THE ONTARIO CURRICULUM

GRADES 9–12

# Science



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Educators should be aware that, with the exception of **the Grade 9 science course, 2022 (SNC1W)**, the 2008 Science curriculum for Grade 10 and the 2008 Science curriculum for Grades 11–12 remain in effect. All secondary science courses for Grades 10–12 will continue to be based on those documents. All references to Grade 9 that appear in *The Ontario Curriculum, Grades 9 and 10: Science, 2008* and *The Ontario Curriculum, Grades 11 and 12: Science, 2008* have been superseded by *The Ontario Curriculum, Grade 9: Science, 2022.* As of September 2022, this course replaces Science, Grade 9, Academic (SNC1D) and Science, Grade 9, Applied (SNC1P). These courses expired at the end of the 2021-22 school year.

## Contents



Une publication équivalente est disponible en français sous le titre suivant : Le curriculum de l’Ontario, de la 9e à la 12e année – Sciences

# SNC1W - Science, Grade 9

De-streamed

Issued: 2022

This course enables students to develop their understanding of concepts related to biology, chemistry, physics, and Earth and space science, and to relate science to technology, society, and the environment. Throughout the course, students will develop and refine their STEM skills as they use scientific research, scientific experimentation, and engineering design processes to investigate concepts and apply their knowledge in situations that are relevant to their lives and communities. Students will continue to develop transferable skills as they become scientifically literate global citizens.
Prerequisite: None
**Disciplines**: Science

## Introduction

### Preface

This curriculum policy presents the compulsory Grade 9 science course, 2022 (SNC1W). This course supersedes the two Grade 9 courses outlined in *The Ontario Curriculum, Grades 9 and 10: Science, 2008.* Effective September 2022, all science programs for Grade 9 will be based on the expectations outlined on this site.

The Grade 9 science curriculum focuses on the fundamental concepts of science and on science, technology, engineering, and mathematics (STEM) skills. It supports students in making connections between skills and concepts and the practical applications of science in their lives, and in learning about biology, chemistry, physics, and Earth and space science. This curriculum is designed to help students prepare for deeper levels of science as they continue in secondary school and beyond.

In addition to the considerations outlined in this curriculum context, all of the general "Program Planning" sections on this site apply to this course. Educators should review and implement these sections, as well as the components that appear below.

### Vision and Goals of the Grade 9 Science Course

The vision of the Grade 9 science course is for students to acquire and develop the skills and knowledge they need to thrive in today's rapidly changing world. As discoveries and innovations in STEM increasingly impact our lives, science continues to adapt and evolve. A central component of this curriculum is safe, practical, hands-on, experiential learning that will support students in becoming successful and discerning individuals who are scientifically literate.

Throughout the Grade 9 science course, students apply scientific and engineering design processes to develop their sense of wonder about the world, to explore their curiosity about what they observe, and to investigate problems relating to science, technology, society, and the environment. Students are encouraged to consider what practical steps they themselves can take to help solve some of these problems.

This curriculum provides numerous opportunities for students to develop essential STEM skills and to extend and deepen their understanding of the fundamental concepts of science. Students will continue to develop the ability to make connections that honour the complex, cross-curricular, and sometimes ambiguous nature of modern scientific problems. As they bring experiences from their own lives to the classroom, students are encouraged to see the connections between science and other subject areas.

Concepts and skills related to environmental education[1] appear throughout the curriculum, providing students with opportunities to investigate the world around them and to build the skills and knowledge that serve as the foundation for deep understanding about complex and interconnected issues such as dynamic equilibrium, biodiversity, sustainability, and climate change. Learning in all strands is enriched when students think critically about environmental issues when relating science to society, or when developing innovative solutions through a scientific or engineering design process.

As students progress through the course, they gain an appreciation for the broad range of STEM fields and sectors, including skilled trades. They also come to realize that, while they are all impacted in various ways by discoveries and innovations in these areas, they can one day become contributing members of these fields and sectors and shape the direction of future scientific and technological innovation, to help support a better future for all.

While embodying optimism and hope for the future, this course provides opportunities to investigate exciting innovations, discoveries, and concepts in science. The curriculum also provides opportunities for students to consider the intended and unintended consequences of scientific progress as they relate science to our changing world, and as they investigate important issues such as climate change and issues related to the impact of emerging technologies, which can include bias, accessibility, and ethical concerns.

Ensuring that all students see themselves as confident, effective science learners and practitioners is at the forefront of the program. Students analyse scientific discoveries and innovations made by people

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[1] "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."

– Ontario Ministry of Education, *Shaping Our Schools, Shaping Our Future: Report of the Working Group on Environmental Education* (June 2007), p. 6

with diverse experiences and integrate their own scientific skills and knowledge to enhance their learning in the classroom. Students explore Indigenous knowledges, which can broaden their understanding of and appreciation for Indigenous cultures and practices, and also provide them with valuable ways in which to investigate how diverse perspectives enrich scientific practices.

Finally, the science curriculum helps students develop important scientific literacy skills that will enable them to thrive in their future professional and personal lives, and to become discerning, knowledgeable, and active problem solvers in their communities.

In summary, the Ontario Grade 9 science course aims to provide all students with the skills and knowledge required to:

- apply research, experimentation, and engineering design skills to help find solutions to complex problems in their own lives and in the lives of those in their communities;
- understand the cross-curricular and cross-disciplinary nature of problem solving within the STEM fields;
- appreciate the wonder and awe of the world and be optimistic and realistic about the power and limitations of science to solve environmental and social problems;
- consider carefully the intended and unintended consequences of scientific progress;
- develop scientific literacy and skills that will allow them to be discerning citizens and find answers to scientific questions;
- see themselves as future contributing members of STEM fields and sectors, including skilled trades;
- see themselves as confident, effective science learners, with rich social and cultural backgrounds that can help them to contribute to scientific discovery and related technological innovation;
- discover effective, equitable, inclusive, and sustainable solutions to scientific and technological problems that impact their lives and the lives of those in their communities;
- recognize the importance of Indigenous knowledges and ways of knowing, and of bringing diverse perspectives to current challenges within STEM fields.

The three main goals of the Grade 9 science course are for students:

1. to develop the skills and make the connections needed for scientific investigation
2. to relate science to our changing world, including technology, society, the economy, and the environment
3. to investigate and understand scientific concepts

Achieving these three goals will enable students to develop a high degree of scientific literacy.

## The Importance of STEM Education

STEM education is the cross-curricular study of science, technology, engineering, and mathematics, and the application of those subjects in real-world contexts. As students engage in STEM education, they develop the transferable skills that they need to meet the demands of today's global economy and society, and to become scientifically literate citizens.

STEM education helps students develop an understanding and appreciation of each of the core subjects of science, technology, and mathematics. At the same time, it supports a more holistic understanding and application of skills and knowledge related to engineering design and innovation. STEM learning integrates and applies concepts, processes, and ways of thinking associated with these subjects to enable students to design economical, ethical, innovative, and sustainable solutions to technical and complex real-world problems.

Skills developed through STEM education include computational thinking, coding, innovation, and scientific and engineering design. These skills are in high demand in today's globally connected world, as advancements in science continue to impact all areas of our lives, and they form a critical component of the Grade 9 science course. Students use an engineering design process and associated skills to design, build, and test devices, models, structures, and systems and they write and execute code in investigations and when modelling concepts.

Approaches to STEM education may vary across Ontario schools. STEM-related subjects may be taught separately, but cross-curricular connections should form a part of student learning. Strand A of the Grade 9 science course focuses on the STEM skills and connections that frame learning in the other four strands: Biology, Chemistry, Physics, and Earth and Space Science. Strand A also provides opportunities for critical cross-curricular learning as students consider the connections between science and other subject areas. The Grade 9 science course also encourages students to examine various STEM-related careers, including skilled trades.

Classroom activities focused on solving real-world problems and on understanding practical applications of concepts can combine components from two or more STEM-related subjects and can include contexts related to the student's home and community or to various occupations, including the skilled trades. The integration of a number of STEM-related subjects can reinforce students' understanding of each subject and of the interrelationships among them.

Curriculum expectations related to exploring Indigenous knowledges and ways of knowing can create opportunities for inclusive and impactful integrative studies. Diverse perspectives engage students in a variety of creative and critical thinking processes that are essential for developing innovative, ethical, and effective solutions to societal and environmental problems.

The themes and components of STEM education are woven throughout the Grade 9 science curriculum to ensure that Ontario educators and students become innovators and leaders for ethical and sustainable change in society and the workforce, and to create opportunities in our diverse communities to foster integrative thinking and problem solving. The curriculum also supports the development of scientific literacy in students, enabling them to better appreciate, understand, and navigate the world in which they live.

## Curiosity and Wonder in Science

Curiosity and wonder are at the core of scientific disciplines and should be at the core of student-centred science education. Students come to school with a natural curiosity about the way in which the world works, and as they learn about natural phenomena, scientific concepts and theories, and scientific discoveries and innovations made by diverse individuals, they can be amazed and inspired. The Ontario science curriculum strives to nurture and support curiosity and wonder in order for all students to enjoy science, to be engaged and achieve success within the program, and to see themselves as confident learners and as scientifically literate individuals. The curriculum also strives to inspire students with a spirit of inventing, designing, making, and entrepreneurship as they use their knowledge from the classroom to develop innovative, made-in-Canada solutions to global issues.

Within the science classroom, students' curiosity may be expressed explicitly, with direct questions, such as "How does that work?", or expressed subtly as they consider the results of an experiment or the results of testing an engineered design. They may bring questions into the classroom about scientific phenomena they have observed in their own lives, or initial classroom investigations may lead them to extend their thinking and further compare and analyse concepts. Processes such as scientific research, scientific experimentation, and engineering design provide a framework within which to situate and nurture this curiosity. Students can revise and refine their initial questions, and then proceed through a formal process to seek answers or develop solutions.

Wonder is exhibited as students are surprised at the results of their research, experimentation, or engineered design, or as they admire the natural processes that make up our world. By offering a wide variety of investigations, the Ontario curriculum provides opportunities for students to appreciate and wonder about scientific concepts and processes, as well as current and emerging technologies and innovations.

The excitement and promise of discoveries and innovations is balanced with an awareness of the limitations, and potentially harmful impacts, of science. Students should develop an understanding of the types of problems that can be solved by science, as well as of the critical role that human creativity, empathy, and ethics have in innovations and solutions that support accessibility, inclusivity, and equity for all.

In addition to being at the core of scientific disciplines, curiosity and wonder should be integral components of helping students develop the skills and make the connections needed for scientific investigation; develop the ability to relate science to our changing world; explore and understand concepts; and develop as scientifically literate individuals.

# The Program in Science

## Overview

The Grade 9 science course builds on the elementary science and technology program and is based on the same broad areas of learning. The first strand focuses on investigation skills. Each of the other four strands focuses on one of the scientific subdisciplines – biology, chemistry, physics, and Earth and space science. The transition from Grade 8 to Grade 9 is a smooth one because the strands of the elementary science and technology curriculum are closely aligned with those of the Grade 9 science course.

The Grade 9 science course is designed to be inclusive of all students in order to facilitate their transition from the elementary grades to the secondary level. It offers opportunities for all students to build a solid foundation in science, broaden their knowledge and skills, and begin to see themselves as scientists. This approach allows students to make informed decisions in choosing future science courses based on their interests, and in support of future plans for apprenticeship training, university, college, community living, or the workplace.

Similar to the elementary curriculum, the Grade 9 course adopts a strong focus on the processes that best enable students to understand scientific concepts and learn related skills. Attention to scientific and engineering design processes is considered essential to a balanced science program. In this course, these processes include a scientific research process, a scientific experimentation process, and an engineering design process.

Throughout the course, students make connections to real-life applications and to their lived experiences. Teachers implement the curriculum through effective assessment and instructional practices that are rooted in culturally responsive and relevant pedagogy (CRRP). Teachers utilize a variety of assessment and instructional approaches that provide students with multiple entry points to access science learning and multiple opportunities to demonstrate their achievement in science.

This course continues the learning from the elementary science and technology curriculum and prepares students for success in all senior secondary science courses in all pathways moving forward. Students who successfully complete the Grade 9 science course may proceed to a science course in Grade 10.

The course information that appears in the next section is in effect starting in the 2022–23 school year. The 2008 science curriculum for Grade 10 and the 2008 science curriculum for Grades 11–12 remain in effect. All references to Grade 9 that appear in *The Ontario Curriculum, Grades 9 and 10: Science, 2008* and *The Ontario Curriculum, Grades 11 and 12: Science, 2008* have been superseded by the section below.

# Courses in Science, Grades 9 to 12

## Science

| Grade | Course Name | Course Type | Course Code | Prerequisite |
|---|---|---|---|---|
| 9 | Science | De-streamed | SNC1W | None |
| 10 | Science | Academic | SNC2D | Grade 9 Science, De-streamed (2022), or Grade 9 Science, Academic (2008), or Grade 9 Science, Applied (2008) |
| 10 | Science | Applied | SNC2P | Grade 9 Science, De-streamed (2022), or Grade 9 Science, Academic (2008), or Grade 9 Science, Applied (2008) |
| 12 | Science | University/College | SNC4M | Grade 10 Science, Academic, or any Grade 11 university, university/college, or college preparation course in science |
| 12 | Science | Workplace | SNC4E | Grade 10 Science, Applied, or a Grade 10 Locally Developed Compulsory Credit (LDCC) course in science |

## Biology

| Grade | Course Name | Course Type | Course Code | Prerequisite |
|---|---|---|---|---|
| 11 | Biology | University | SBI3U | Grade 10 Science, Academic |
| 11 | Biology | College | SBI3C | Grade 10 Science, Academic or Applied |
| 12 | Biology | University | SBI4U | Grade 11 Biology, University |

## Chemistry

| Grade | Course Name | Course Type | Course Code | Prerequisite |
|---|---|---|---|---|
| 11 | Chemistry | University | SCH3U | Grade 10 Science, Academic |
| 12 | Chemistry | University | SCH4U | Grade 11 Chemistry, University |
| 12 | Chemistry | College | SCH4C | Grade 10 Science, Academic or Applied |

## Earth and Space Science

| Grade | Course Name | Course Type | Course Code | Prerequisite |
|---|---|---|---|---|
| 12 | Earth and Space Science | University | SES4U | Grade 10 Science, Academic |

## Environmental Science

| Grade | Course Name | Course Type | Course Code | Prerequisite |
|---|---|---|---|---|
| 11 | Environmental Science | University/College | SVN3M | Grade 10 Science, Academic or Applied |
| 11 | Environmental Science | Workplace | SVN3E | Grade 9 Science, De-streamed (2022), or Grade 9 Science, Academic (2008), or Grade 9 Science, Applied (2008), or a Grade 9 or 10 Locally Developed Compulsory Credit (LDCC) course in science |

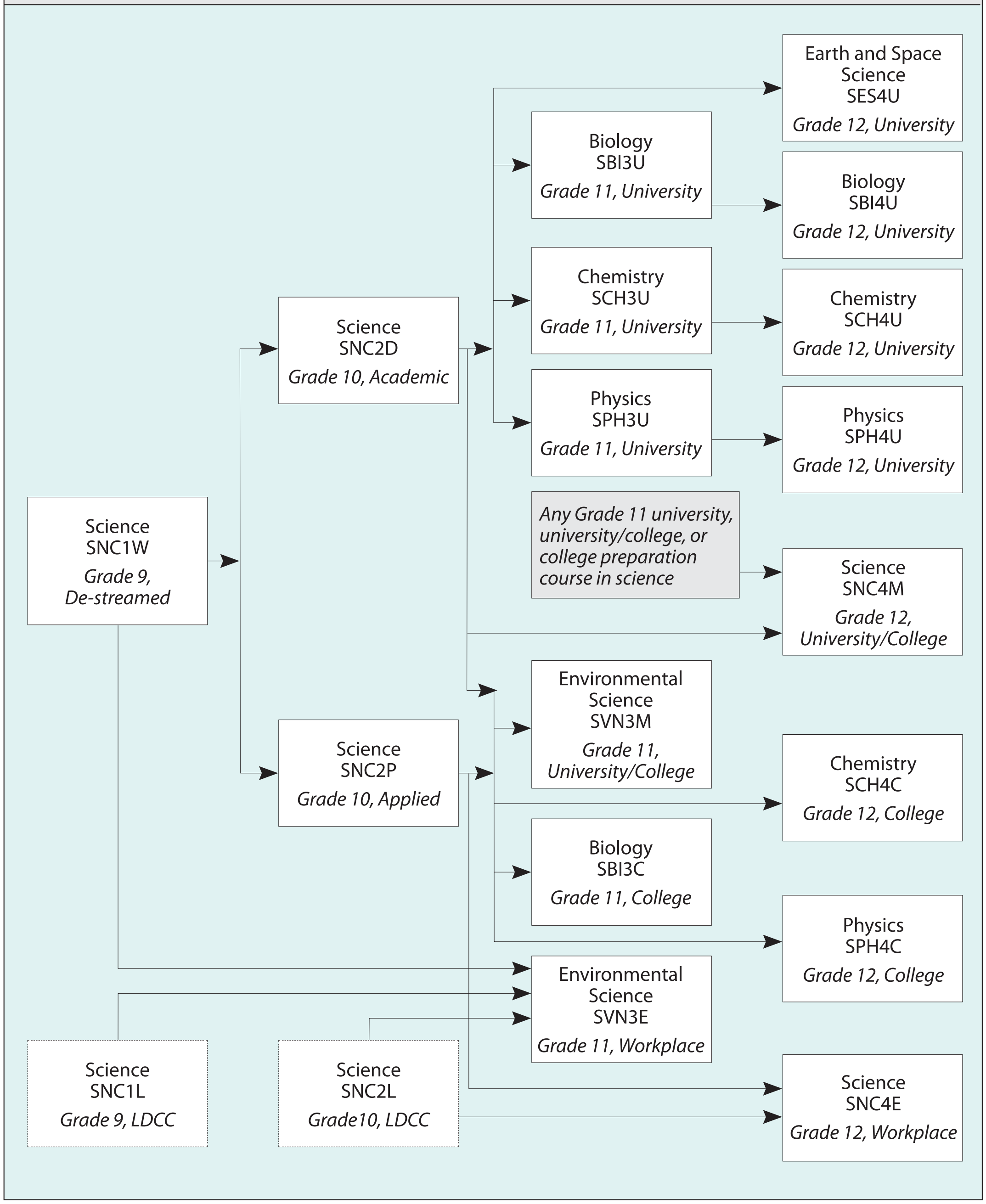
## Physics

| Grade | Course Name | Course Type | Course Code | Prerequisite |
|---|---|---|---|---|
| 11 | Physics | University | SPH3U | Grade 10 Science, Academic |
| 12 | Physics | University | SPH4U | Grade 11 Physics, University |
| 12 | Physics | College | SPH4C | Grade 10 Science, Academic or Applied |

*Note:* Each of the courses listed above is worth one credit.

## 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:* LDCC – locally developed compulsory credit course (LDCC courses are not outlined in this curriculum.)

***Note:*** For students who completed any of the Grade 9 science courses prior to September 2022, refer to the prerequisite chart on page 13 of *The Ontario Curriculum, Grades 9 and 10: Science, 2008.*

## Half-Credit Courses

The course outlined in this curriculum is designed to be offered as a full-credit course. However, it may also be delivered as two half-credit courses. Half-credit courses, which require a minimum of fifty-five hours of scheduled instructional time, must 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.
- Students must successfully complete both parts of the course if it is to be used as a prerequisite for another course.
- 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 report all half-credit courses to the ministry annually in the School October Report.

# Curriculum Expectations

*The Ontario Curriculum, Grade 9: Science, 2022* identifies the expectations for the course and describes the skills and knowledge that students are expected to acquire, demonstrate, and apply in their class work and investigations, and in various other activities on which their achievement is assessed and evaluated.

***Mandatory learning is described in the overall and specific expectations of the curriculum.***

Two sets of expectations – overall expectations and specific expectations – are listed for each *strand*, or broad area of the curriculum, in Grade 9 science. The strands include Strand A: STEM Skills, Careers, and Connections and four other strands, lettered B, C, D and E. *Taken together, the overall and specific expectations represent the mandated curriculum*.

The *overall expectations* describe in general terms the skills and knowledge that students are expected to demonstrate by the end of the course. The *specific expectations* describe the expected skills and knowledge in greater detail. The specific expectations are organized 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). This organization is not meant to imply that the expectations in any one group are achieved independently of the expectations in the other groups, nor is it intended to imply that the learning associated with the expectations happens in a linear, sequential way. The numbered headings are used merely as an organizational structure to help teachers focus on particular aspects of knowledge, concepts, and skills as they develop various lessons and learning activities for students.

In the Grade 9 science course, the overall expectations outline the fundamental concepts and skills that are required for students to become scientifically literate global citizens. The curriculum focuses on connecting, developing, reinforcing, and refining the knowledge, concepts, and skills that students acquire as they work towards meeting the overall expectations in the course. This approach reflects and accommodates the progressive nature of development of knowledge, concepts, and skills in science learning. In the course, the two overall expectations in each strand are developed in related sets of specific expectations.

### Teacher Supports

Specific expectations are accompanied by supports such as examples and/or instructional tips.[2] The examples are meant to clarify the requirement specified in the expectation, illustrating the kind of skill or knowledge, the specific area of learning, the depth of learning, and/or the level of complexity that the expectation entails. The instructional tips suggest instructional strategies and authentic contexts for the effective modelling, practice, and application of scientific concepts. The examples and instructional tips are optional supports that teachers can draw on to support teaching and learning, in addition to developing their own supports 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 be inclusive and, wherever possible, reflect the diversity of the student population and the population of the province.

## Fundamental Concepts and “Big Ideas” in Science

This course provides numerous opportunities for students to develop essential STEM skills and make important connections that will allow them to deepen their understanding of the fundamental concepts and big ideas of science. The fundamental concepts in science provide a framework for the development of scientific knowledge. They also help students to integrate scientific knowledge with knowledge in other subject areas, such as technological education, mathematics, geography, and the arts. The fundamental concepts that are addressed in the Ontario science curriculum are matter, energy, systems and interactions, structure and function, sustainability and stewardship, and change and continuity. These fundamental concepts are described in the following chart.

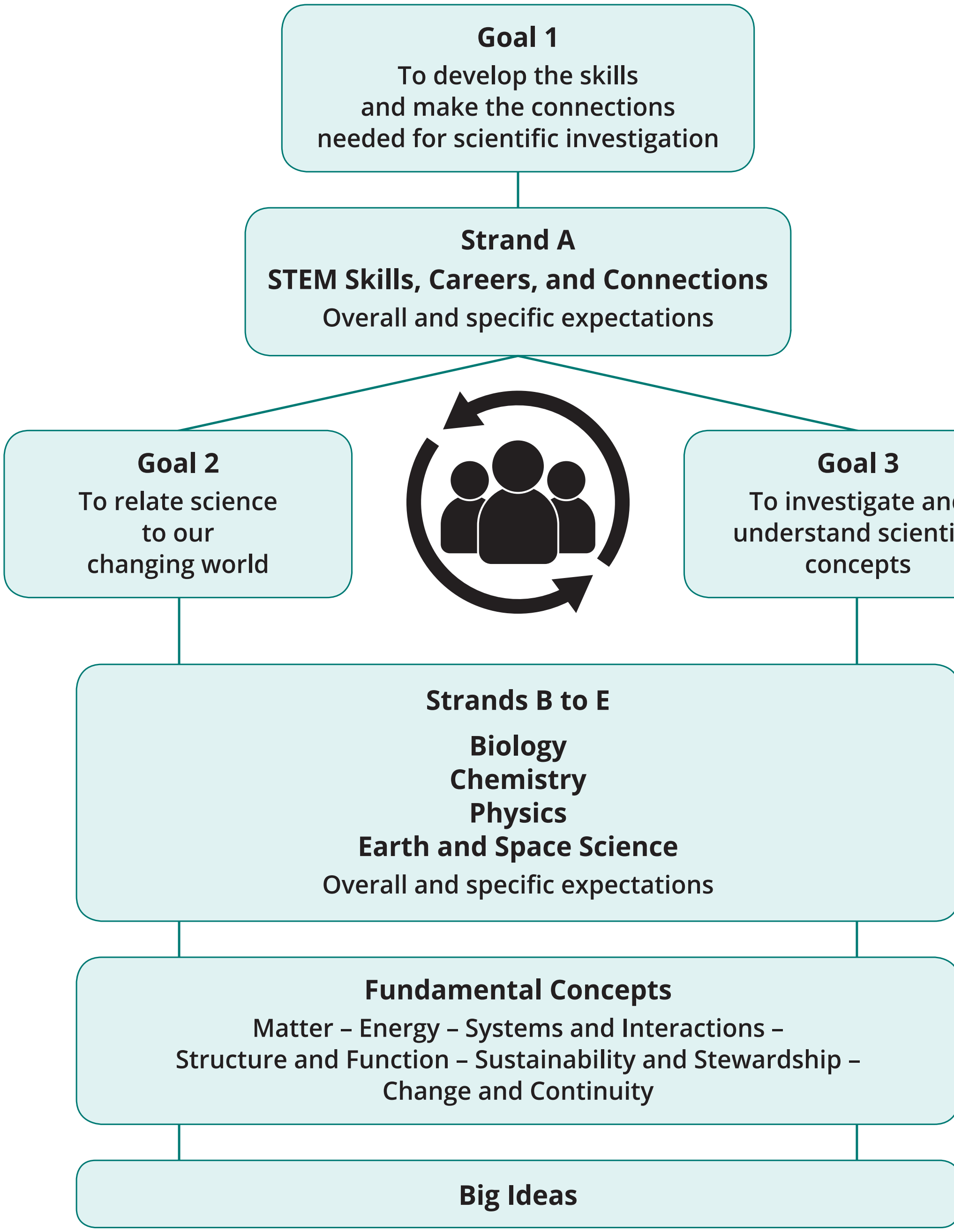
| Fundamental Concepts | |
|---|---|
| **Matter** | Matter is anything that has mass and occupies space. Matter has particular structural and behavioural characteristics. |
| **Energy** | Energy comes in many forms, and can change forms. Energy is required to make things happen (to do work). Work is done when a force causes movement. |

[2] The teacher supports will be made available at a later date, after the issuing of the curriculum expectations and the curriculum context.

| | |
|---|---|
| **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-made 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. 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 as follows: using non-renewable resources with care; reusing and recycling what we can; and 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. |

In this course, "big ideas" describe the aspects of the fundamental concepts that are addressed in each strand. Developing an understanding of the big ideas requires students to consider and apply STEM skills as they engage in investigative processes and make connections between related scientific concepts, between science and other disciplines, and between science and everyday life.

The relationships between the fundamental concepts, STEM skills and connections, big ideas, goals of the science program, and overall and specific expectations of this curriculum are indicated in the following chart.




## Big Ideas

### Biology

- Environmental sustainability depends on the dynamic equilibrium of ecosystems.

- The cycling of matter and flow of energy within and between Earth’s four spheres are natural processes that help maintain balance in ecosystems.
- Human activities, including activities that contribute to climate change, impact environmental sustainability, and it is our collective responsibility to mitigate these impacts.

**Chemistry**

- Atoms are the building blocks of matter.
- There is a relationship between the atomic structure of elements, their properties, and the organization of the periodic table.
- Elements and compounds have specific physical and chemical properties, which determine their uses.
- The use of elements and compounds in consumer products and chemical technologies has both positive and negative impacts on society, the economy, and the environment.

**Physics**

- The distinct properties of static and current electricity can be explained by the behaviour of electric charges.
- Electrical energy can be produced from renewable and non-renewable sources and converted to other forms of energy to meet various needs.
- The production and consumption of electrical energy has social, economic, and environmental impacts that can be addressed through sustainable practices.

**Earth and Space Science**

- The solar system and the universe have various components with distinct characteristics that can be investigated and quantified.
- The Sun plays a critical role in sustaining life on Earth and in contributing to renewable energy production.
- Space observation, space exploration, and associated space exploration technologies advance our understanding of the universe, and have social, economic, and environmental impacts.

## The Strands and Topics in the Grade 9 Science Course

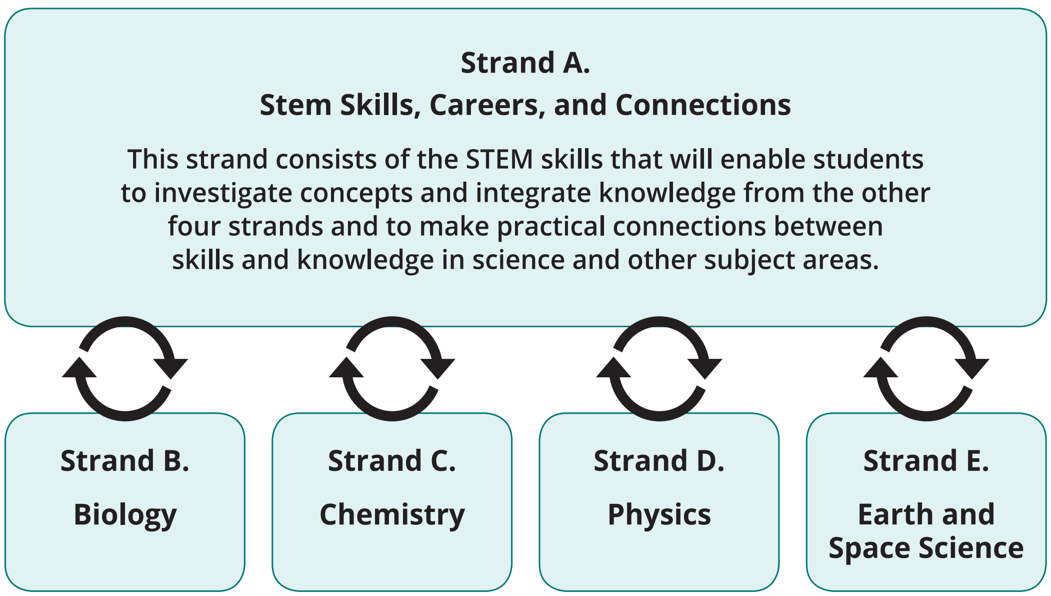
The expectations in the science curriculum are organized into five distinct but related strands. Strand A is an overarching strand that focuses on the STEM skills and connections that will enable students to investigate concepts and integrate knowledge from each of the other strands and to make connections between science and other subject areas. This strand also encourages students to examine various STEM-related careers, including skilled trades. In Strands B through E, students integrate Strand A expectations as they develop their understanding of strand-specific concepts, investigate phenomena, and make meaningful connections to the real world.

Throughout the course, learning related to the expectations in Strand A occurs in the context of learning related to the other four strands.

The five strands are as follows:

- A. STEM Skills, Careers, and Connections
- B. Biology
- C. Chemistry
- D. Physics
- E. Earth and Space Science

The chart below illustrates the relationship between Strand A and the other four strands.




## Strand A – STEM Skills, Careers, and Connections

Strand A focuses on the STEM skills that will enable students to explore and investigate scientific concepts. Students apply these skills as they integrate knowledge from the other four strands and as they make connections between these skills, their scientific knowledge, real-world issues in science, and various STEM-related occupations, including skilled trades.

In this strand, students use scientific research, scientific experimentation, and engineering design processes to carry out investigations, design solutions to problems, develop a conceptual understanding of the science they are learning, and communicate their findings. Students also use coding to investigate and model scientific concepts and relationships. Through the planning and conducting of hands-on investigations, students apply knowledge and understanding of established health and safety procedures.

In Strand A, students design an experiment or a prototype to explore a problem relevant to a STEM-related occupation or skilled trade. Students continue to develop and apply scientific literacy skills to examine local and global social and environmental issues, and assess how the development and application of science is influenced by social, economic, and cultural contexts. Students analyse the contributions to science by people with diverse lived experiences and from various communities and have the opportunity to learn about Indigenous sciences and to make connections to First Nations, Métis, and Inuit knowledge systems and perspectives.

## Strand B – Biology

In this strand, students develop an understanding of sustainable ecosystems and how sustainability is related to various ecological factors and processes, such as biodiversity, air and water quality, and soil health. Students assess how human activities impact the environment, including how they contribute to climate change, and explore ways to address some of the impacts. Students investigate the flow of energy and the cycling of matter in the environment and the importance of these natural processes in maintaining a dynamic equilibrium in ecosystems.

## Strand C – Chemistry

In this strand, students explore the relevance of chemistry to their daily lives by investigating the use and safe disposal of various elements and compounds. Additionally, they assess the impacts of chemical processes and technologies on society and the environment. Students investigate the nature of matter by studying properties of elements and compounds, the structure of atoms, and the relationship between the atomic structure of elements and the organization of the periodic table.

## Strand D – Physics

In this strand, students develop an understanding of the impacts of electrical energy production and consumption on society, the environment, and the economy, and explore ways to achieve sustainable practices. Students also investigate the nature of electric charges, including properties of static and current electricity, and explain the relationships between various electrical quantities.

## Strand E – Earth and Space Science

In this strand, students investigate the impacts of space exploration on society, the environment, and the economy, and the importance to society of technological innovations resulting from space exploration. Students also learn about the components of the solar system and the universe and the Sun’s relationship to processes on Earth.

## Topics in Grade 9 Science

Strands B through E in the Grade 9 course cover the four major scientific subdisciplines – biology, chemistry, physics, and Earth and space science. 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 below provides an outline of the topics in Grade 9 science, and also shows their broad connections to the science and technology curriculum for Grades 6 to 8.

### Topics in Science and Technology, Grades 6–8, and Topics in Science, Grade 9

| | | | | |
|---|---|---|---|---|
| | **STEM Skills and Connections** | | | |
| | **STEM Investigation and Communication Skills<br>Coding and Emerging Technologies<br>Applications, Connections, and Contributions** | | | |
| **Grade** | **Life Systems** | **Matter and Energy** | **Structures and Mechanisms** | **Earth and Space Systems** |
| **6** | Biodiversity | Electrical Phenomena, Energy, and Devices | Flight | Space |
| **7** | Interactions in the Environment | Pure Substances and Mixtures | Form, Function, and Design of Structures | Heat in the Environment |
| **8** | Cells | Fluids | Systems in Action | Water Systems |
| | **STEM Skills, Careers, and Connections** | | | |
| | **STEM Investigation Skills<br>Applications, Careers, and Connections** | | | |
| **Grade** | **Biology** | **Chemistry** | **Physics** | **Earth and Space Science** |
| **9** | Sustainable Ecosystems and Climate Change | The Nature of Matter | Characteristics and Applications of Electricity | Space Exploration |

# Scientific and Engineering Design Processes

In addition to developing knowledge related to specific concepts, the study of science offers students varied opportunities to learn skills that are relevant to their everyday world. Strand A is focused on such skills, and refers to the following three processes:

- a scientific research process
- a scientific experimentation process
- an engineering design process

The skills associated with these processes include:

- initiating and planning (e.g., asking questions, clarifying problems, planning procedures)
- performing and recording (e.g., following procedures, accessing information, recording observations and findings)
- analysing and interpreting (e.g., organizing data, reflecting on the effectiveness of actions performed, drawing conclusions)
- communicating (e.g., using appropriate vocabulary, communicating findings in a variety of ways)

## Scientific Processes

There are a variety of processes that are followed when investigating questions in a scientific manner. In scientific investigations, students engage in activities that allow them to develop knowledge and understanding of scientific ideas in much the same way that scientists do. Like scientists, students must develop skills in the two major processes of scientific investigations: research and experimentation. These two processes play an important role in the Grade 9 science course. Teachers should ensure that students engage often in these processes and consider ethical protocols when doing so, as they develop skills and knowledge in the other four strands of the course.

When planning scientific investigations, teachers should also consider the impact that emerging technologies are having on scientific processes, and how scientific processes have led to innovations and new technologies. For example, ongoing advances in technology are changing how data is obtained, processed, stored, and visualized, as well as how scientific knowledge is shared; at the same time, scientific discoveries related to materials and their use are being applied to the development of new technologies. In this context, teachers can make important connections between technology and science, showing how they are interrelated. They can encourage students to use technologies to support their scientific investigations, and students can consider how their research and experimentation findings relate to potential new technologies.

## Scientific Research Process

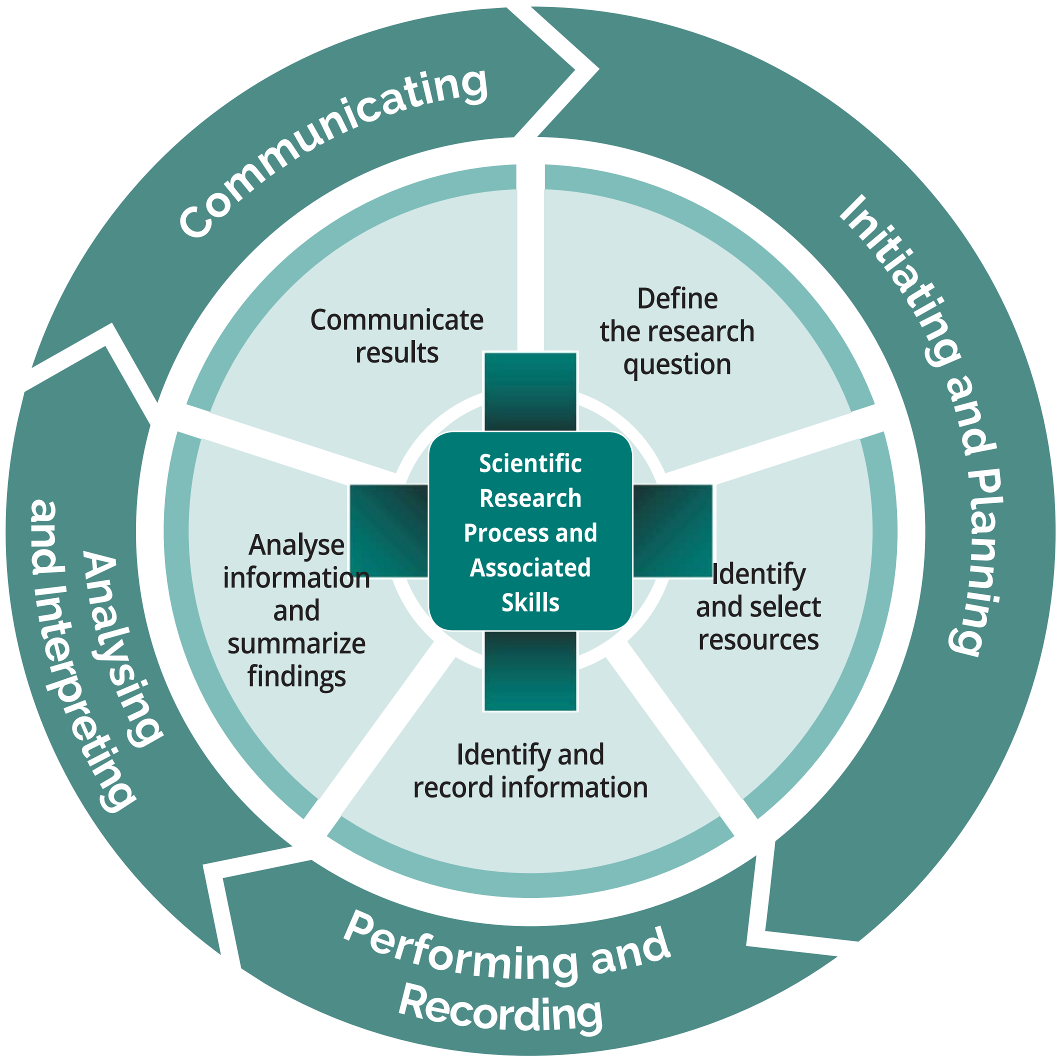
Scientific research includes both primary research, which is done through first-hand, direct observation of objects, living things, phenomena, and systems; and secondary research, which is done by reviewing the work and the findings of others. Research is a starting point for investigations, and it can also play a role during or after an experiment to support or build upon findings and observations.

Research does not always follow a linear path. New information or findings may lead students to refine their research question(s) or change the course of the intended research. This should not be a source of concern, as there are times when research proceeds in this manner, with new findings impacting the researcher and the research process itself.

The most appropriate entry points into a scientific research process, and the most appropriate components of the process to be focused on, may depend on student readiness. Prior experience and knowledge, as well as access to resources, the context of the learning, and the amount of time available, may also be factors. For these reasons, educators may need to provide multiple entry points to engage all students in the learning.

Considering the vast and ever-increasing number of sources of information available today, students need to be aware of how to find and identify appropriate information during research. Critical-thinking skills are essential to assess the information gathered, in part by considering the biases, interests, and motivation of the authors, as well as the trustworthiness of the source or publisher. Students should also carefully consider how scientific knowledge is shared, whether in formal, peer-reviewed contexts or through less formal channels such as social media.

The following diagram summarizes the scientific research process and shows how its components relate to the skills of *initiating and planning; performing and recording; analysing and interpreting*; and *communicating.*




The components of a research process are described in more detail below. The process will not always be linear, and these components are meant as a general guide to the process.

***Initiating and Planning***

- **Define the research question**
    - develop several specific and concise research questions
    - select an appropriate research question for investigation
    - identify prior knowledge and experience related to the research question
    - identify key words
    - develop a work plan
    - consider resources available
- **Identify and select resources**

- identify various resources to consult
- consult the selected resources, by using various research tools and/or by visiting a library, museum, or other facility
- consider bias in the resources
- select relevant and appropriate resources

***Performing and Recording***

- **Identify and record information**
    - classify resources by subtopics
    - identify important data from the selected resources
    - identify important information, and record it in the form of notes, graphics, or illustrations or using audio and video formats
    - keep track of references for all resources

***Analysing and Interpreting***

- **Analyse information and summarize findings**
    - look for missing or conflicting ideas
    - rank the information according to its relevance
    - eliminate unnecessary data
    - consider bias in the data or on the part of the researcher
    - check whether the data answers the research question
    - answer the research question and write a summary

***Communicating***

- **Communicate results**
    - choose a form or medium for communication that is appropriate for the intended audience
    - choose the information to share, and develop a draft presentation or publication, using appropriate vocabulary
    - consider cultural, ethical, and other implications related to the communication of the work
    - review the draft, considering the audience's perspective, and edit as required
    - present or publish the work

## Scientific Experimentation Process

Experimentation involves performing various steps to test and validate or reject a hypothesis, as well as manipulating different variables in order to observe the results. It involves experiential, hands-on learning that engages and empowers students as they develop their investigation skills.

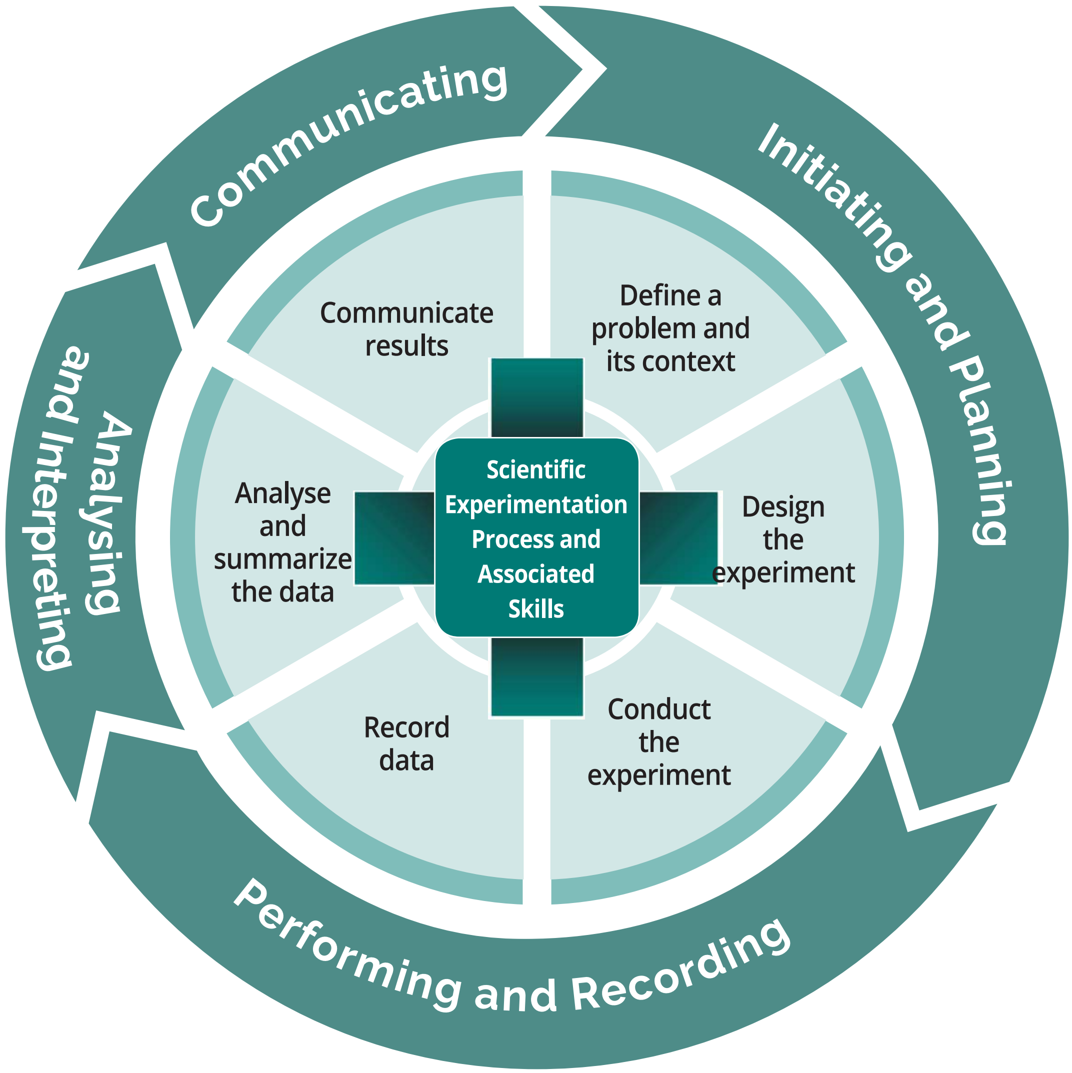
A process of experimentation is often iterative and may involve conducting *fair tests* to determine the effects of changing one factor in an experimental set-up. In a fair test, the student identifies variables that may affect the results of the experiment; selects one variable to be altered (tested) while keeping other variables constant; measures all trials in the same way; and repeats tests to determine the validity of the results. As part of their experimentation, students are encouraged to consider the concept of *fair tests*, and whether or not complete objectivity and the absence of bias is possible in science investigations.

As with the scientific research process described above, the most appropriate entry points into a scientific experimentation process, and the most appropriate components of the process to be focused on, may depend on student readiness. Prior experience and knowledge, as well as access to tools and equipment, the context of the learning, and the amount of time available may also be factors. Educators may therefore need to provide multiple entry points to engage all students in the learning. In any given classroom, students may demonstrate a wide range of strengths and needs. It is important that experiments are attuned to this diversity and include an integrated process that responds to the unique strengths and needs of each student.

It is important to have students conduct experiments in all strands, so that students can gain experience doing different types of experiments in different contexts. This also ensures that students are provided with hands-on, experiential, and exciting ways to uncover a broad range of scientific concepts. The experiments can be small or large, guided by the teacher or student-led. They can be designed to consolidate existing skills and knowledge or to introduce new skills and develop new knowledge.

Students should follow established experimental and health and safety procedures. They should also be guided to eventually develop their own experimental procedures, keeping health and safety in mind.

The following diagram summarizes the scientific experimentation process and shows how its components relate to the skills of *initiating and planning; performing and recording; analysing and interpreting*; and *communicating.*




Components of this experimentation process are described in more detail below. The process will not always be linear, and these components are meant as a general guide to the process.

***Initiating and Planning***

- **Define a problem and its context**
    - identify and review resources related to an area of investigation
    - consider questions related to the area of investigation
    - define a specific problem, and identify what is to be investigated
    - formulate a hypothesis or consider expected results
- **Design the experiment**
    - clearly define the steps of the experiment
    - identify the materials, equipment, and health and safety precautions needed

    - consider the variables that will remain constant and those that will be changed
    - identify the data to be collected

***Performing and Recording***

- **Conduct the experiment**
    - carry out the experiment, paying close attention to the designed steps
    - follow all procedures and processes related to health and safety and environmental sustainability
- **Record data**
    - consider the potential type of data to be obtained
    - consider how to best record, organize, and represent the data
    - record clear and precise data

***Analysing and Interpreting***

- **Analyse and summarize the data**
    - perform any required calculations
    - represent the data, using appropriate forms
    - explain the result obtained based on the data
    - review the identified resources, considering the results from the experiment
    - develop a clear and concise conclusion based on a summary of the data
    - consider sources of error and how to minimize these sources of error in future experiments

***Communicating***

- **Communicate results**
    - choose a form or medium for communication that is appropriate for the intended audience
    - choose the information to share, and develop a draft presentation or publication, using appropriate vocabulary
    - review the draft, considering the audience’s perspective, and edit as required
    - present or publish the work

## Engineering Design Process

An engineering design process (EDP) provides a framework for students and teachers as they plan and build solutions to problems or develop ways to address needs that connect to the curriculum and the world around them. An EDP recognizes that twenty-first-century science problems can be complex and sometimes ambiguous, and provides appropriate, purposeful stages to navigate these challenges.

Like the two scientific processes described above, an EDP is an iterative process that may involve students revisiting a prior stage as they acquire new information about the problem being investigated, or as they acquire a better understanding of the person or people for whom they are designing a solution. Students may even restart, or repeat, the entire process when one approach proves unsuccessful. This should be seen as an important and necessary part of learning and design in science.

Since students will be seeking solutions to problems that will impact others, ethical issues as well as the perspectives and needs of a variety of individuals and communities should be considered throughout the process. Students can conduct interviews with end-users, or they can research individuals or communities that may be affected by potential solutions. Their approach should be empathetic, and students should consider various perspectives, as well as factors such as usability and environmental sustainability, throughout the process.

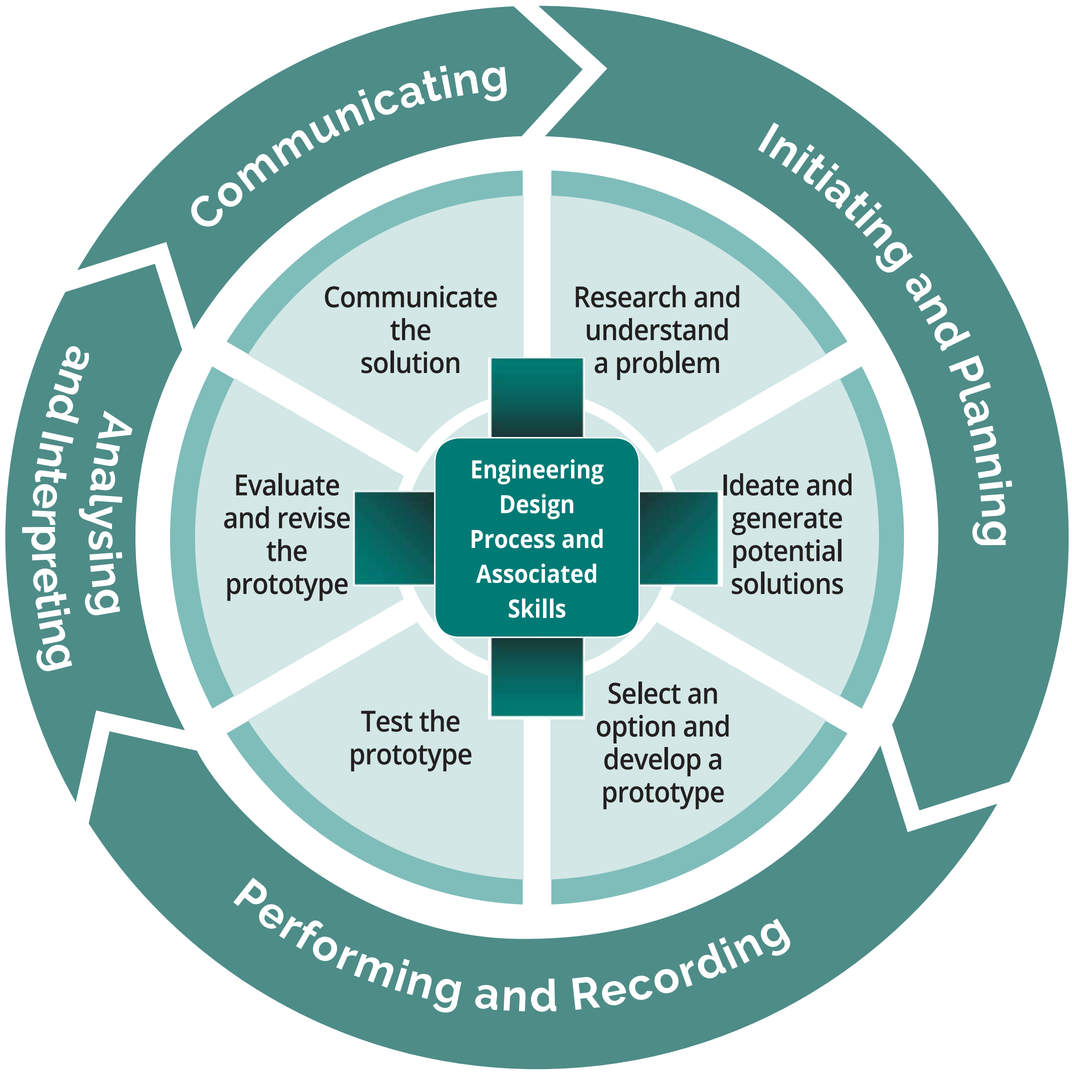
The EDP described below involves students initiating and planning solutions, performing tests and recording data, analysing and interpreting results, and communicating those results using appropriate vocabulary and forms for a variety of purposes. The end product of the EDP might not be a tangible object; it might instead be a computer simulation or a model, or even a new scientific process or system.

As with scientific processes, there is no single EDP, but rather a range of engineering practices that are followed when designing solutions or developing projects. Students and teachers may find the need to emphasize specific aspects of the EDP provided, or to make substitutions with components of processes that they may find elsewhere. Students and teachers may even find other EDPs that they may want to work with, and a comparison of various processes may prove beneficial for students and teachers.

Appropriate entry points into the EDP and the specific components of the process that are focused on may depend on student readiness. Prior experience and knowledge, as well as access to resources, the context of the learning, and the amount of time available, may also be factors; therefore, educators may need to provide multiple entry points to engage all students in the learning.

The EDP provided here allows students to engage with important scientific concepts and skills within curriculum expectations as they develop the transferable skills and cross-curricular concepts that embody STEM education.

The following diagram summarizes the EDP and shows how its components relate to the skills of *initiating and planning; performing and recording; analysing and interpreting*; and *communicating.*




Components of this EDP are described in more detail below. The process will not always be linear, and these components are meant as a general guide to the process.

***Initiating and Planning***

- **Research and understand a problem**
    - identify and review resources related to a problem
    - identify the users affected by the problem
    - conduct interviews with those affected by the problem
    - listen closely to those affected by the problem and use empathy to understand their experiences, perspectives, and concerns
    - review related problems and solutions to these problems
    - identify issues related to sustainability and to health and safety

- **Ideate and generate potential solutions**
    - brainstorm several ideas and potential solutions
    - review potential solutions, considering related research, problems, and solutions
    - develop specific success criteria and constraints, and evaluate potential solutions based on these criteria and constraints
    - consider the end-users and those impacted by potential solutions, taking into consideration their experiences, perspectives, and concerns
    - consider applying related and existing solutions (or some aspects of them) to the identified problem
    - consider developing new solutions that are different from existing solutions
    - refine or combine potential solutions

***Performing and Recording***

- **Select an option and develop a prototype**
    - select the most appropriate solution, based on established criteria
    - plan the design of the solution, considering the required stages as well as available materials, equipment, and time
    - consider the economic, environmental, ethical, and health and safety concerns related to the potential design
    - consider the key components of the design, and ensure that they can be effectively produced
    - construct a prototype of the design
- **Test the prototype**
    - develop tests to evaluate the solution
    - conduct tests in a variety of contexts, including in controlled and in real-world environments and with various potential users
    - record observations and data
    - obtain feedback on the prototype from others, including teachers, classmates, friends, family members, and/or community members

***Analysing and Interpreting***

- **Evaluate and revise the prototype**
    - analyse results from testing to determine what changes should be made to the prototype to enhance the end-user experience
    - considering the results of testing, review initial resources, existing knowledge, and other brainstormed ideas to improve upon the design
    - consider additional components, materials, equipment, or time needed
    - refine the prototype to develop a finished product

***Communicating***

- **Communicate the solution**
  - choose a form or medium for communication that is appropriate for the intended audience
  - identify the important information and components of the solution or project to share, and develop a draft or plan for the presentation or demonstration, using appropriate vocabulary
  - consider issues that might arise during the presentation or demonstration, and minimize their risk
  - review drafts and plans, considering the audience's perspective, and make changes as required
  - present or finalize the design or solution

# Program Planning and Cross-Curricular and Integrated Learning in Science

Educators consider many factors when planning a science program that cultivates the best possible environment in which all students can maximize their learning. This section highlights important areas of focus that educators should consider, including areas of cross-curricular and integrated learning, as they plan effective and inclusive science programs. In addition, all of the general "Program Planning" sections on this site apply to this curriculum.

## Instructional Approaches in Science

Effective science instruction in the Grade 9 de-streamed science course begins with knowing the complex identities and profiles of the students, having high academic expectations for and of all students, providing supports when needed, and believing that all students can learn and do science. Teachers incorporate culturally responsive and relevant pedagogy (CRRP) and provide authentic learning experiences to meet individual students' learning strengths and needs. Effective science instruction focuses on the development of conceptual understanding and takes place in a safe and inclusive learning environment, where all students are valued, empowered, engaged, and able to take risks.

Learning should be relevant: embedded in the lived realities of all students and inspired by authentic, real-life contexts as much as possible. This approach allows students to develop key scientific concepts and skills, to appreciate the beauty and wide-ranging nature of science, and to realize the potential of science to raise awareness and effect social change that is innovative and sustainable. A focus on making learning relevant supports students in their use of scientific reasoning to make connections throughout their lives.

### Universal Design for Learning (UDL) and Differentiated Instruction (DI)

Students in every science classroom vary in their identities, lived experiences, personal interests, learning profiles, and readiness to learn new concepts and skills. Universal Design for Learning (UDL) and differentiated instruction (DI) are robust and powerful approaches to designing assessment and instruction to engage all students in scientific tasks that develop conceptual understanding. UDL and DI can be used in combination to help teachers respond effectively to the strengths and needs of all students.

The aim of the UDL framework is to assist teachers in designing science programs and environments that provide all students with equitable access to the science curriculum. Teachers take into account students' diverse learner profiles by designing tasks that offer individual choice, ensuring relevance and authenticity, providing graduated levels of challenge, and fostering collaboration in the science classroom. Teachers also represent concepts and information in multiple ways to help students become resourceful and knowledgeable learners. For example, teachers use a variety of media to ensure that students are provided with alternatives for auditory and visual information. To support learners as they focus strategically on their learning goals, teachers create an environment in which learners can express themselves using a range of kinesthetic, visual, and auditory strengths. For example, teachers can vary ways in which students can respond and demonstrate their understanding of concepts, and support students in goal-setting, planning, and time-management skills related to their science learning.

Designing science tasks through UDL allows the learning to be "low floor, high ceiling" – that is, all students are provided with the opportunity to find their own entry point to the learning. Teachers can then support students in working at their own pace and provide further support as needed, while continuing to move student learning forward by using varied approaches and engaging students in learning tasks with varied levels of complexity and challenge. This is an inclusive approach that is grounded in a growth mindset: the belief that everyone can do well in science.

While UDL provides teachers with broad principles for planning science instruction and learning experiences for a diverse group of students, DI allows them to address specific skills and learning needs. DI is student centred and involves a strategic blend of whole-class, small-group, and individual learning activities to suit students' differing strengths, interests, and levels of readiness to learn. Attending to students' varied readiness for learning science is an important aspect of differentiated teaching. Learners who are ready for greater challenges need support in aiming higher, developing belief in excellence, and co-creating problem-based tasks to increase the complexity while still maintaining joy in learning. Students who are struggling to learn a concept need to be provided with the scaffolding and encouragement to reach high standards. To make certain concepts more accessible, teachers can employ strategies such as offering students choice, and providing open-ended problems that are based on relevant real-life situations and supported with visual and hands-on learning.

Universal Design for Learning and differentiated instruction are integral aspects of an inclusive science program and the achievement of equity in science education. More information on these approaches can be found in the ministry publication *Learning for All: A Guide to Effective Assessment and Instruction for All Students, Kindergarten to Grade 12* (2013).

## Health and Safety in Science Education

In Ontario, various laws, including the Education Act, the Occupational Health and Safety Act (OHSA), Ryan's Law (Ensuring Asthma Friendly Schools), 2015, and Sabrina's Law, 2005, collectively ensure that school boards provide a safe and productive learning and work environment for both students and employees. Under the Education Act, teachers are required to ensure that all reasonable safety procedures are carried out in the programs and activities for which they are responsible. Teachers should always model safe practices; communicate safety requirements to students in accordance with school board policies, Ministry of Education policies, and any applicable laws; and encourage students to assume responsibility for their own safety and the safety of others.

Concern for safety must be an integral part of instructional planning and implementation. Teachers are encouraged to review:

- their responsibilities under the Education Act;
- their rights and responsibilities under the Occupational Health and Safety Act;
- their school board's health and safety policy for employees;
- their school board's policies and procedures relating to student health and safety (e.g., those related to concussions, medical conditions such as asthma, outdoor education excursions);
- relevant provincial subject association guidelines and standards for student health and safety;
- any additional mandatory requirements, particularly for higher-risk activities (e.g., field trips, workplaces), including requirements for approvals (e.g., from the supervisory officer), permissions (e.g., from parents),[3] and/or qualifications.

Wherever possible, potential risks should be identified and procedures developed to prevent or minimize, and respond to, incidents and injuries. School boards provide and maintain safe equipment, facilities, materials, and tools as well as qualified instruction. In safe learning environments, teachers will:

- be aware of up-to-date safety information;
- plan activities with safety as a primary consideration;
- inform students and parents of risks involved in activities;
- observe students to ensure that they are following safe practices, including the wearing of personal protective equipment;
- have a plan in case of emergency;
- show foresight;
- act quickly.

[3] The word *parent(s)* is used on this website to refer to parent(s) and guardian(s). It may also be taken to include caregivers or close family members who are responsible for raising the child.

To carry out their responsibilities with regard to safety, it is important not only that teachers have concern for their own safety and that of students, but also that they have:

- the knowledge necessary to safely use the materials, tools, and procedures involved in science;
- 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.

*Note:* Teachers supervising students using power equipment such as drills, sanders, and saws need to have specialized training in handling such tools.

Students should be made aware that health and safety is everyone’s responsibility – at home; at school; in the community, including in the natural environment; and while visiting, and participating in experiential learning in, workplace settings. Teachers should ensure that students have the knowledge and skills needed for safe participation in all learning activities. Students must be able to demonstrate knowledge of the equipment, facilities, materials, and tools being used and the procedures necessary for their safe use.

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 safety and that of others.

An important part of scientific research, scientific experimentation, and engineering design processes is that students select appropriate equipment, materials, and tools for their investigations and designs. Schools and boards should collaborate to ensure that students have access to the necessary facilities, equipment, materials, and tools to support their learning and maintain a safe learning environment.

Learning outside the classroom, such as on field trips or during field studies, can provide a meaningful and authentic dimension to students’ learning experiences. Teachers must plan these activities carefully in accordance with their school board’s relevant policies and procedures and in collaboration with other school board staff (e.g., the principal, outdoor education lead, supervisory officer) to ensure students’ health and safety.

The information provided in this section is not exhaustive. Teachers are expected to follow all school board health and safety policies and procedures.

# Coding and the Impact of Emerging Technologies

## Coding Concepts and Skills

Strand A, STEM Skills, Careers, and Connections, includes expectations related to the application of coding concepts and skills that are to be integrated across the other four strands. This allows students to explore a wide variety of scientific concepts and contexts through coding, while also learning valuable skills related to the automation and control of systems.

In Grade 9 science, coding is to be integrated across the strands as a means of providing the following:

- a hands-on, experiential way to learn about scientific concepts. For example, students can create models or simulations and then alter their components to see how the changes affect the system. This approach gives students a better understanding of both the system itself and the scientific concepts involved;
- a hands-on, experiential way to do science. For example, students can obtain data from sensors and use coding concepts and skills to analyse experimental data, draw conclusions, and solve scientific problems;
- a hands-on, experiential way to demonstrate their learning. For example, students can program automated digital stories, dioramas, presentation components, or interactive museum displays to showcase their skills and knowledge and to teach others about scientific concepts in an engaging and interactive way;
- a hands-on, experiential way to learn about the digital world around them. For example, students can learn about algorithms and automation and can develop an understanding of how social media, autonomous cars, artificial intelligence, and other digital technologies are programmed. Digital technologies are demystified as students develop an understanding of the foundational instructions that program our digital world;
- an opportunity to share and take pride in their work. For example, after students have programmed a computer, they can share their project with their classmates, peers, family, and/or community members. This gives them an opportunity to connect with others in a science context;
- an opportunity for agency in their science learning. For example, the coding context provides students with multiple entry points and multiple directions to take, allowing them to be creative and innovative as they design and build scientific solutions, and as they imagine what might be possible in the future;
- an opportunity for students to realize that they can shape the future in a positive way. For example, while students are accustomed to using digital technologies, they learn through coding that they also have the opportunity to develop these technologies and create change.

Teachers may find it valuable to connect coding expectations with an engineering design process (EDP), as the development of a coding project often requires a guiding design framework for which an EDP is very well suited. Students can define and research the specific science problem that they want to solve through coding and then generate ideas and select the best plan or program design. Coding environments allow for rapid ideating, prototyping, testing, and evaluating as students refine and debug their projects, projects, and as they connect these projects to entrepreneurial ventures or to solving problems in their communities. The finalizing and sharing stage of an EDP provides an exciting and enriching classroom and school experience where students can showcase their coding projects to classmates, peers, and/or the school community. Finally, students or teachers should find creative ways of archiving projects, through digital storage of code, photographs, or videos. Many students may want to keep these archived projects in a science portfolio.

It is important to note that the coding expectations in Grade 9 science build on the coding expectations in Grade 1 to 8 science and technology, and that these coding expectations complement the coding expectations in Grade 1 to 8 mathematics and in Grade 9 mathematics. Students and teachers will find that the skills and knowledge developed in one curriculum area will be supported in the other. By complementing each other, these expectations provide students with an in-depth exploration of coding concepts and skills within science, science and technology, and mathematics, which speaks to coding's cross-curricular nature and its application in a wide variety of STEM fields.

### The Impact of Emerging Technologies

The science curriculum includes learning related to the impact of emerging technologies on everyday life and in various STEM-related careers, including the skilled trades. This is an engaging topic that can capture the imagination of students as they consider exciting innovations in science across all subdisciplines of science, and as they imagine a hopeful future. This topic also provides students with an opportunity to critically assess technologies and to consider issues surrounding accessibility, privacy, appropriate use, bias, ethical design, and environmental sustainability.

Teachers and students may want to investigate emerging technologies, such as artificial intelligence and automation, that impact a wide range of areas and disciplines, including careers. They may also want to explore emerging technologies in specific areas, such as sustainable agricultural practices, green chemistry, electrical energy production and storage, and space exploration.

Students will assess the impact of emerging technologies on their own lives and the lives of others, in fields of study within science, and on related careers. In doing so, students can use a critical lens when investigating important environmental and societal issues related to science, and can be optimistic and excited about the future. This learning also provides an opportunity for students to see themselves working with and further developing these emerging technologies in the future.

## Skilled Trades

A skilled trade is a career path that requires hands-on work and specialty knowledge. Skilled trades workers apply scientific concepts as they build and maintain infrastructure like our homes, schools, hospitals, roads, water treatment plants, power stations, farms, and parks. They keep industries running and perform many services that we rely on every day, such as hairstyling, plumbing, food preparation, and social services. There is a wide variety of skilled trades in Ontario, falling under the sectors of construction, industrial, motive power, and service.

Throughout the science curriculum, students will describe practical applications of scientific concepts in their home and community. These expectations provide opportunities for students to learn about science, technology, and innovation related to the skilled trades. In addition, a number of scientific concepts within the Biology, Chemistry, Physics, and Earth and Space Science strands relate directly to the creative and critical-thinking, problem-solving, and hands-on work essential to the skilled trades. Educators are encouraged to help students make these important connections, as they provide students with authentic, meaningful, and hands-on experiences and activities that connect directly to their lives and communities. Educators are also encouraged to provide students with valuable experiential learning opportunities that connect students with role models with diverse lived experiences. Classroom presentations given by guest speakers from under-represented populations, such as women engaged in the skilled trades, may provide an excellent opportunity to do so.

The secondary technological education curriculum includes broad-based areas of learning that relate to many skilled trades, and it is important that students become aware of and exposed to the skilled trades and apprenticeship as a potential pathway.

## Climate Change

Climate change is an important topic addressed in age-appropriate learning throughout the strands of the science course. While climate change concepts and discussions address important environmental concerns, it is important to also foster hope and optimism in teaching and learning about climate change and other environmental issues. Students will develop the skills and knowledge needed to understand the causes and potential innovative solutions and mitigation strategies related to climate change and other environmental issues, and how they can make the most environmentally responsible decisions possible, given the choices they have.

# Assessment and Evaluation of Student Achievement

*Growing Success: Assessment, Evaluation, and Reporting in Ontario Schools, First Edition, Covering Grades 1 to 12, 2010* sets out the Ministry of Education's assessment, evaluation, and reporting policy. The policy aims to maintain high standards, improve student learning, and benefit all students, parents,[4] and teachers in elementary and secondary schools across the province. Successful implementation of

[4] The word *parent(s)* is used on this website to refer to parent(s) and guardian(s). It may also be taken to include caregivers or close family members who are responsible for raising the child.

this policy depends on the professional judgement[5] of teachers at all levels as well as their high expectations of all students, and on their ability to work together with and to build trust and confidence among parents and students.

Major aspects of assessment, evaluation, and reporting policy are summarized in the main "Assessment and Evaluation" section. The key tool for assessment and evaluation in science – the achievement chart – is provided below.

## Culturally Responsive and Relevant Assessment and Evaluation in Science

Culturally responsive and relevant pedagogy (CRRP) reflects and affirms students' racial and social identities, languages, and family structures. It involves careful acknowledgement, respect, and understanding of the similarities and differences among students, and between students and teachers, in order to respond effectively to student thinking and promote student learning.

Engaging in assessment from a CRRP stance requires that teachers gain awareness of and reflect on their own beliefs about who a science learner is and what they can achieve (see the questions for consideration provided below). In this process, teachers engage in continual self-reflection – and the critical analysis of various data – to understand and address the ways in which teacher identity and bias affect the assessment and evaluation of student learning. Assessment from a CRRP stance starts with having a deep knowledge of every student and understanding of how they learn best.

The primary purpose of assessment is to improve student learning. Assessment *for* learning creates opportunities for teachers to intentionally learn about each student and their sociocultural and linguistic background in order to gather a variety of evidence about their learning in a way that is reflective of and responsive to each student's strengths, experiences, interests, and cultural ways of knowing. Ongoing descriptive feedback and responsive coaching for improvement are essential for improving student learning.

Teachers engage in assessment *as* learning by creating ongoing opportunities for all students to develop their capacity to be confident, independent, autonomous learners who set individual goals, monitor their own progress, determine next steps, and reflect on their thinking and learning in relation to learning goals and curriculum expectations. One way in which teachers differentiate assessment is by providing tasks that allow multiple entry points for all students to engage and that enable all students to access complex science.

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[5] "Professional judgement", as defined in *Growing Success* (p. 152), is "judgement that is informed by professional knowledge of curriculum expectations, context, evidence of learning, methods of instruction and assessment, and the criteria and standards that indicate success in student learning. In professional practice, judgement involves a purposeful and systematic thinking process that evolves in terms of accuracy and insight with ongoing reflection and self-correction".

Assessment *of* learning is used by the teacher to summarize learning at a given point in time. This summary is used to make judgements about the quality of student learning on the basis of established criteria, to assign a value to represent that quality, and to support the communication of information about achievement to each student, parents, teachers, and others.

The evidence that is collected about student learning, including observations and conversations as well as student products, should reflect and affirm the student's lived experiences within their school, home, and community, learning strengths, and scientific knowledge. This process of triangulating evidence of student learning allows teachers to improve the accuracy of their understanding with respect to how each student is progressing in their learning.

When teachers engage in the process of examining their own biases regarding classroom assessment and evaluation practices, they might consider some of the following questions:

- Are the tasks accessible to, and inclusive of, all learners? Do the tasks include appropriate and varied entry points for all students?
- Do the tasks connect to students' prior learning and give them opportunities to be sense makers and to integrate their new learning? Do the selected tasks reflect students' identities and lived experiences?
- Do all students have equitable access to the tools they need to complete the tasks being set?
- What opportunities can teachers build into their practice to offer students descriptive feedback to enhance learning? Are graded assessment tasks used in a way that complements the use of descriptive feedback for growth?
- How can information be conveyed about students' learning progress to students and parents in an ongoing and meaningful way?
- What is the purpose of assigning and grading a specific task or activity? Are student choice and agency considered?
- How do teacher biases influence decisions about what tasks or activities are chosen for assessment?

## The Achievement Chart for Grade 9 Science

The achievement chart identifies four categories of knowledge and skills and four levels of achievement in Grade 9 science. (For important background, see "Content Standards and Performance Standards" in the main Assessment and Evaluation section.)

| **Knowledge and Understanding –** Subject-specific content acquired in the course (knowledge), and the comprehension of its meaning and significance (understanding) | | | | |
|---|---|---|---|---|
| **Categories** | **50–59% (Level 1)** | **60–69% (Level 2)** | **70–79% (Level 3)** | **80–100% (Level 4)** |
| | The student: | | | |

| | | | | |
|---|---|---|---|---|
| **Knowledge of content** *(e.g., facts, terminology, definitions)* | 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 and problem-solving skills and/or processes | | | | |
| **Categories** | **50–59% (Level 1)** | **60–69% (Level 2)** | **70–79% (Level 3)** | **80–100% (Level 4)** |
| | The student: | | | |
| **Use of initiating and planning skills and strategies** *(e.g., formulating questions, identifying problems, developing hypotheses, scheduling, 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; examining different points of view; selecting tools, equipment, materials, and technology; observing; manipulating materials; 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, developing solutions, considering diverse perspectives)* | 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 | | | | |
| **Categories** | **50–59% (Level 1)** | **60–69% (Level 2)** | **70–79% (Level 3)** | **80–100% (Level 4)** |
| | The student: | | | |

| | | | | |
|---|---|---|---|---|
| **Expression and organization of ideas and information in oral, visual, and/or written forms** *(e.g., diagrams, models, articles, project journals, reports)* | 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 |
| **Communication for different audiences** *(e.g., peers, adults, community members)* **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, formulas, SI units)* | uses conventions, vocabulary, and terminology with limited effectiveness | uses conventions, vocabulary, and terminology with some effectiveness | uses conventions, vocabulary, and terminology with considerable effectiveness | uses conventions, vocabulary, and terminology with a high degree of effectiveness |
| **Application –** The use of knowledge and skills to make connections within and between various contexts | | | | |
| **Categories** | **50–59% (Level 1)** | **60–69% (Level 2)** | **70–79% (Level 3)** | **80–100% (Level 4)** |
| | The student: | | | |
| **Application of knowledge and skills** *(e.g., concepts and processes; procedures related to the safe use of tools, equipment, materials, and technology; 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 and technology, investigation skills)* **to new contexts** | transfers knowledge and skills to new contexts with limited effectiveness | transfers knowledge and skills to new contexts with some effectiveness | transfers knowledge and skills to new contexts with considerable effectiveness | transfers knowledge and skills to new contexts with a high degree of effectiveness |

| | | | | |
|---|---|---|---|---|
| **Making connections within and between various contexts** (*e.g., connections between sciences; connections to everyday and real-life situations; connections among concepts within science; connections involving use of prior knowledge and experience; connections among science and other disciplines, including other STEM [science, technology, engineering, and mathematics] subjects)* | makes connections within and between various contexts with limited effectiveness | makes connections within and between various contexts with some effectiveness | makes connections within and between various contexts with considerable effectiveness | makes connections within and between various contexts with a high degree of effectiveness |
| **Proposing courses of practical action to deal with problems relating to our changing world** | 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 |

## Criteria and Descriptors for Grade 9 Science

To guide teachers in their assessment and evaluation of student learning, the achievement chart provides “criteria” and “descriptors” within each of the four categories of knowledge and skills.

A set of criteria is identified for each category in the achievement chart. The criteria are subsets of the knowledge and skills that define the category. The criteria identify the aspects of student performance that are assessed and/or evaluated, and they serve as a guide to what teachers look for. In the Grade 9 science course, the criteria for each category are as follows:

***Knowledge and Understanding***

- knowledge of content (e.g., facts, terminology, definitions)
- 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 problems, developing hypotheses, scheduling, selecting strategies and resources, developing plans)
- use of processing skills and strategies (e.g., performing and recording; gathering evidence and data; examining different points of view; selecting tools, equipment, materials, and technology; observing; manipulating materials; 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, developing solutions, considering diverse perspectives)

***Communication***

- expression and organization of ideas and information in oral, visual, and/or written forms (e.g., diagrams, models, articles, project journals, reports)
- communication for different audiences (e.g., peers, adults, community members) 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, formulas, International System of Units)

***Application***

- application of knowledge and skills (e.g., concepts and processes; procedures related to the safe use of tools, equipment, materials, and technology; investigation skills) in familiar contexts
- transfer of knowledge and skills (e.g., concepts and processes, safe use of equipment and technology, investigation skills) to new contexts
- making connections within and between various contexts (e.g., connections between sciences; connections to everyday and real-life situations; connections among concepts within science; connections involving use of prior knowledge and experience; connections among science and other disciplines, including other STEM [science, technology, engineering, and mathematics] subjects)
- proposing courses of practical action to deal with problems relating to our changing world

Descriptors indicate the characteristics of the student's performance, with respect to a particular criterion, on which assessment or evaluation is focused. *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.

# Expectations by Strand

# A. STEM Skills, Careers, and Connections

*This strand focuses on science, technology, engineering, and mathematics (STEM) investigation skills, practical applications of science, connections between science and various careers, and contributions to the development of science from people* *with diverse lived experiences. The learning related to this strand takes place in the context of learning in the Biology, Chemistry, Physics, and Earth and Space Science strands.*

# Overall expectations

Throughout this course, in connection with the learning in the Biology, Chemistry, Physics, and Earth and Space Science strands, students will:

## A1. STEM Investigation Skills

apply scientific processes and an engineering design process in their investigations to develop a conceptual understanding of the science they are learning, and apply coding skills to model scientific concepts and relationships

# Specific expectations

Throughout this course, in connection with the learning in the other strands, students will:

A1.1 apply a scientific research process and associated skills to conduct investigations, making connections between their research and the scientific concepts they are learning

A1.2 apply a scientific experimentation process and associated skills to conduct investigations, making connections between their observations and findings and the scientific concepts they are learning

A1.3 apply an engineering design process and associated skills to design, build, and test devices, models, structures, and/or systems

A1.4 apply coding skills to investigate and to model scientific concepts and relationships

A1.5 apply their knowledge and understanding of safe practices and procedures, including the Workplace Hazardous Materials Information System (WHMIS), while planning and carrying out hands-on investigations

## A2. Applications, Careers, and Connections

analyse how scientific concepts and processes can be applied in practical ways to address real-world issues and in various careers, and describe contributions to science from people with diverse lived experiences

# Specific expectations

Throughout this course, in connection with the learning in the other strands, students will:

A2.1 design an experiment or a prototype to explore a problem relevant to a STEM-related occupation, such as a skilled trade, using findings from research

A2.2 describe how scientific innovations and emerging technologies, including artificial intelligence systems, impact society and careers

A2.3 analyse how the development and application of science is economically, culturally, and socially contextualized, by investigating real-world issues

A2.4 apply scientific literacy skills when investigating social and environmental issues that have personal, local, and/or global impacts

A2.5 analyse contributions to science by people from various communities, including communities in Canada

# B. Biology

## Sustainable Ecosystems and Climate Change

*In this strand, students integrate learning from Strand A as they investigate concepts, develop and apply skills, and make meaningful connections to their lives, their communities, and the environment.*

## Overall expectations

By the end of this course, students will:

### B1. Relating Science to Our Changing World

assess impacts of climate change on ecosystem sustainability and on various communities, and describe ways to mitigate these impacts

## Specific expectations

By the end of this course, students will:

B1.1 assess impacts of climate change on the sustainability of local and global ecosystems, describe local or global initiatives for combatting climate change, and identify solutions to address some of the impacts

B1.2 assess impacts of climate change on communities in Canada, including First Nations, Métis, and Inuit communities

B1.3 investigate and explain how sustainable practices used by various communities, including First Nations, Métis, and Inuit communities, reflect an understanding of the importance of the dynamic equilibrium of ecosystems

### B2. Investigating and Understanding Concepts

demonstrate an understanding of the dynamic and interconnected nature of ecosystems, including how matter cycles and energy flows through ecosystems

## Specific expectations

By the end of this course, students will:

B2.1 investigate interactions between the biosphere, hydrosphere, lithosphere, and atmosphere, and explain why these interactions are important for ecosystem sustainability

B2.2 explain how naturally occurring phenomena, including the cycling of matter and the flow of energy, contribute to the dynamic equilibrium within and between ecosystems

B2.3 compare and contrast the processes of cellular respiration and photosynthesis, and explain how their complementary relationship contributes to the dynamic equilibrium of ecosystems

B2.4 investigate factors and processes, including biodiversity, air and water quality, soil health, and succession, and explain how they contribute to ecosystem sustainability

B2.5 explain the effects of various human activities on the dynamic equilibrium of ecosystems

B2.6 identify and use various indicators of climate change to describe the impacts of climate change on local and global ecosystems, and analyse how human activities contribute to climate change

B2.7 explain how sustainable practices related to the cycling of matter and the flow of energy can be applied in agricultural innovations

# C. Chemistry

## The Nature of Matter

*In this strand, students integrate learning from Strand A as they investigate concepts, develop and apply skills, and make meaningful connections to their lives, their communities, and the environment.*

## Overall expectations

By the end of this course, students will:

### C1. Relating Science to Our Changing World

assess social, environmental, and economic impacts of the use of elements, compounds, and associated technologies

## Specific expectations

By the end of this course, students will:

C1.1 assess social, environmental, and economic impacts of processes associated with the life cycle of consumer products, considering the elements and compounds used to make them, and suggest ways to enhance positive impacts and/or minimize negative impacts

C1.2 analyse impacts of using emerging chemical technologies in various fields, including in the skilled trades, and assess factors that influence the development of these technologies

## C2. Investigating and Understanding Concepts

demonstrate an understanding of the nature of matter, including the structure of the atom, physical and chemical properties of common elements and compounds, and the organization of elements in the periodic table

## Specific expectations

By the end of this course, students will:

C2.1 investigate properties, changes, and interactions of matter that are important for the dynamic equilibrium of ecosystems and their sustainability

C2.2 research the role of experimental evidence in the development of various atomic models, and compare and contrast different models of the atom

C2.3 identify the location, relative mass, and charge of subatomic particles within an atom, using the Bohr-Rutherford model

C2.4 explain the relationship between the position of an element in the periodic table and the structure of its atoms, using models

C2.5 investigate the physical and chemical properties of elements, and use their findings to relate these properties to the organization of the periodic table, classify elements, and identify patterns in the periodic table

C2.6 investigate and describe physical and chemical properties of elements and compounds, including those that make up common household products

C2.7 describe the relationship between the structure of simple compounds and their chemical formulas

# D. Physics

## Principles and Applications of Electricity

*In this strand, students integrate learning from Strand A as they investigate concepts, develop and apply skills, and make meaningful connections to their lives, their communities, and the environment.*

# Overall expectations

By the end of this course, students will:

## D1. Relating Science to Our Changing World

assess social, environmental, and economic impacts of electrical energy production and consumption, and describe ways to achieve sustainable practices

# Specific expectations

By the end of this course, students will:

D1.1 assess social, environmental, and economic benefits and challenges resulting from the production of electrical energy from various sources

D1.2 evaluate how electrical energy production and consumption impact various communities locally or globally, and describe ways to achieve sustainable practices

D1.3 develop a plan of action to address a local or global electrical energy production or consumption issue, including strategies for energy conservation

D1.4 analyse social, environmental, and economic impacts of emerging technologies related to electrical energy production, consumption, storage, and conservation

## D2. Investigating and Understanding Concepts

demonstrate an understanding of the nature of electric charges, including properties of static and current electricity

# Specific expectations

By the end of this course, students will:

D2.1 conduct investigations to explain the behaviour of electric charges in static and current electricity, and to relate the observed behaviour to the properties of subatomic particles and atomic structure

D2.2 determine the conductivity of various materials by investigating their ability to hold or transfer electric charges

D2.3 identify the components of a direct current (DC) circuit and explain their functions, and identify electrical quantities, their symbols, and their corresponding International System of Units (SI) units

D2.4 investigate the relationships between electric current, potential difference, and resistance in electrical circuits, and develop a mathematical model to represent the relationships

D2.5 apply a mathematical model to calculate electric current, potential difference, and resistance in real-world situations

D2.6 construct series and parallel circuits to compare electric current, potential difference, and resistance in both types of circuits

D2.7 explain the difference between electricity and electrical energy

D2.8 determine the efficiency of various electrical devices that consume or produce electrical energy, and identify the energy transformations in each device

# E. Earth and Space Science

## Space Exploration

*In this strand, students integrate learning from Strand A as they investigate concepts, develop and apply skills, and make meaningful connections to their lives, their communities, and the environment.*

## Overall expectations

By the end of this course, students will:

### E1. Relating Science to Our Changing World

evaluate social, environmental, and economic impacts of space exploration and of technological innovations derived from space exploration

## Specific expectations

By the end of this course, students will:

E1.1 evaluate social, environmental, and economic impacts of space observation and exploration

E1.2 evaluate how space observation and exploration technologies contribute to our understanding of climate change, natural disasters, and other phenomena

E1.3 assess ways in which technological innovations related to space observation and exploration are applied in various fields, including their contributions to sustainable practices on Earth

### E2. Investigating and Understanding Concepts

demonstrate an understanding of the components, characteristics, and associated phenomena of the solar system and the universe, and the importance of the Sun to processes on Earth

## Specific expectations

By the end of this course, students will:

E2.1 describe the importance of the Sun and its characteristics, including its role in the solar system and in sustaining life on Earth

E2.2 explain how the Sun’s energy causes natural phenomena on Earth, and how these phenomena contribute to renewable energy production

E2.3 summarize observational evidence used to support theories about the origin and evolution of the universe and the solar system, considering diverse ways of knowing

E2.4 describe major components of the solar system and the universe and compare their characteristics

E2.5 quantify distances in the solar system and the universe by applying an understanding of relative distances and sizes and using appropriate units of measure

E2.6 conduct investigations to explain the causes of various astronomical phenomena that can be observed from Earth

# Information for Parents

A parent’s guide to Science, Grade 9 (2022)For informational purposes only, not part of official issued curriculum.
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# Resources

Sample Course Plans – Grade 9 Science, De-streamed (SNC1W), 2022

Key Changes – Grade 9 Science, De-streamed (SNC1W)

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