, conservation officer, sound and light technician) and the education and training necessary for these careers

**A2.2** identify scientists, including Canadians (e.g., Maude Abbott, Paul Kebarle, Reginald Fessenden, James Hillier), who have made a contribution to the fields of science under study

# B. BIOLOGY: TISSUES, ORGANS, AND SYSTEMS

## OVERALL EXPECTATIONS

By the end of this course, students will:

**B1.** analyse some current technologies or substances that have an impact on human tissues, organs, or systems, and evaluate their effects on human health;

**B2.** investigate cell division, cell specialization, and the organization of systems in animals, including humans, using various laboratory techniques;

**B3.** demonstrate an understanding of the hierarchical organization of cells, from tissues, to organs, to systems in animals, including humans.

## SPECIFIC EXPECTATIONS

### B1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

**B1.1** analyse, on the basis of research, medical imaging technologies (e.g., ultrasound, X-rays, computerized axial tomography [CT or CAT] scan, magnetic resonance imaging [MRI], microscopy, biophotonics) used in Canada to explore, diagnose, or treat the human body, and communicate their findings [PR, AI, C]

*Sample issue:* The diagnostic use of nuclear isotopes has saved lives by providing more reliable diagnoses of certain diseases. However, in the longer term, nuclear medicine could have harmful effects on the human body.

*Sample questions:* How have today's X-rays improved over those in the past? How is ultrasound used to monitor fetal development? How has the development of imaging technologies improved the diagnosing of diseases not visible to the human eye?

**B1.2** evaluate the effects that use of or exposure to a technology, substance, or environmental factor (e.g., cellphones, X-rays, UV radiation, personal audio players, cigarette smoke, pesticides, food additives/preservatives, vitamins, gene therapy) may have on the function of human tissues, organs, or systems [AI, C]

*Sample issue:* Cellphones are widely used in Canada. However, some studies have suggested that radiation emitted from cellphones may cause damage to the brain, particularly in children.

*Sample questions:* What impact does the ingestion of food additives have on the cells of the digestive system? What impact does smoking have on lung tissue? What effects does exposure to UV radiation have on skin? How can using a personal audio player affect a person's auditory system?

### B2. Developing Skills of Investigation and Communication

By the end of this course, students will:

**B2.1** use appropriate terminology related to human cells, tissues, organs, and systems, including, but not limited to: *absorption, anaphase, capillaries, concentration, differentiation, diffusion, interphase, metaphase, osmosis, prophase, red blood cells, regeneration,* and *telophase* [C]

**B2.2** examine cells under a microscope or similar instrument to identify the various stages of mitosis in animals [PR, AI]

**B2.3** investigate, using a microscope or similar instrument, cell specialization in the human body, focusing on different types of human cells (e.g., muscle cells, epithelial cells, nerve cells), and draw labelled biological diagrams of each type of cell [PR, C]

**B2.4** compare, on the basis of observation (e.g., using pictures, videos, or images), the division of cancerous cells and non-cancerous cells, and describe the impact of cancerous cells on the human body [PR, AI]

**B2.5** locate, through a laboratory or computer-simulated dissection, the organs of a specific system of an animal (e.g., a worm, a frog, a fish), and describe their interrelationship [PR, AI, C]

**B2.6** use scientific investigation skills to research health problems related to tissues, organs, or systems in humans (e.g., asthma, sickle-cell anemia, heart disease, Crohn's disease), and communicate their findings [IP, PR, C]

## B3. Understanding Basic Concepts

By the end of this course, students will:

**B3.1** describe the cell cycle in animals, and explain its importance for the growth of cells and repair of tissues

**B3.2** describe the structure, function, and importance of specialized cells and tissues in multi-cellular organisms (e.g., neurons have many branching dendrites and long axons to receive and transmit messages; muscle cells have a higher concentration of mitochondria, which produce energy)

**B3.3** explain cell organization by describing the link between cells, tissues, organs, and systems in the human body

**B3.4** explain the general function of some of the systems in the human body (e.g., the function of the circulatory system is to transport materials through the body; the function of the digestive system is to absorb nutrients; the function of the respiratory system is to bring oxygen into and remove carbon dioxide from the body)

**B3.5** describe the interaction of systems in the human body (e.g., the respiratory system brings oxygen into the body, and the circulatory system transports the oxygen to cells), and explain why these interactions are necessary for survival

# C. CHEMISTRY: CHEMICAL REACTIONS AND THEIR PRACTICAL APPLICATIONS

## OVERALL EXPECTATIONS

By the end of this course, students will:

**C1.** analyse how chemical reactions are employed in common products and processes, and assess the safety and environmental hazards associated with them;

**C2.** investigate, through inquiry, the characteristics of simple chemical reactions;

**C3.** demonstrate an understanding of simple chemical reactions and the language and ways to represent them.

## SPECIFIC EXPECTATIONS

### C1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

**C1.1** analyse, on the basis of research, the function of chemical reactions in the production of selected products and/or in processes commonly encountered at home or in the workplace (e.g., carbonation of soft drinks; rust proofing), and communicate their findings [IP, PR, AI, C]

*Sample questions:* How does the addition of ethanol to gasoline result in cleaner engine emissions? What chemical reactions are used in the rust-proofing process? How can chemical reactions affect the decomposition of important nutrients in food?

**C1.2** identify practical applications of chemical reactions in a particular profession (e.g., ceramics, cosmetology, firefighting, heating and cooling system technology, food preparation, plumbing, custodial services), and assess the associated hazards, including hazards associated with the handling and disposal of chemicals [PR, AI, C]

*Sample issue:* Class B fire extinguishers containing ammonium phosphate, sodium bicarbonate, or potassium bicarbonate are effective in smothering fires involving flammable liquids. However, some of these chemicals are corrosive and can cause damage if introduced to an ecosystem.

*Sample questions:* How do lab technicians protect themselves from chemical reactions in their work environment? What applications of chemical reactions are used by hair stylists? What precautions can they take in using and disposing of the chemicals? What types of chemical reactions do chefs need to be aware of when they process or store food? What precautions should an auto mechanic take when changing the fluids in a car?

### C2. Developing Skills of Investigation and Communication

By the end of this course, students will:

**C2.1** use appropriate terminology related to chemical reactions, including, but not limited to: *antacid*, *dilute*, *neutralization*, *product*, *reactant*, and *word equation* [C]

**C2.2** construct molecular models of simple chemical reactions (e.g., $C + O_2 \rightarrow CO_2$; $2H_2 + O_2 \rightarrow 2H_2O$), and produce diagrams of these models [PR, C]

**C2.3** conduct and observe inquiries related to simple chemical reactions, including synthesis, decomposition, and displacement reactions, and represent them using a variety of formats (e.g., word equations, balanced chemical equations, molecular models) [PR, AI, C]

**C2.4** use an inquiry process to investigate the law of conservation of mass in a chemical reaction (e.g., compare the values before and after the reaction), and account for any discrepancies [PR, AI]

**C2.5** use an inquiry process to investigate acid–base neutralization reactions (e.g., neutralize a dilute solution of sodium hydroxide with dilute hydrochloric acid and extract the sodium chloride produced) [PR, AI]

**C2.6** conduct an inquiry to classify some common substances as acidic, basic, or neutral (e.g., use acid–base indicators or pH strips to classify common household substances) [PR, AI]

**C2.7** investigate applications of acid–base reactions in common products and processes (e.g., compare the effectiveness of different brands of antacid tablets, using quantitative analysis) [PR, AI]

## C3. Understanding Basic Concepts

By the end of this course, students will:

**C3.1** describe the relationships between chemical formulae, composition, and names of simple compounds (e.g., carbon dioxide, $CO_2$, has one more oxygen atom than carbon monoxide, CO)

**C3.2** name and write the formulae for simple ionic and molecular compounds (e.g., NaCl, NaOH, $H_2O$, $CO_2$)

**C3.3** write word equations and balanced chemical equations for simple chemical reactions (e.g., $2H_2 + O_2 \rightarrow 2H_2O$)

**C3.4** describe the process of neutralization for simple acid–base reactions (i.e., an acid reacts with a base to form a salt and often water)

**C3.5** describe how the pH scale is used to identify the concentration of acids and bases

# D. EARTH AND SPACE SCIENCE: EARTH'S DYNAMIC CLIMATE



## OVERALL EXPECTATIONS

By the end of this course, students will:

**D1.** analyse effects of human activity on climate change, and effects of climate change on living things and natural systems;

**D2.** investigate various natural and human factors that have an impact on climate change and global warming;

**D3.** demonstrate an understanding of various natural and human factors that contribute to climate change and global warming.

## SPECIFIC EXPECTATIONS

### D1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

**D1.1** analyse, on the basis of research, various ways in which living things and natural systems have been affected by climate change (e.g., the effect of loss of permafrost on northern roads and housing; the effect of longer growing seasons in some regions on farmers; the effect of warming oceans on coral reefs), and communicate their findings [IP, PR, AI, C]

*Sample issue:* Some areas of Canada have been experiencing hotter and drier summers, resulting in poor harvests, loss of wetland habitat, and increased incidence of forest fires. However, in other areas, an increase in the number of frost-free days has extended the agricultural growing season.

*Sample questions:* What effect does climate change have on air quality and extreme weather phenomena? How does global warming increase the vulnerability of Canadian forests to fire and pests? How does the destruction of forests affect animals and humans?

**D1.2** analyse ways in which human actions (e.g., burning fossil fuels, implementing tree-planting programs) have increased or decreased the production of greenhouse gases [AI, C]

*Sample issue:* Motor vehicle emissions are a major contributor to greenhouse gases. People can reduce such emissions by walking, biking, or using public transportation instead of driving; by keeping their vehicle in good operating condition; or by driving a hybrid vehicle.

*Sample questions:* Why do government and/or industry offer rebates to consumers buying programmable thermostats and compact fluorescent light bulbs? How does the production of oil from the Alberta oil sands contribute to greenhouse gas emissions? What is the difference in greenhouse gas emissions between a traditional SUV and a hybrid vehicle? What is "clean coal", and what is its impact on greenhouse gas emissions? How does large-scale livestock farming increase the production of greenhouse gases? What actions have you and/or your community taken to help reduce levels of greenhouse gases?

### D2. Developing Skills of Investigation and Communication

By the end of this course, students will:

**D2.1** use appropriate terminology related to Earth's dynamic climate, including, but not limited to: *anthropogenic, atmosphere, carbon footprint, carbon sink, climate, greenhouse gases, hydrosphere,* and *weather* [C]

**D2.2** investigate the principles of the natural greenhouse effect, using simulations, diagrams, and/or models, and compare these principles to those of an actual greenhouse [PR, AI]

**D2.3** use a research process to investigate a source of greenhouse gases (e.g., decaying garbage, animal digestive processes, burning biomass) and its effect on a region of Canada (e.g., melting of the polar ice cap in the Arctic, shrinking of glaciers in the Rockies) [IP, PR, AI]

**D2.4** conduct an inquiry to determine how different factors (e.g., an increase in surface temperature, an increase in water temperature) affect global warming and climate change [PR]

**D2.5** investigate their personal carbon footprint, using a computer simulation or numerical data (e.g., determine carbon emissions that result from their travelling to school, work, and recreation venues; from vacation travelling; from buying products imported from distant countries), and plan a course of action to reduce their footprint (e.g., a plan to increase their use of bicycles or public transit; to eat more local foods) [PR, AI, C]

**D2.6** compare different tools or systems used by scientists to make informed decisions on global climate change (e.g., Ecoregions of Canada, bioclimate profiles) [PR, AI]

**D2.7** compare different perspectives and/or biases evident in discussions of climate change in scientific and non-scientific media (e.g., with reference to knowledge, beliefs, and/or values) [PR, AI]

## D3. Understanding Basic Concepts

By the end of this course, students will:

**D3.1** describe the principal components of Earth's climate system (e.g., the sun, oceans, and the atmosphere; the topography and configuration of land masses)

**D3.2** describe the natural greenhouse effect, its importance for life, and the difference between it and the anthropogenic greenhouse effect

**D3.3** describe how heat is transferred and stored in both hydrospheric and atmospheric heat sinks

**D3.4** identify different greenhouse gases (e.g., carbon dioxide, methane, water vapour, nitrous oxide), and explain how they are produced naturally in the environment

**D3.5** describe methods by which greenhouse gases are produced by humans (e.g., burning of biomass, chemical reactions involving pollutants)

**D3.6** identify the natural and human causes of climate change in the world and, in particular, how Canada contributes to climate change

**D3.7** identify indicators of global climate change (e.g., changes in: the mass of glacial and polar ice, sea levels, wind patterns, global carbon budget assessments, migratory patterns of birds)

# E. PHYSICS: LIGHT AND APPLICATIONS OF OPTICS

## OVERALL EXPECTATIONS

By the end of this course, students will:

**E1.** analyse how properties of light and colour are applied in technology and the impact of these technologies on society;

**E2.** investigate, through inquiry, properties of light, and predict its behaviour in mirrors and as it passes through different media;

**E3.** demonstrate an understanding of characteristics and properties of light, particularly with respect to reflection and refraction and the addition and subtraction of colour.

## SPECIFIC EXPECTATIONS

### E1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

**E1.1** analyse how additive and/or subtractive colour theory are applied in technologies used in everyday life (e.g., stop lights, high-definition television, colour monitors, coloured spotlights) [AI, C]

*Sample issue:* Colour monitors, developed through the application of additive colour theory, enable computers to be used for a range of scientific, medical, and artistic functions that were not possible with old black-and-white monitors.

*Sample questions:* What are some of the safety uses of lights that employ colour filters? How do the advantages and disadvantages of liquid-crystal displays (LCDs) affect their uses? How can colour filters on glasses assist people with dyslexia? What role do additive and subtractive colour theories play in theatre productions and in movies?

**E1.2** describe the role of selected optical technologies in the transmission of information, and analyse their impact on society (e.g., cellphones, optical fibre cables, satellite dishes) [AI, C]

*Sample issue:* Text messaging on cellphones has become a standard mode of communication, particularly among young people. Some experts are concerned that text messaging has a negative influence on the way we communicate with each other, as it reduces verbal communication and the use of conventional written language.

*Sample questions:* How does virtual reality technology attempt to decrease pain and anxiety during medical procedures? What impact has the use of optical fibre cables had on the way we receive and communicate information? How has it made telecommuting possible for some types of workers?

### E2. Developing Skills of Investigation and Communication

By the end of this course, students will:

**E2.1** use appropriate terminology related to light and optics, including, but not limited to: *angle of incidence, angle of reflection, angle of refraction, centre of curvature, focal length, luminescence, magnification, principal axis, radius of curvature,* and *vertex* [C]

**E2.2** use an inquiry process to investigate the laws of reflection; use these laws to explain the characteristics of images formed by plane, converging (concave), and diverging (convex) mirrors; and draw ray diagrams to illustrate their observations [PR, AI, C]

**E2.3** use an inquiry process to investigate the refraction of light as it passes through a variety of media (e.g., the angles of incidence and refraction as light passes through a clear acrylic block) [PR]

**E2.4** predict the qualitative characteristics of images (e.g., location, orientation, size, type) formed by converging lenses, test their predictions through inquiry, and draw ray diagrams to record their observations [IP, PR, AI, C]

**E2.5** investigate how various objects or media (e.g., opaque, translucent, and transparent materials; black-and-white surfaces) reflect, transmit, or absorb light, and record their observations using ray diagrams [PR, C]

**E2.6** predict the effect of shining a coloured light on objects of different colours, and test their predictions through inquiry [IP, PR, AI, C]

**E2.7** construct an optical device (e.g., a funhouse mirror, a device that produces an optical illusion, a solar oven) that uses a variety of mirrors [PR]

## E3. Understanding Basic Concepts

By the end of this course, students will:

**E3.1** describe various types of light emissions (e.g., chemiluminescence, bioluminescence, incandescence, electric discharge) and how they produce light

**E3.2** identify and label the visible and invisible regions of the electromagnetic spectrum, and identify the colours that make up visible white light

**E3.3** explain the laws of reflection of light, and identify ways in which light reflects from various types of mirrors (e.g., plane, converging, diverging)

**E3.4** describe qualitatively how visible light is refracted at the interface between two different media

**E3.5** use additive colour theory to predict the results of combining primary and secondary light colours

**E3.6** use subtractive colour theory to describe the effect of colour filters on white light

**E3.7** explain how the colour of an object is determined by reflection, absorption, and transmission of colour

**E3.8** explain how the properties of light or colour are applied in the operation of an optical device (e.g., a reflecting telescope, stop lights, stage lights)

# GLOSSARY

The following definitions of terms are intended to help teachers and parents use this document.

***abiotic factors.*** The physical but non-living features of an ecosystem (e.g., light, gases, atmosphere, soil, rock, ice, climate, non-living organic matter).

***absorption* (biology).** The movement of fluid or a dissolved substance across a membrane.

***absorption* (physics).** A process whereby energy is transformed by matter (e.g., light rays that are absorbed through a medium are transformed into and emerge as a different form of energy).

***acid.*** A sour, water-soluble substance capable of many chemical reactions, such as neutralizing a base; a substance with a pH less than 7.

***acid–base indicator.*** A substance that indicates the acidity or basicity of a solution by undergoing characteristic colour changes.

***additive colour theory of light.*** A theory that states that white light is composed of different colours (wavelengths) of light. When the additive primary colours of light (red, green, and blue [RGB]) are combined, white light is produced.

***albedo.*** The fraction of incident light or electromagnetic radiation that is reflected by the surface of an object (e.g., an object's ability to reflect sunlight).

***alternating current (AC).*** An electric current that reverses its direction with a constant frequency.

***ammeter.*** An instrument that is used to measure current.

***ampere.*** The SI metric unit of electric current.

***angle of incidence.*** The angle between the incident ray and the normal in a ray diagram.

***angle of reflection.*** The angle between the reflected ray and the normal in a ray diagram.

***angle of refraction.*** The angle between the refracted ray and the normal in a ray diagram.

***antacid.*** A substance capable of neutralizing an acid (e.g., sodium bicarbonate).

***anthropogenic.*** Relating to or resulting from the influence of humans on nature.

***aquatic ecosystem.*** An ecosystem based in water (e.g., a pond, a lake, a river, an underground water body, an ocean).

***aqueous solution.*** A homogeneous mixture of substances dissolved in water.

***asterism.*** A recognizable pattern of stars that form a separate entity within a larger constellation (e.g., the Big Dipper in Ursa Major; Orion's Belt in Orion).

***astronomical phenomenon.*** Any observable occurrence relating to astronomy.

***astronomical unit (AU).*** A unit used to measure distances within the solar system, equivalent to the average distance between the earth and the sun (approximately 150 million km).

***atmosphere.*** A gaseous mass of air surrounding a celestial body, such as the earth.

***atom.*** The smallest part of an element that can exist.

***atomic number.*** The unique number of protons in one atom of an element.

***atomic structure.*** The configuration of subatomic particles within an atom (e.g., an atom of hydrogen has the structure of one proton in its nucleus surrounded by one electron).

***aurora borealis.*** The northern lights, produced by the collision of charged particles of the solar wind with molecules in the earth's atmosphere.

***base.*** A bitter, water-soluble substance capable of many chemical reactions, such as combining with an acid to produce a salt and water; a substance with a pH greater than 7.

***big bang theory.*** The most widely accepted scientific theory used to account for the origin of the universe. The theory states that the universe began from an infinitely dense point that expanded rapidly to form all matter and energy in the universe.

***binary compound.*** A substance formed from two elements.

***bioaccumulation.*** The process by which chemicals (e.g., pesticides) collect in organisms in progressively higher concentrations towards the top of food chains.

***biodiversity.*** The variety of species (types) of organisms at all levels of classification in an ecosystem, and the variety of ecosystems, globally or within a specific geographic region.

***bioluminescence.*** Light produced from a biochemical reaction in a living organism.

***biosphere.*** The portion of Earth (air, land, water) that supports living organisms.

***biotic factors.*** The living components of an ecosystem (e.g., animals, plants, bacteria).

***Bohr atomic model.*** A model of the atom proposed by the Danish physicist Niels Bohr, in which protons and neutrons are confined in a dense, positively charged core called the nucleus, surrounded by electrons in specific orbits.

***boiling point.*** The unique temperature at which a particular liquid begins to form bubbles inside the liquid. The boiling point temperature is dependent upon the external atmospheric pressure.

***carbon footprint.*** The impact human activities have on the environment in terms of the amount of greenhouse gases produced, measured in units of carbon dioxide.

***carbon sink.*** A naturally occurring reservoir that removes carbon dioxide from the atmosphere. Naturally occurring sinks are oceans and plants, as well as organisms that remove carbon from the atmosphere.

***carrying capacity.*** The maximum population size of a given species that an ecosystem can support without reducing its ability to support the same species in the future.

***celestial navigation.*** The use of the positions of stars to determine location and direction when travelling.

***celestial object.*** Any structure (e.g., a moon, a star, a planet, a nebula) that exists in space.

***cell differentiation.*** A stage of development of a living thing during which specialized cells form.

***cell division.*** A process by which a cell, called the parent cell, divides into two or more cells, called daughter cells. Cell division is usually a small segment of a cell's cycle.

***cell specialization.*** The process by which cells develop from similar cells into cells that have specific functions within a multi-cellular organism.

***cell theory.*** A theory that states that all living organisms are made up of one or more cells, that cells are the basic structural and functional units in living organisms, and that all cells come from pre-existing cells.

***cellular respiration.*** A process in which the chemical bonds of energy-rich molecules such as glucose are converted into energy usable for metabolic processes in organisms.

***characteristic.*** A distinguishing trait or quality of a substance or object.

***characteristics of images.*** Qualities that help define the nature of an image, including distance (from image to vertex), orientation (upright or inverted), magnification (whether smaller than, larger than, or the same size as the object), and type (real or virtual).

***chemical change.*** A change in a substance that results in the formation of a new substance.

***chemical equation.*** A method of expressing a chemical change using the chemical formulae of reactants and products.

***chemical property.*** A quality of a substance that allows it to enter into a chemical reaction (e.g., an acid's capacity to be neutralized by a base; the tendency of iron to rust).

***chemical reaction.*** A process in which substances interact, causing the formation of new substances with new properties (e.g., the burning of wood to form smoke and ash, with heat given off).

***chemiluminescence.*** Light produced from a chemical reaction without a rise in temperature.

***chloroplast.*** Organelles found in plant cells and some algae (eukaryotic) that conduct photosynthesis.

***circuit diagram.*** A two-dimensional representation of an operating electrical circuit.

***climate.*** The characteristic pattern of weather conditions within a region, including temperature, wind velocity, precipitation, and other abiotic features, averaged over a long period of time.

***cloning.*** The process of creating identical genetic copies of cells from an original cell. In nature, cloning occurs by asexual reproduction.

***combustion.*** A chemical reaction with oxygen that produces heat and light.

***compound.*** A substance made up of two or more elements (e.g., water is a compound consisting of two elements, hydrogen and oxygen).

***concentration.*** The amount of a particular substance in a specific amount of another substance; also, the amount of dissolved substance contained per unit of volume of solvent.

***conduction.*** The movement or transmission of thermal or electrical energy through a substance.

***conductivity.*** A measure of a material's ability to conduct heat or electricity.

***conductor.*** A material that has a high thermal and electrical conductivity (e.g., a metal).

***constellation.*** A group of stars perceived as a figure or design.

***converging (convex) lens.*** A lens that is thickest in the middle, causing parallel rays of light to converge to a focus.

***converging (concave) mirror.*** A mirror that curves inward, causing parallel rays to come to a principal focal point.

***current.*** The rate of movement of electric charge through a conductor.

***current electricity.*** The flow of electricity in a circuit through a conductor.

***decomposition reaction.*** A chemical change in which a complex compound is broken down into simpler compounds or elements. For example, in the process of rotting and decay known as decomposition, the complex organic materials in plants and animals break down into simple inorganic elements that can be returned to the atmosphere and soil.

***diffusion.*** The gradual movement of particles from an area of higher concentration to an area of lower concentration.

***dilute.*** A substance that has a relatively low concentration of solute. A dilute solution is created by modifying or adding a substance to a solution.

***direct current (DC).*** An electric current in which the net flow of charged particles travels in one direction only.

***displacement reaction (single).*** A reaction in which one element in a compound replaces another element in a compound.

***disturbed ecosystem.*** An ecosystem that has been altered by human activity.

***diverging (concave) lens.*** A lens that is thinnest in the middle, causing parallel rays of light to diverge.

***diverging (convex) mirror.*** A mirror that curves outward, causing parallel rays to spread farther apart from a principal focal point.

***diversity.*** An abundance of variety in the plant and animal communities and species within a given area.

***ecosystem.*** A complex, self-regulating system through which energy and materials are transferred, made up of a group of living organisms and their abiotic environment, which interact as a unit.

***efficiency.*** The amount of useful energy production achieved in relation to the amount of energy supplied.

***electric charge.*** Positively or negatively charged particles that exert an electric force.

***electric current.*** A measure of the number of charged particles that pass by a point in an electrical circuit each second.

***electric discharge.*** The very quick transfer of an electric charge.

***electrical circuit.*** A circular path for electron flow, including a source, a load, and conducting wires.

***electrical energy consumption.*** The amount of electrical energy used, usually measured in kilowatt-hours.

***electrical load.*** A device that uses electrical energy in a circuit.

***electrical source.*** A source of electrical energy that creates potential difference in a circuit (e.g., a battery, an electrical outlet).

***electromagnetic radiation.*** Radiation consisting of electromagnetic waves that travel at the speed of light (e.g., visible light, radio waves, gamma rays, X-rays).

***electromagnetic spectrum.*** The entire range of wavelengths or frequencies of electromagnetic radiation, extending from gamma rays to the longest radio waves, including visible light.

***electron.*** A small, negatively charged particle that travels in an orbit around the nucleus of an atom and acts as the particle of electricity in solids.

***electrostatics.*** The study of electric charges at rest.

***element.*** A pure substance that cannot be broken down into simpler substances (e.g., iron, sulfur, oxygen).

***environment.*** All the biotic and abiotic elements that surround and affect organisms or groups of organisms and influence their survival and development.

***equilibrium.*** A state in which opposing forces or actions are balanced. Equilibrium may be either static or dynamic.

***extrapolate.*** To infer values by extending or projecting known information (e.g., to draw conclusions about the future from observed trends in a graph).

***fluorescence.*** A light emitted during exposure of the source to electromagnetic radiation.

***focal length.*** The distance from the vertex to the principal focus of a curved mirror.

***friction.*** The force resisting the relative motion of two surfaces in contact.

***gravitational force.*** The force of attraction between all masses in the universe, especially the attraction of the earth's mass to bodies situated within the earth's gravitational field.

***greenhouse gas.*** An atmospheric gas that allows solar radiation to pass through the atmosphere but absorbs the radiation that Earth emits back to space, thereby trapping heat and making the planet's surface warmer. These gases include carbon dioxide, water vapour, methane, and the fluorocarbons.

***group* (chemistry).** *See* periodic group.

***hydrosphere.*** The collective mass of water found on, under, and over the surface of the earth.

***image.*** A reproduction of an object, such as may be produced by an optical device (e.g., by a lens or a mirror).

***incandescence.*** A light omitted from a material because of the high temperature of that material (e.g., from a filament in an incandescent light bulb).

***incident ray.*** A ray of light travelling from a source towards an object.

***induction (of electric charge).*** The movement of electrons in a substance, caused by a nearby charged object without direct contact between the substance and the object.

***insulator (electric).*** A solid, liquid, or gas that resists or blocks the flow of electricity (e.g., wood).

***ion.*** An atom (or group of atoms) that has become charged because of an imbalance in the number of electrons and protons.

***ionic compound.*** A compound that is held together by ionic bonds. It is composed of one or more positively charged ions and one or more negatively charged ions.

***invasive species.*** A species that is introduced by human activity to an ecosystem not native to that species and that has an adverse effect on the ecosystem.

***kilowatt.*** 1000 watts.

***kilowatt-hour (kWh).*** A unit of work or energy equal to that expended by one kilowatt in one hour.

***law of attraction.*** Particles with opposite charges attract one another.

***law of conservation of mass.*** A fundamental law of chemical reactions that states that the total mass of the reactants in a chemical reaction is always equal to the total mass of the products.

***law of repulsion.*** Particles with identical charges repel one another.

***laws of reflection.*** The angle of incidence is equal to the angle of reflection. The incident, normal, and reflected rays all lie on the same plane.

***light year (ly).*** A unit used to measure interstellar distance, equivalent to the distance travelled by light (at 300 000 km/s) in one year (approximately 9.5 trillion km).

***limiting factor.*** An environmental factor that prevents an increase in the number and/or size of organisms in a population or in the distribution of the population in an ecosystem.

***lithosphere.*** The solid upper layer of Earth, consisting of the crust and upper mantle.

***luminescence.*** The emission of light by a material or an object that has not been heated (e.g., fluorescence, phosphorescence).

***magnetosphere.*** The region of space enclosed by a celestial object's magnetic field.

***magnification.*** The degree of enlargement of an optically or electronically produced image.

***mass number.*** The sum of the protons and neutrons in the nucleus of an atom. Mass number is not the same as the average atomic mass found in the periodic table.

***meristem.*** An unspecialized cell found in plants that gives rise to a specific specialized cell.

***mesophyll.*** The tissue in the middle of a leaf, consisting of cells that contain chloroplast.

***metabolic processes.*** The chemical reactions and pathways in a cell or organism that are necessary for life.

***mirage.*** An optical effect, sometimes seen in the desert or over hot pavement, that may have the appearance of a pool of water or a mirror in which distant objects are seen as inverted. It is caused by the bending of light rays through layers of air having very large temperature gradients.

***mitosis.*** The process by which a cell divides and produces two identical daughter cells.

***mixture.*** The substance that is formed when two or more substances composed of different kinds of particles are added together. The substances are chemically combined and may be separated again. Mixtures are divided into solutions and mechanical mixtures.

***molecule.*** A combination of two or more atoms held together by covalent bonds. A fundamental unit forming a compound.

***multimeter.*** A device that measures several different electrical quantities including voltage, current, and resistance.

***natural ecosystem.*** An ecosystem that has not been altered by human activity.

***natural greenhouse effect.*** Warming created by the heat energy radiated by the sun and greenhouse gases that are normally present in the earth's atmosphere. It keeps the earth's climate warm enough to sustain life.

***neutralization reaction.*** A reaction of an acid and base to produce water and a salt. *Salt* is a general term used to describe one of the products of a neutralization reaction. Table salt, or sodium chloride, is a particular example of a salt.

***neutron.*** A particle located in the nucleus that is electrically neutral and has approximately the same mass as a proton.

***non-renewable energy sources.*** Energy sources that are finite and cannot be renewed naturally. Examples are fossil fuels (natural gas, propane, coal, petroleum) and uranium. Such sources will eventually be depleted or become too expensive or too environmentally damaging to extract.

***opaque.*** Not allowing light to pass through.

***organ.*** A part of the body, such as the heart or stomach, made of several different groups of tissues that work together to perform a specific function or group of functions.

***organelles.*** Cell components that perform specific functions for the cell.

***osmosis.*** The movement of a fluid, usually water, through a selectively permeable membrane from an area of higher concentration to an area of lower concentration.

***parallel circuit.*** An electric circuit in which components are arranged such that electrons can flow along more than one path.

***particle theory of matter.*** The theory that explains the behaviour of solids, liquids, and gases. The theory states that all matter is made up of tiny particles that are always moving, that are attracted to each other as a result of molecular forces, and that have very large space between them compared to the particles themselves.

***period* (chemistry).** A horizontal row in the periodic table of elements.

***periodic group.*** A vertical column in the periodic table of elements.

***periodic table.*** A graphic arrangement of chemical elements into rows and columns, devised by Dmitri Mendeleev in the nineteenth century, based on patterns of similar properties.

***pH scale.*** A numerical scale ranging from 0 to 14 used to classify aqueous solutions as acidic, basic, or neutral. Acidic solutions have a pH less than 7. Basic solutions have a pH greater than 7. Neutral solutions have a pH equal to 7.

***phloem.*** Specialized plant tissue used for carrying sugars and amino acids.

***phosphorescence.*** A light that is emitted while the source is exposed to electromagnetic radiation, and that continues after the excitation source has been removed.

***photosynthesis.*** The process by which green plants, algae, and certain bacteria make energy for themselves by using the energy from sunlight plus water to convert carbon dioxide into carbohydrates. The process produces oxygen as a byproduct. Photosynthesis produces the oxygen and carbohydrates that all animals need to survive.

***physical properties.*** Qualities or attributes of matter that do not involve chemical change.

***plane mirror.*** A mirror with a flat reflective surface.

***polyatomic ion.*** A charged particle containing more than one atom.

***potential difference.*** The difference in electric charge between two points that will cause current to flow in a closed circuit.

***precipitate.*** A solid, insoluble product of a chemical reaction found in a liquid.

***product.*** The new substance formed during a chemical reaction.

***property.*** An attribute common to all substances or objects of the same group.

***proton.*** The dense, positively charged particle found in the nucleus of an atom.

***pure substance.*** A substance made of only one kind of material and having uniform properties throughout.

***qualitative data.*** Information describing the characteristics or properties of the objects or substances being observed.

***quantitative data.*** Information concerning the amounts or measurements of the objects or substances being observed.

***reactant.*** A material that starts a chemical reaction.

***reflection.*** The changing of direction of a light ray caused by bouncing it off a surface. All objects reflect light to some extent, some (such as a mirror) better than others. Sound can also be reflected; a common example of this is an echo.

***refraction.*** The bending of light as it travels from a material with one refractive index to a material with a different refractive index.

***renewable energy sources.*** Energy sources that can be replenished by natural processes in a relatively short period of time (e.g., energy from the sun, wind, tide, waves, biomass).

***resistance.*** The degree to which a substance opposes the flow of an electric current through it.

***retrograde motion.*** The movement of an object in the sky, usually a planet, from east to west, rather than in its normal motion from west to east. This effect is generally produced when Earth is passing the planet in its orbit.

***salinity.*** The amount of dissolved salt in water.

***satellite.*** A celestial body orbiting another of larger size; or a human-made object or vehicle orbiting the earth, the moon, or other celestial bodies.

***scientific inquiry.*** The cognitive strategy and hands-on procedures through which students develop knowledge and understanding of scientific ideas and of the various methods scientists use to study the natural world.

***scientific investigation.*** Inquiry or research in which skills, habits of mind, concepts, and procedures that are fundamental to the development of scientific knowledge are systematically applied in order to advance scientific knowledge.

***scientific literacy.*** The possession of the scientific knowledge, skills, and habits of mind required to thrive in the science-based world of the twenty-first century.

***scientific research.*** The process through which students locate, gather, record, analyse, and synthesize information to develop their knowledge and understanding of scientific concepts and theories.

***series circuit.*** An electrical circuit in which the components are arranged one after another in a series. A series circuit has only one path for electron flow.

***SI.*** The international system of metric measurement (from the French *Système international d'unités*) in which the quantities of length, mass, time, electric current, temperature, luminous intensity, and amount of substance are assigned precisely defined base units from which all other units are derived by multiplication or division.

***Snell's law.*** When light travels from one medium to another, the product of the index of refraction of the initial medium and the sine of the angle of incidence is equal to the product of the index of refraction of the final medium and the sine of the angle of refraction.

***solar system.*** The sun together with all the planets and other celestial bodies that are held by its gravitational attraction and travel around it.

***solar wind.*** A stream of fast-moving charged particles ejected by the sun into the solar system. The stream produces the aurora borealis when it collides with Earth's atmosphere. The solar wind would destroy life on Earth if it were not deflected by Earth's magnetic field.

***soluble.*** A substance that is able to be dissolved.

***static electricity.*** An electric charge that builds up on the surface of an object when it is rubbed against another object made of different material.

***stem cell.*** An unspecialized cell that gives rise to various specialized cells.

***stomate.*** The opening between guard cells in the epidermis of a plant through which gases pass.

***subtractive colour theory of light.*** A theory that states that coloured matter selectively absorbs different colours (wavelengths of light). When all colours are absorbed, no light is reflected to the eye and the material appears black. For coloured material, the colours that are absorbed are "subtracted" from the reflective light that is seen by the eye.

***succession.*** The relatively predictable sequence of changes in the composition of communities following a natural or human disturbance of their environment. For example, following activity that leaves a clearing in the forest, the first trees to return (the "pioneer species") are often fast-growing, shade-intolerant varieties. These are eventually replaced by shade-tolerant species that can grow beneath the pioneer species.

***sustainability.*** A condition or process that can be maintained without interruption, weakening, or loss of valued qualities. Sustainability ensures that a population remains within the carrying capacity of its environment. The term is often used in reference to the ability to meet the needs of the present generation without compromising the ability of future generations to meet their needs.

***synthesis reaction.*** A process in which two or more simple substances combine to produce a more complex substance.

***terrestrial ecosystem.*** An ecosystem based on land (e.g., a forest, sand dunes, grasslands).

***transgenic organs.*** Organs that are transplanted into an organism from a different species.

***translucent.*** Able to transmit light but in a diffused manner that prevents objects or images from being seen distinctly.

***transmission (of light).*** A process whereby light passes through matter and may be refracted and/or absorbed.

***transparent.*** Able to transmit light so well that objects or images can be seen as though there were no intervening material.

***triboluminescence.*** Light produced from friction.

***universe.*** Everything that physically exists: the entirety of space and time, and all forms of matter and energy.

***vertex.*** The middle point of a curved mirror

***virtual image.*** An image formed when the light rays from an object pass through a lens. Although the image does not form a visible projection on a screen, it has a definite position and size and can be imagined.

***viscosity.*** The degree to which a fluid resists flow under pressure.

***volt.*** The SI metric unit of electric potential and electromotive force.

***voltmeter.*** A device for measuring electrical potential difference in volts.

***watershed.*** The entire geographical area drained by a river and its tributaries.

***weather.*** The specific condition of the atmosphere at a particular place and time. It is measured in terms of such things as wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation. In most places, weather can change from hour to hour, day to day, and season to season.

***WHMIS.*** An acronym that stands for Workplace Hazardous Materials Information System. This system, which is in use across Canada, allows employers and workers to obtain information about hazardous materials in their workplace in order to protect their health and ensure their safety.

***word equation.*** A method of expressing a chemical change using the names of reactants and products.

***xylem.*** A complex, specialized, water-carrying tissue in the vascular system of higher plants.

The Ministry of Education wishes to acknowledge the contributions of the many individuals, groups, and organizations that participated in the development and refinement of this curriculum policy document.

Printed on recycled paper

08-003
ISBN 978-1-4249-8078-9 (Print)
ISBN 978-1-4249-8079-6 (PDF)
ISBN 978-1-4249-8080-2 (TXT)

© Queen's Printer for Ontario, 2008