


# Atlantic Canada Science Curriculum

*New Brunswick  
Department of Education  
Educational Programs & Services Branch*

New  Nouveau  
**Brunswick**

## Science 9

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# CURRICULUM

**2002**

Additional copies of this document (*Science Grade 9*) may be  
obtained from the Instructional Resources Branch.

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## Foreword

The pan-Canadian *Common Framework of Science Learning Outcomes K to 12*, released in October 1997, assists provinces in developing a common science curriculum framework.

New science curriculum for the Atlantic Provinces is described in *Foundation for the Atlantic Canada Science Curriculum (1998)*.

This curriculum guide is intended to provide teachers with the overview of the outcomes framework for science education. It also includes suggestions to assist teachers in designing learning experiences and assessment tasks.

## Acknowledgements

The departments of Education of New Brunswick, Newfoundland and Labrador, Nova Scotia and Prince Edward Island gratefully acknowledge the collaborative effort of all teachers and other educators and stakeholders across Atlantic Canada who contributed to the development of the Grade 9 Science Curriculum.



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The placement of the units in this curriculum guide is not meant to suggest coverage sequence. Units can be covered in any order.



# Introduction

## Background

The curriculum described in *Foundation for the Atlantic Canada Science Curriculum* was planned and developed collaboratively by regional committees. The process for developing the common science curriculum for Atlantic Canada involved regional consultation with the stakeholders in the education system in each Atlantic province. The Atlantic Canada science curriculum is consistent with the framework described in the pan-Canadian *Common Framework of Science Learning Outcomes K to 12*.

## Aim

The aim of science education in the Atlantic provinces is to develop scientific literacy.

Scientific literacy is an evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem-solving, and decision-making abilities; to become lifelong learners; and to maintain a sense of wonder about the world around them. To develop scientific literacy, students require diverse learning experiences that provide opportunities to explore, analyse, evaluate, synthesize, appreciate, and understand the interrelationships among science, technology, society, and the environment.





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# Program Design and Components

## Learning and Teaching Science

What students learn is fundamentally connected to how they learn it. The aim of scientific literacy for all has created a need for new forms of classroom organization, communication, and instructional strategies. The teacher is a facilitator of learning whose major tasks include

- creating a classroom environment to support the learning and teaching of science
- designing effective learning experiences that help students achieve designated outcomes
- stimulating and managing classroom discourse in support of student learning
- learning about and then using students' motivations, interests, abilities, and learning styles to improve learning and teaching
- assessing student learning, the scientific tasks and activities involved, and the learning environment to make ongoing instructional decisions
- selecting teaching strategies from a wide repertoire

Effective science learning and teaching take place in a variety of situations. Instructional settings and strategies should create an environment that reflects a constructive, active view of the learning process. Learning occurs through actively constructing one's own meaning and assimilating new information to develop a new understanding.

The development of scientific literacy in students is a function of the kinds of tasks they engage in, the discourse in which they participate, and the settings in which these activities occur. Students' disposition towards science is also shaped by these factors. Consequently, the aim of developing scientific literacy requires careful attention to all of these facets of curriculum.

Learning experiences in science education should vary and should include opportunities for group and individual work, discussion among students as well as between teacher and students, and hands-on/minds-on activities that allow students to construct and evaluate explanations for the phenomena under investigation. Such investigations and the evaluation of the evidence accumulated provide opportunities for students to develop their understanding of the nature of science and the nature and status of scientific knowledge.

## Writing in Science

Learning experiences should provide opportunities for students to use writing and other forms of representation as ways to learning. Students, at all grade levels, should be encouraged to use writing to speculate, theorize, summarize, discover connections, describe processes, express understandings, raise questions, and make sense of new information using their own language as a step to the language of science. Science logs are useful for such expressive and reflective writing. Purposeful note making is an intrinsic part of learning in science, helping students better record, organize, and understand information from a variety of sources. The process of creating webs, maps, charts, tables, graphs, drawing, and diagrams to represent data and results helps students learn and also provides them with useful study tools.

Learning experiences in science should also provide abundant opportunities for students to communicate their findings and understandings to others, both formally and informally, using a variety of forms for a range of purposes and audiences. Such experiences should encourage students to use effective ways of recording and conveying information and ideas and to use the vocabulary of science in expressing their understandings. It is through opportunities to talk and write about the concepts they need to learn that students come to better understand both the concepts and related vocabulary.

Learners will need explicit instruction in, and demonstration of, the strategies they need to develop and apply in reading, viewing, interpreting, and using a range of science texts for various purposes. It will be equally important for students to have demonstrations of the strategies they need to develop and apply in selecting, constructing, and using various forms for communicating in science.

## **The Three Processes of Scientific Literacy**

An individual can be considered scientifically literate when he/she is familiar with, and able to engage in, three processes: inquiry, problem solving, and decision making.

### **Inquiry**

Scientific inquiry involves posing questions and developing explanations for phenomena. While there is general agreement that there is no such thing as the scientific method, students require certain skills to participate in the activities of science. Skills such as questioning, observing, inferring, predicting, measuring, hypothesizing, classifying, designing experiments, collecting data, analysing data, and interpreting data are fundamental to engaging in science. These activities provide students with opportunities to understand and practise the process of theory development in science and the nature of science.

### **Problem Solving**

The process of problem solving involves seeking solutions to human problems. It consists of proposing, creating, and testing prototypes, products, and techniques to determine the best solution to a given problem.

### **Decision Making**

The process of decision making involves determining what we, as citizens, should do in a particular context or in response to a given situation. Decision-making situations are important in their own right, and they also provide a relevant context for engaging in scientific inquiry and/or problem solving.

## Meeting the Needs of All Learners

*Foundation for the Atlantic Canada Science Curriculum* stresses the need to design and implement a science curriculum that provides equitable opportunities for all students according to their abilities, needs, and interests. Teachers must be aware, of and make adaptations to accommodate, the diverse range of learners in their class. To adapt instructional strategies, assessment practices, and learning resources to the needs of all learners, teachers must create opportunities that will permit them to address their various learning styles.

As well, teachers must not only remain aware of and avoid gender and cultural biases in their teaching; they must also actively address cultural and gender stereotyping (e.g., about who is interested in and who can succeed in science and mathematics). Research supports the position that when science curriculum is made personally meaningful and socially and culturally relevant, it is more engaging for groups traditionally underrepresented in science, and indeed, for all students.

While this curriculum guide presents specific outcomes for each unit, it must be acknowledged that students will progress at different rates.

Teachers should provide materials and strategies that accommodate student diversity, and should validate students when they achieve the outcomes to the best of their abilities.

It is important that teachers articulate high expectations for all students and ensure that all students have equitable opportunities to experience success as they work toward achieving designated outcomes. Teachers should adapt classroom organization, teaching strategies, assessment practices, time, and learning resources to address students' needs and build on their strengths. The variety of learning experiences described in this guide provide access for a wide range of learners. Similarly, the suggestions for a variety of assessment practices provide multiple ways for learners to demonstrate their achievements.

## Assessment and Evaluation

The terms **assessment** and **evaluation** are often used interchangeably, but they refer to quite different processes. Science curriculum documents developed in the Atlantic region use these terms for the processes described below.

**Assessment** is the systematic process of gathering information on student learning.

**Evaluation** is the process of analysing, reflecting upon, and summarizing assessment information, and making judgments or decisions based upon the information gathered.

The assessment process provides the data, and the evaluation process brings meaning to the data. Together, these processes improve teaching and learning. If we are to encourage enjoyment in learning for students now and throughout their lives, we must develop strategies to involve students in assessment and evaluation at all levels. When students are aware of the outcomes for which they are responsible and of the criteria by which their work will be assessed or evaluated, they can make informed decisions about the most effective ways to demonstrate their learning.

The Atlantic Canada science curriculum reflects the three major processes of science learning: inquiry, problem solving, and decision making. When assessing student progress, it is helpful to know some activities/skills/actions that are associated with each process of science learning. Student learning may be described in terms of ability to perform these tasks.

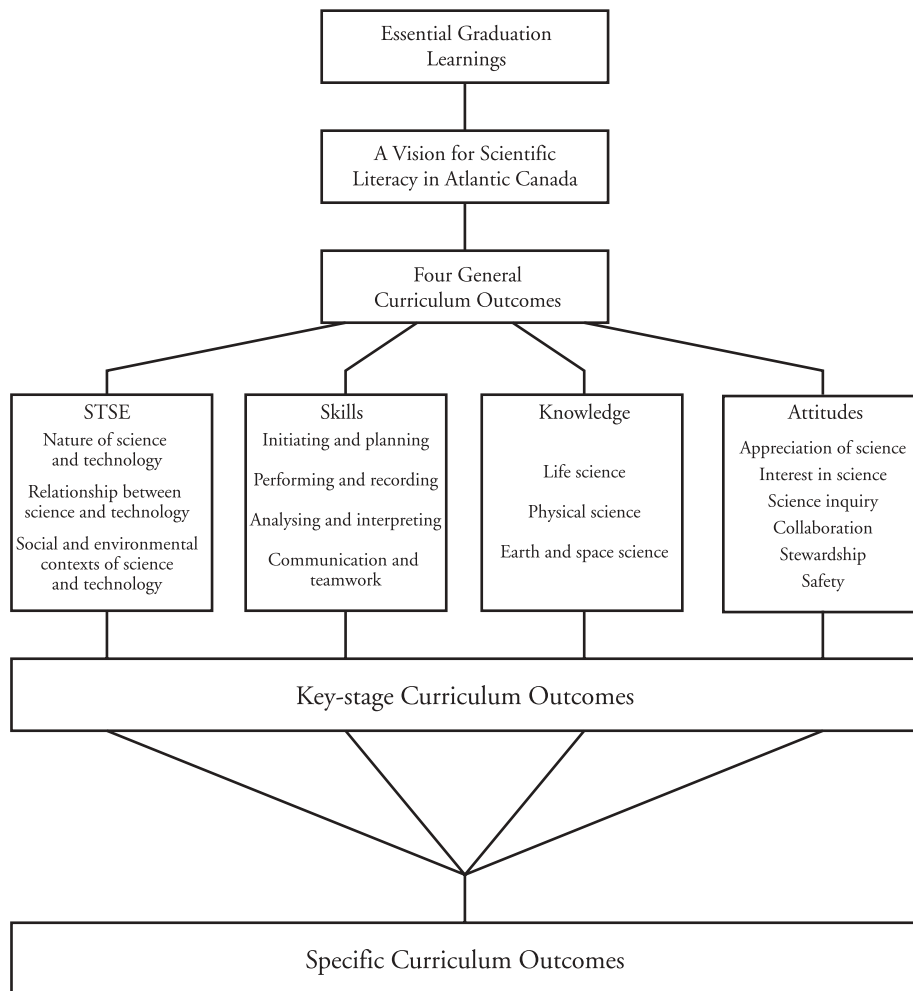


# Curriculum Outcomes Framework

## Overview

The science curriculum is based on an outcomes framework that includes statements of essential graduation learnings, general curriculum outcomes, key-stage curriculum outcomes, and specific curriculum outcomes. The general, key-stage, and specific curriculum outcomes reflect the pan-Canadian *Common Framework of Science Learning Outcomes K to 12*. The diagram below provides the blueprint of the outcomes framework.

## Outcomes Framework



## Essential Graduation Learnings

Essential graduation learnings are statements describing the knowledge, skills, and attitudes expected of all students who graduate from high school. Achievement of the essential graduation learnings will prepare students to continue to learn throughout their lives. These learnings describe expectations not in terms of individual school subjects but in terms of knowledge, skills, and attitudes developed throughout the curriculum. They confirm that students need to make connections and develop abilities across subject boundaries and to be ready to meet the shifting and ongoing opportunities, responsibilities, and demands of life after graduation. Provinces may add additional essential graduation learnings as appropriate. The essential graduation learnings are:

### *Aesthetic Expression*

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

### *Citizenship*

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

### *Communication*

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

### *Personal Development*

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

### *Problem Solving*

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

### *Technological Competence*

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



## General Curriculum Outcomes

The general curriculum outcomes form the basis of the outcomes framework. They also identify the key components of scientific literacy. Four general curriculum outcomes have been identified to delineate the four critical aspects of students' scientific literacy. They reflect the wholeness and interconnectedness of learning and should be considered interrelated and mutually supportive.

## Science, Technology, Society, and the Environment

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

## Skills

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

## Knowledge

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

## Attitudes

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

## Key-Stage Curriculum Outcomes

Key-stage curriculum outcomes are statements that identify what students are expected to know, be able to do, and value by the end of grades 3, 6, 9, and 12 as a result of their cumulative learning experiences in science. The key-stage curriculum outcomes are from the *Common Framework for Science Learning Outcomes K–12*.

## Specific Curriculum Outcomes

Specific curriculum outcome statements describe what students are expected to know and be able to do at each grade level. They are intended to help teachers design learning experiences and assessment tasks. Specific curriculum outcomes represent a framework for assisting students to achieve the key-stage curriculum outcomes, the general curriculum outcomes, and ultimately, the essential graduation learnings.

Specific curriculum outcomes are organized in units for each grade level.

## Attitude Outcomes

It is expected that the Atlantic Canada science program will foster certain attitudes in students throughout their school years. The STSE, skills, and knowledge outcomes contribute to the development of attitudes, and opportunities for fostering these attitudes are highlighted in the Elaborations—Strategies for Learning and Teaching sections of each unit.

Attitudes refer to generalized aspects of behaviour that teachers model for students by example and by selective approval. Attitudes are not acquired in the same way as skills and knowledge. The development of positive attitudes plays an important role in students' growth by interacting with their intellectual development and by creating a readiness for responsible application of what students learn.

Since attitudes are not acquired in the same way as skills and knowledge, outcome statements for attitudes are written as key-stage curriculum outcomes for the end of grades 3, 6, 9, and 12. These outcome statements are meant to guide teachers in creating a learning environment that fosters positive attitudes.

## Common Framework of Science Learning Outcomes K–12, Attitude Outcome Statements

*For grades 7–9 it is expected that students will be encouraged to*

Appreciation of Science	Interest in Science	Scientific Inquiry
<p><b>422</b> appreciate the role and contribution of science and technology in our understanding of the world</p> <p><b>423</b> appreciate that the applications of science and technology can have advantages and disadvantages</p> <p><b>424</b> appreciate and respect that science has evolved from different views held by women and men from a variety of societies and cultural backgrounds</p> <p><i>Evident when students, for example,</i></p> <ul style="list-style-type: none"> <li>• recognize the potential conflicts of differing points of view on specific science-related issues</li> <li>• consider more than one factor or perspective when formulating conclusions, solving problems, or making decisions on STSE issues</li> <li>• recognize the usefulness of mathematical and problem-solving skills in the development of a new technology</li> <li>• recognize the importance of drawing a parallel between social progress and the contributions of science and technology</li> <li>• establish the relevance of the development of information technologies and science to human needs</li> <li>• recognize that science cannot answer all questions</li> <li>• consider scientific and technological perspectives on an issue</li> <li>• identify advantages and disadvantages of technology</li> <li>• seek information from a variety of disciplines in their study</li> <li>• avoid stereotyping scientists</li> <li>• show an interest in the contributions women and men from many cultural backgrounds have made to the development of science and technology</li> </ul>	<p><b>425</b> show a continuing curiosity and interest in a broad scope of science-related fields and issues</p> <p><b>426</b> confidently pursue further investigations and readings</p> <p><b>427</b> consider many career possibilities in science- and technology-related fields</p> <p><i>Evident when students, for example,</i></p> <ul style="list-style-type: none"> <li>• attempt at home to repeat or extend a science activity done at school</li> <li>• actively participate in co-curricular and extra-curricular activities such as science fairs, science clubs, or science and technology challenges</li> <li>• choose to study topics that draw on research from different science and technology fields</li> <li>• pursue a science-related hobby</li> <li>• discuss with others the information presented in a science show or on the Internet</li> <li>• attempt to obtain information from a variety of sources</li> <li>• express a degree of satisfaction at understanding science concepts or resources that are challenging</li> <li>• express interest in conducting science investigations of their own design</li> <li>• choose to investigate situations or topics that they find challenging</li> <li>• express interest in science- and technology-related careers</li> <li>• discuss the benefits of science and technology studies</li> </ul>	<p><b>428</b> consider observations and ideas from a variety of sources during investigations and before drawing conclusions</p> <p><b>429</b> value accuracy, precision, and honesty</p> <p><b>430</b> persist in seeking answers to difficult questions and solutions to difficult problems</p> <p><i>Evident when students, for example,</i></p> <ul style="list-style-type: none"> <li>• ask questions to clarify meaning or confirm their understanding</li> <li>• strive to assess a problem or situation accurately by careful analysis of evidence gathered</li> <li>• propose options and compare them before making decisions or taking action</li> <li>• honestly evaluate a complete set of data based on direct observation</li> <li>• critically evaluate inferences and conclusions, basing their arguments on fact rather than opinion</li> <li>• critically consider ideas and perceptions, recognizing that the obvious is not always right</li> <li>• honestly report and record all observations, even when the evidence is unexpected and will affect the interpretation of results</li> <li>• take the time to gather evidence accurately and use instruments carefully</li> <li>• willingly repeat measurements or observations to increase the precision of evidence</li> <li>• choose to consider a situation from different perspectives</li> <li>• identify biased or inaccurate interpretations</li> <li>• report the limitations of their designs</li> <li>• respond skeptically to a proposal until evidence is offered to support it</li> <li>• seek a second opinion before making a decision</li> <li>• continue working on a problem or research project until the best possible solutions or answers are identified</li> </ul>

## Common Framework of Science Learning Outcomes K–12, Attitude Outcome Statements (*continued*)

*For grades 7–9 it is expected that students will be encouraged to*

Collaboration	Stewardship	Safety in Science
<p><b>431</b> work collaboratively in carrying out investigations as well as in generating and evaluating ideas</p> <p><i>Evident when students, for example,</i></p> <ul style="list-style-type: none"> <li>• assume responsibility for their share of the work to be done</li> <li>• willingly work with new individuals regardless of their age, their gender, or their physical or cultural characteristics</li> <li>• accept various roles within a group, including that of leadership</li> <li>• help motivate others</li> <li>• consider alternative ideas and interpretations suggested by members of the group</li> <li>• listen to the points of view of others</li> <li>• recognize that others have a right to their points of view</li> <li>• choose a variety of strategies, such as active listening, paraphrasing, and questioning, in order to understand others' points of view</li> <li>• seek consensus before making decisions</li> <li>• advocate the peaceful resolution of disagreements</li> <li>• can disagree with others and still work in a collaborative manner</li> <li>• are interested and involved in decision making that requires full-group participation</li> <li>• share the responsibility for carrying out decisions</li> <li>• share the responsibility for difficulties encountered during an activity</li> </ul>	<p><b>432</b> be sensitive and responsible in maintaining a balance between the needs of humans and a sustainable environment</p> <p><b>433</b> project, beyond the personal, consequences of proposed actions</p> <p><i>Evident when students, for example,</i></p> <ul style="list-style-type: none"> <li>• show respect for all forms of life</li> <li>• consider both the immediate and long-term effects of their actions</li> <li>• assume personal responsibility for their impact on the environment</li> <li>• modify their behaviour in light of an issue related to conservation and protection of the environment</li> <li>• consider the cause-and-effect relationships of personal actions and decisions</li> <li>• objectively identify potential conflicts between responding to human wants and needs and protecting the environment</li> <li>• consider the points of view of others on a science-related environmental issue</li> <li>• consider the needs of other peoples and the precariousness of the environment when making decisions and taking action</li> <li>• insist that issues be discussed using a bias-balanced approach</li> <li>• participate in school or community projects that address STSE issues</li> </ul>	<p><b>434</b> show concern for safety in planning, carrying out, and reviewing activities</p> <p><b>435</b> become aware of the consequences of their actions</p> <p><i>Evident when students, for example,</i></p> <ul style="list-style-type: none"> <li>• read the labels on materials before using them, and ask for help if safety symbols are not clear or understood</li> <li>• readily alter a procedure to ensure the safety of members of the group</li> <li>• select safe methods and tools for collecting evidence and solving problems</li> <li>• listen attentively to and follow safety procedures explained by the teacher or other leader</li> <li>• carefully manipulate materials, using skills learned in class or elsewhere</li> <li>• ensure the proper disposal of materials</li> <li>• immediately respond to reminders about the use of safety precautions</li> <li>• willingly wear proper safety attire without having to be reminded</li> <li>• assume responsibility for their involvement in a breach of safety or waste disposal procedures</li> <li>• stay within their own work area during an activity, respecting others' space, materials, and work</li> <li>• take the time to organize their work area so that accidents can be prevented</li> <li>• immediately advise the teacher of spills, breaks, and unusual occurrences, and use appropriate techniques, procedures, and materials to clean up</li> <li>• clean their work area during and after an activity</li> <li>• seek assistance immediately for any first aid concerns like burns, cuts, or unusual reactions</li> <li>• keep the work area uncluttered, with only appropriate materials present</li> </ul>

## Curriculum Guide Organization

Specific curriculum outcomes are organized in units for each grade level. Each unit is organized by topic. Suggestions for learning, teaching, assessment, and resources are provided to support student achievement of the outcomes.

The order in which the units of a grade appear in the guide is meant to suggest a sequence. In some cases, the rationale for the recommended sequence is related to the conceptual flow across the year. That is, one unit may introduce a concept that is then extended in a subsequent unit. Likewise, one unit may focus on a skill or context that will be built upon later in the year.

Some units or certain aspects of units may also be combined or integrated. This is one way of assisting students as they attempt to make connections across topics in science or between science and the real world. In some cases, a unit may require an extended time frame to collect data on weather patterns, plant growth, etc. These cases may warrant starting the activity early and overlapping it with the existing unit. In all cases, the intent is to provide opportunities for students to deal with science concepts and scientific issues in personally meaningful and socially and culturally relevant contexts.

## Unit Organization

Each unit begins with a two-page synopsis. On the first page, introductory paragraphs provide a unit overview. These are followed by a section that specifies the focus (inquiry, problem solving, and/or decision making) and possible contexts for the unit. Finally, a curriculum links paragraph specifies how this unit relates to science concepts and skills addressed in other grades so teachers will understand how the unit fits with the students' progress through the complete science program.

The second page of the two-page overview provides a table of the outcomes from the *Common Framework of Science Learning Outcomes K to 12* that the unit will address. The numbering system used is the one in the pan-Canadian document as follows:

- 100s—Science-Technology-Society-Environment (STSE) outcomes
- 200s—Skills outcomes
- 300s—Knowledge outcomes
- 400s—Attitude outcomes

These code numbers appear in brackets after each specific curriculum outcome (SCO).

# The Four-Column Spread

All units have a two-page layout of four columns as illustrated below. In some cases, the four-column spread continues to the next two-page layout. Outcomes are grouped by a topic indicated at the top of the left page.

## Two-Page, Four-Column Spread

<p style="text-align: right; font-size: small;">CURRICULUM OUTCOMES</p> <p><b>Interactions within Ecosystems: Components of an Ecosystem</b></p> <hr/> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 20%; text-align: left; font-size: small;">Outcomes</th> <th style="text-align: left; font-size: small;">Elaborations—Strategies for Learning and Teaching</th> </tr> </thead> <tbody> <tr> <td style="font-size: small;"> <p><i>Students will be expected to</i></p> <ul style="list-style-type: none"> <li>• identify, delimit, and investigate questions related to a local ecosystem (208-2, 208-3)</li> <li>• use instruments effectively and accurately to investigate components of an ecosystem (209-3)</li> <li>• organize and record data collected in an investigation of an ecosystem (209-4)</li> <li>• describe interactions between biotic and abiotic factors in an ecosystem (306-3)</li> <li>• identify the roles of producers, consumers, and decomposers in a local ecosystem and describe both their diversity and their interactions (304-2)</li> <li>• classify organisms as producers, consumers, and decomposers (210-1)</li> </ul> </td> <td style="font-size: small;"> <p>Questions directed to the students concerning local habitats and the changes or proposed changes to them can elicit interest and discussion at the beginning of the unit of study—questions, such as “What do you think will happen to the wildlife in an area if a baseball field is built?” or “What kinds of animals would a community attract if a proposed landfill site were built?”</p> <p>Students should develop questions to investigate, such as “What types of species live in a particular ecosystem?” Students have investigated and studied components and elementary relationships of and in ecosystems in grades 4 and 6. A K-W-L (What I Know–Want to Learn–Learned) chart can be started. With this approach, previous knowledge and understanding can be assessed and areas of common interests can be identified.</p> <p>Students will need to visit a local habitat in order to make observations. They may visit an area that is or is going to be modified in order to gain an appreciation of how changes might affect the ecosystem.</p> <p>At this level, activities exploring the interactions and the environment should be limited to the following physical or abiotic factors in the environment: temperature, moisture, light, aeration, and salinity. A class discussion of the area and a visit to the area will permit the students to observe and note what is there. Students can use instruments such as magnifying glasses, field binoculars, and hand-held microscopes to closely observe organisms in the ecosystem. Students can use thermometers to compare temperatures at different locations in the area being investigated. Light meters can also be used by some students to investigate any differences in light intensities. Upon return to class, students can attempt to classify the features and components of the ecosystem they observed which may lead to an emergent understanding of the biotic and abiotic factors in the area studied.</p> <p>By discussing the roles and the needs of the living things identified in the ecosystem, students can extend their understanding of the roles and relationships among the producers, consumers, and decomposers. Students should know that one of the most important roles green plants have in any ecosystem is that of being a food (energy) source for consumers and decomposers. The process of photosynthesis can be explored by placing seedlings in light and darkness for several days to see the effect light has on plants. Glass containers can be placed on small plants to view the transpired water condensed on the inside of the glass. Small squares of cardboard or aluminium foil can be carefully attached to both sides of a leaf on a plant and removed several days later to observe its effects.</p> </td> </tr> </tbody> </table> <p style="font-size: x-small; margin-top: 10px;">20 ATLANTIC CANADA SCIENCE CURRICULUM: GRADE 7</p>	Outcomes	Elaborations—Strategies for Learning and Teaching	<p><i>Students will be expected to</i></p> <ul style="list-style-type: none"> <li>• identify, delimit, and investigate questions related to a local ecosystem (208-2, 208-3)</li> <li>• use instruments effectively and accurately to investigate components of an ecosystem (209-3)</li> <li>• organize and record data collected in an investigation of an ecosystem (209-4)</li> <li>• describe interactions between biotic and abiotic factors in an ecosystem (306-3)</li> <li>• identify the roles of producers, consumers, and decomposers in a local ecosystem and describe both their diversity and their interactions (304-2)</li> <li>• classify organisms as producers, consumers, and decomposers (210-1)</li> </ul>	<p>Questions directed to the students concerning local habitats and the changes or proposed changes to them can elicit interest and discussion at the beginning of the unit of study—questions, such as “What do you think will happen to the wildlife in an area if a baseball field is built?” or “What kinds of animals would a community attract if a proposed landfill site were built?”</p> <p>Students should develop questions to investigate, such as “What types of species live in a particular ecosystem?” Students have investigated and studied components and elementary relationships of and in ecosystems in grades 4 and 6. 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Small squares of cardboard or aluminium foil can be carefully attached to both sides of a leaf on a plant and removed several days later to observe its effects.</p>	<p style="text-align: right; font-size: small;">CURRICULUM OUTCOMES</p> <p><b>Interactions within Ecosystems: Components of an Ecosystem</b></p> <hr/> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%; text-align: left; font-size: small;">Tasks for Instruction and/or Assessment</th> <th style="text-align: left; font-size: small;">Resources/Notes</th> </tr> </thead> <tbody> <tr> <td style="font-size: small;"> <p><b>Observation</b></p> <ul style="list-style-type: none"> <li>• Does the student use the instrument for collecting data (e.g., magnifying glass) appropriately and safely? (209-3)</li> </ul> <p><b>Journal</b></p> <ul style="list-style-type: none"> <li>• The thing that surprised me the most when I visited our ecosystem was ... 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<p><i>Students will be expected to</i></p> <ul style="list-style-type: none"> <li>• identify, delimit, and investigate questions related to a local ecosystem (208-2, 208-3)</li> <li>• use instruments effectively and accurately to investigate components of an ecosystem (209-3)</li> <li>• organize and record data collected in an investigation of an ecosystem (209-4)</li> <li>• describe interactions between biotic and abiotic factors in an ecosystem (306-3)</li> <li>• identify the roles of producers, consumers, and decomposers in a local ecosystem and describe both their diversity and their interactions (304-2)</li> <li>• classify organisms as producers, consumers, and decomposers (210-1)</li> </ul>	<p>Questions directed to the students concerning local habitats and the changes or proposed changes to them can elicit interest and discussion at the beginning of the unit of study—questions, such as “What do you think will happen to the wildlife in an area if a baseball field is built?” or “What kinds of animals would a community attract if a proposed landfill site were built?”</p> <p>Students should develop questions to investigate, such as “What types of species live in a particular ecosystem?” Students have investigated and studied components and elementary relationships of and in ecosystems in grades 4 and 6. A K-W-L (What I Know–Want to Learn–Learned) chart can be started. With this approach, previous knowledge and understanding can be assessed and areas of common interests can be identified.</p> <p>Students will need to visit a local habitat in order to make observations. They may visit an area that is or is going to be modified in order to gain an appreciation of how changes might affect the ecosystem.</p> <p>At this level, activities exploring the interactions and the environment should be limited to the following physical or abiotic factors in the environment: temperature, moisture, light, aeration, and salinity. A class discussion of the area and a visit to the area will permit the students to observe and note what is there. Students can use instruments such as magnifying glasses, field binoculars, and hand-held microscopes to closely observe organisms in the ecosystem. Students can use thermometers to compare temperatures at different locations in the area being investigated. Light meters can also be used by some students to investigate any differences in light intensities. Upon return to class, students can attempt to classify the features and components of the ecosystem they observed which may lead to an emergent understanding of the biotic and abiotic factors in the area studied.</p> <p>By discussing the roles and the needs of the living things identified in the ecosystem, students can extend their understanding of the roles and relationships among the producers, consumers, and decomposers. Students should know that one of the most important roles green plants have in any ecosystem is that of being a food (energy) source for consumers and decomposers. The process of photosynthesis can be explored by placing seedlings in light and darkness for several days to see the effect light has on plants. Glass containers can be placed on small plants to view the transpired water condensed on the inside of the glass. Small squares of cardboard or aluminium foil can be carefully attached to both sides of a leaf on a plant and removed several days later to observe its effects.</p>								
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*Column One: Outcomes*

The first column provides the specific curriculum outcomes. These are based on the pan-Canadian *Common Framework of Science Learning Outcomes K to 12*. The statements involve the Science-Technology-Society-Environment (STSE), skills, and knowledge outcomes indicated by the outcome number(s) that appears in parenthesis after the outcome. Some STSE and skills outcomes have been written in a context that shows how these outcomes should be addressed.

Specific curriculum outcomes have been grouped by topic. Other groupings of outcomes are possible and in some cases may be necessary to take advantage of local situations. The grouping of outcomes provides a suggested teaching sequence. Teachers may prefer to plan their own teaching sequence to meet the learning needs of their students.

Column One and Column Two define what students are expected to learn, and be able to do.

*Column Two: Elaborations—  
Strategies for Learning and  
Teaching*

The second column may include elaborations of outcomes listed in column one, and describes learning environments and experiences that will support students' learning.

The strategies in this column are intended to provide a holistic approach to instruction. In some cases, they address a single outcome; in other cases, they address a group of outcomes.

*Column Three: Tasks for  
Instruction and/or  
Assessment*

The third column provides suggestions for ways that students' achievement of the outcomes could be assessed. These suggestions reflect a variety of assessment techniques and materials that include, but are not limited to, informal/formal observation, performance, journal, interview, paper and pencil, presentation, and portfolio. Some assessment tasks may be used to assess student learning in relation to a single outcome, others to assess student learning in relation to several outcomes. The assessment item identifies the outcome(s) addressed by the outcome number in brackets after the item.

*Column Four: Resources/  
Notes*

This column provides an opportunity for teachers to make note of useful resources. Although Science 9 (Nelson) is the text that is primarily referred in the column, teachers are encouraged to seek other resources to help address a particular outcome.

All audiovisual movies stated can be obtained through Instructional Resources, New Brunswick Department of Education.





REPRODUCTION



**Unit 1**  
**Life Science:**  
**Reproduction**

# Reproduction

## Introduction

Reproduction is an essential biological mechanism for the continuity and diversity of species. Students should be provided with opportunities to explore the fundamental processes of reproduction. As well, heredity and the transmission of traits from one living generation to the next will be examined.

The ability of scientists and technologists to manipulate, alter, and substitute genetic material in a variety of cells has increased greatly in recent years. Students will have the opportunity to investigate and debate the current developments and uses of gene manipulation and therapy. An STSE “Science-Technology-Society-Environment” approach to this unit should provide the framework around which an investigation into the ever-expanding world of genetics and gene manipulation can develop. At this level, an elementary introduction to the science of genetics is expected.

## Focus and Context

The focus of this unit is inquiry. The unit is subdivided into three sections: cellular processes, asexual and sexual reproduction, and genetic changes. In the first section, students will investigate and study the role of the nucleus in determining mitosis or meiosis. Students will have an introduction to these two processes of cell division. In the second section, students will explore the processes of asexual and sexual reproduction in representative organisms and compare the two processes. Finally, the current topics of cloning, gene therapy, and genetic manipulation will be investigated in the context of genetic changes and the debates and discussions that accompany these topics and issues.

## Science Curriculum Links

By the end of **grade three**, students have explored the life cycles of several common animals and plants. At the end of **grade six**, students should be able to describe the role played by body systems in helping humans and other animals to grow and reproduce. Last year, students were formally introduced to the cell as a living system that exhibits all the characteristics of life. Students also investigated the structural and functional relationships between and among cells, tissues, organs, and systems in the human body.

In **Biology 12**, students will have the opportunity to study a unit in biology called “Genetic Continuity.” Meiosis and mitosis will be explored in detail at this level. As well, students will have the opportunity to develop an understanding of Mendelian genetics, including the concepts of dominance, co-dominance, recessiveness, and independent assortment. Much of the foundation for that unit of study is found in this unit

## Curriculum Outcomes

STSE	Skills	Knowledge
<p><i>Students will be expected to</i></p> <p><b>Nature of Science and Technology</b></p> <p><b>109-14</b> explain the importance of using precise language in science and technology</p> <p><b>110-3</b> identify major shifts in scientific world views</p> <p><b>Relationships Between Science and Technology</b></p> <p><b>111-1</b> provide examples of scientific knowledge that have resulted in the development of technologies</p> <p><b>Social and Environmental Contexts of Science and Technology</b></p> <p><b>112-12</b> provide examples of Canadian contributions to science and technology</p> <p><b>113-110</b> provide examples of problems that arise at home, in an industrial setting, or in the environment that cannot be solved using scientific and technological knowledge</p>	<p><i>Students will be expected to</i></p> <p><b>Initiating and Planning</b></p> <p><b>208-2</b> identify questions to investigate arising from practical problems and issues</p> <p><b>Performing and Recording</b></p> <p><b>209-5</b> select and integrate information from various print and electronic sources or from several parts of the same source</p> <p><b>209-6</b> use tools and apparatus safely</p> <p><b>Analysing and Interpreting</b></p> <p><b>210-2</b> compile and display data, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, bar graphs, line graphs, and scatter plots</p> <p><b>210-4</b> predict the value of a variable by interpolating or extrapolating from graphical data</p> <p><b>210-8</b> apply given criteria for evaluating evidence and sources of information</p> <p><b>210-9</b> calculate theoretical values of a variable</p> <p><b>Communication and Teamwork</b></p> <p><b>211-2</b> communicate questions, ideas, intentions, plans, and results, using lists, notes in point form, sentences, data tables, graphs, drawings, oral language, and other means</p>	<p><i>Students will be expected to</i></p> <p><b>304-11</b> illustrate and describe the basic process of cell division, including what happens to the cell membrane and the contents of the nucleus</p> <p><b>305-1</b> recognize that the nucleus of a cell contains genetic information and determines cellular processes</p> <p><b>305-2</b> distinguish between sexual and asexual reproduction in representative organisms</p> <p><b>305-3</b> compare sexual and asexual reproduction in terms of their advantages and disadvantages</p> <p><b>305-5</b> discuss factors that may lead to changes in a cell's genetic information</p>

## Cellular Processes

### Outcomes

#### *Students will be expected to*

- recognize that the nucleus of a cell contains genetic information and determines cellular processes (305-1)
- explain the importance of using the terms gene and chromosome properly (109-14)
- identify major shifts in scientific understanding of genetics (110-3)

### Elaborations–Strategies for Learning and Teaching

In grade 8, students explored and learned about the basic concept of the cell. They investigated the similarities and differences between animal and plant cells. Students were also involved in activities that led them to understand and explain that growth and reproduction depend on cell division. In order to be prepared for an investigation of sexual reproduction in plants, a flowering plant such as a lily should be started before the unit begins. Students may be motivated to investigate cellular processes and genetic changes if they are involved in initial discussions or questions centred around topics such as cloning, genetically modified organisms/food, or gene therapy. Students should gain an appreciation of the major shifts in scientific understanding of genetics over the course of their investigation into this topic. The development of breeds of animals with desired traits, identification of the nucleus of the cell as the location of genetic material and the contributions of Watson and Crick can be explored and discussed.

A possible opening to this unit is to call upon students to observe, note, and report differences and similarities among members of their class or families. This activity can compare and contrast genetically determined physical traits such as hair and eye colour, attached/detached ear lobes, and tongue-rollers/non-tongue-rollers. Students can collect data to determine the frequency of these traits in class or within their families. This research can provide the opportunity for students to ask questions about why we are unique yet similar to classmates or other family members. This approach can lead to questions such as “What causes people to be the same and yet different?” and “Are there similar similarities and differences in other species?” Another possible context for investigation is a study of diseases, their causes, and controls.

In grade 8, students compared and contrasted typical animal and plant cells. They investigated and learned about the main components of cells: nucleus, cell membrane/wall, cytoplasm, and chloroplasts. At this level, students should begin their investigation into the role of the nucleus of a cell. In the course of the investigations and activities, students should come to understand the basic functions of chromosomes and genes, and how genetic information is propagated within an organism and passed on to any offspring.

Chromosomes are not normally visible under a light microscope unless the cell being observed is in the process of dividing. Students can observe prepared slides of cells undergoing division in order to view the chromosomes in the nucleus. Students can view slides of onion root tips, for example, in order to see chromosomes in cells that are in the process of dividing. Appropriate videos and computer software can supplement microscope investigations of cellular activity with regard to mitosis and meiosis.

continued...

## Cellular Processes

### Tasks for Instruction and/or Assessment

#### *Performance*

- Do a survey of the people in your family or class in order to collect data on the following:
  - smooth hair line versus widow’s peak
  - can roll tongue versus cannot roll tongue
  - hair on little finger versus no hair on little finger
 Create a data display of your findings. (109-14, 305-1)

#### *Journal*

- Explain the difference between gene and chromosome and why they cannot be used interchangeably. (109-14, 305-1)

#### *Paper and Pencil*

- Research and report on the process of healing wounds. (304-11, 305-1)
- Investigate what Watson and Crick discovered that improved our understanding of genetics. (110-3)
- Use a sketch or drawing to illustrate the difference between a gene and a chromosome. (109-14, 305-1)

#### *Presentation*

- Create a 3-dimensional model of a simplified nucleus containing chromosomes and explain why this term is used and not “genes.” (109-14)
- Draw and label a typical animal cell in which the nucleus and nuclear material is indicated. (305-1)

### Resources/Notes

#### Science 9

- Pg 142-143      5.2  
and  
Pg 176-178      6.1  
(305-1, 109-14)
- Pg 180-183      6.2 & 6.3  
or  
Pg 194-197      6.9  
(110-3)

#### AV

“Geometry of Life” NBDE  
#702332  
(305-1, 109-14, 110-3)

continued...

## Cellular Processes (*continued*)

### Outcomes

#### *Students will be expected to*

- illustrate and describe the basic processes of mitosis and meiosis (304-11)

- determine and graph the theoretical growth rate of a cell, and interpolate and extrapolate the cell population from the graph (210-2, 210-4, 210-9)

### Elaborations–Strategies for Learning and Teaching

Students should come to understand that mitosis is the process of cell division that results in growth and/or cell replacement. Students should come to understand that not all cells have the same rate of cell reproduction. It is not necessary that the students learn the phase names at this stage. Students can be challenged to create simple models of the various stages of mitosis.

The terms gene and chromosome should be carefully distinguished as they are, at times, used interchangeably. Students should come to appreciate that our understanding of the roles of these cellular components has grown tremendously since they were first identified.

**Teacher Note:** *Genes are specific parts or location on chromosomes and one or more genes determine the traits that a person exhibits.* The topic of DNA (deoxyribonucleic acid) is not core at this grade level but may be addressed as an extension or enrichment if time permits or if there is student interest.

Students should investigate the general stages of meiosis in order to compare and contrast this process with mitosis. Emphasis should not be placed on the rote memorization of these two processes, but rather on understanding the results of these two different forms of cell reproduction. Students are not required to learn the names of the phases of mitosis or meiosis at this level. Some commercial resources may contain the phase names for mitosis and meiosis as well as detailed descriptions of each phase. At the grade 9 level, an introductory treatment of these processes is expected. Students should realize that meiosis results in the production of sex cells of most plants and animals. Students can model or act out the process of mitosis and meiosis by pairing up and simulating the process. Students can use different coloured pinnies or labels that indicate the chromosome or chromosome pairs in the process.

Students can do the following activity to experience and appreciate the theoretical exponential growth rate of cells due to mitosis. Ask students if they would prefer to have a million dollars or the total value of pennies on a checkerboard if one penny were placed on the first square and then doubled its value for every subsequent square. Students can do this exercise with a calculator. Students should realize that cells die and are replaced at about the same rate in most cases of cell division. Students can begin a yeast population and study the population growth rate over a short period of time. This activity can also be used to investigate budding.



## Cellular Processes (*continued*)

### Tasks for Instruction and/or Assessment

#### *Performance*

- Search for pictures of cells in various stages of mitosis and/or meiosis on the Internet and describe their similarities and differences. (304-11)

#### *Paper and Pencil*

- Produce a line graph that communicates the exponential growth rate of theoretical cellular reproduction and a line graph of what one would predict as a better representation of real growth. Explain what each line represents. (210-2, 210-4, 210-9)
- In a series of drawings, illustrate/demonstrate the basic processes of mitosis and meiosis. (304-11)
- Construct a concept map for the processes of meiosis and mitosis. (304-11)
- Research and report on the process of healing wounds. (304-11)

#### *Presentation*

- Plan and perform a skit or play that demonstrates the processes of mitosis and meiosis. (304-11)
- Write and perform a play-by-play radio broadcast that demonstrates the four stages of mitosis. (304-11)
- Produce a graph of theoretical cell growth rates and superimpose a graph that would represent a realistic representation of growth rate. (209-9, 210-2, 210-4)

#### *Portfolio*

- Develop a concept map to link terms that have been introduced in this unit (chromosome, gene, asexual, sexual, mitosis, meiosis). (109-14, 304-11)

### Resources/Notes

#### Science 9

- Pg 148-155 for Mitosis 5.4, 5.5, 5.6 and Pg 206-207 Meiosis 7.2 (304-11)
- choose carefully from the following (may need to modify to fit outcome)
  - Pg 160 “Try This”
  - Pg 166-167 5.11
  - Pg 168-169 5.12 (210-2, 210-4, 210-9)

#### AV

“Comparisons of Mitosis and Meiosis” Acces #705597, VH

## Asexual and Sexual Reproduction

### Outcomes

#### *Students will be expected to*

- distinguish between sexual and asexual reproduction in representative organisms (305-2)
- compare sexual and asexual reproduction in terms of their advantages and disadvantages (305-3)
- identify questions to investigate about sexual reproduction in plants (208-2)
- use tools and apparatus safely to investigate the structure of flowers (209-6)
- communicate the results of an investigation into the structure of flowers (211-2)

### Elaborations—Strategies for Learning and Teaching

Students should investigate the various processes of asexual reproduction. Students can observe slides or videos in which the following types of asexual reproduction take place: fission—algae and protozoa; spore production—moulds (on old bread or rotting fruit), budding—yeast or hydra. Students should be able to illustrate various types of asexual and sexual reproduction. For example, students can compare and contrast, using diagrams or sketches, reproduction in yeasts and roses.

Sexual reproduction involves two parents in the majority of cases. Students should come to understand that organisms that reproduce sexually generally show a wider variety of differences in traits within a given species than those organisms that reproduce asexually. Plants such as roses can be investigated and studied to highlight this point. Students should be given the opportunity to communicate the results of this type of research by using such media as posters, multi-media presentations, and drawings.

Students can be challenged to think of the advantages and disadvantages of asexual and sexual reproduction. In asexual reproduction organisms can reproduce alone. However, these organisms must generally rely on a mutation in order to have offspring that are significantly different from the parent cell. Organisms that reproduce sexually generally must have two parents in order to reproduce. Exceptions are found in some organisms that have both male and female parts. A greater variety of traits are possible in species that reproduce sexually. Students can investigate and discuss, for example, the variety of dogs, cats, and roses that exist.

By observing a variety of plants or pictures of plants, students can be challenged to explain their understanding of how plants reproduce. Have students propose questions about plant reproduction to investigate, such as “How do some flowers differ from each other?” and “What are the basic parts of flowers?” Flowering plants should be started early enough to be used for this activity if flowering plants are not obtained by other means. The lily is a good plant to use as the flowers are large and the flower parts are easily distinguished. Using basic tools such as scissors, forceps, hand lenses, and probes, students can investigate flowers in order to study the different parts. Students can sketch the various parts of the flower in order to communicate the results of their investigations.

## Asexual and Sexual Reproduction

### Tasks for Instruction and/or Assessment

#### *Observation*

- **Self-Assessment** (208-2, 209-6, 211-2)

#### Self-Assessment of Plant Reproduction

Tasks	Rarely		Always	
I develop procedures in logical sequence.	1	2	3	4
I use tools carefully and effectively.	1	2	3	4
I keep accurate notes of my observations.	1	2	3	4
I communicate the results of my investigations accurately.	1	2	3	4

#### *Performance*

- What feature of the stigma makes it well suited for receiving pollen grains? (211-2, 305-3)

#### *Paper and Pencil*

- Why would the offspring of organisms that reproduce asexually resemble very closely the parent organism? (303-3)
- Bees gather a sweet fluid called nectar from flowers. In the process, they do something to help fertilize flowers. Research what they inadvertently do when gathering nectar. (305-3)

#### *Presentation*

- Research and report upon the similarities and differences between organisms that reproduce asexually and sexually. (305-2)
- Research cloning techniques in animals and plants. How does cloning resemble asexual reproduction? (305-3)
- Create a poster or mural of organisms that reproduce asexually. (305-2)
- Produce a series of sketches or computer drawings of organisms that reproduce sexually and asexually. (305-3)
- Create a display that illustrates the variety that can occur in a species that reproduces sexually. (305-3)

### Resources/Notes

#### Science 9

- Pg 159-161 5.8  
For a further look at asexual, if time permits
  - pg 190-193 6.7 & 6.8 (305-2, 305-3)
- Pg 208-213  
7.3, 7.4 & 7.5  
(208-2, 209-6, 211-2)

#### AV

“Asexual Reproduction and Alternation of Generations”  
Access  
#705598, VH  
(305-2, 305-3)

“Plant Reproduction” Magic  
#705438, VH  
(208-2, 209-6, 211-2)

## Genetic Changes

### Outcomes

#### *Students will be expected to*

- provide examples of genetic conditions that cannot be cured using scientific and technological knowledge at the present time (113-10)
- compare factors that may lead to changes in a cell's genetic information:
  - mutations caused by nature
  - mutations caused by human activities (305-5)
- evaluate information and evidence gathered on the topic of genetics and genetic engineering (209-5, 210-8)
- provide examples of how the knowledge of cellular functions has resulted in the development of technologies (111-1)
- provide examples of Canadian contributions to science and technology related to heredity and genetic engineering (112-12)

### Elaborations–Strategies for Learning and Teaching

A general survey of some genetic conditions that are presently not curable can set the stage for this section. Students should investigate situations in which science and technology have yet to solve problems associated with reproduction and genes such as certain causes of cancer and certain conditions, cystic fibrosis, for example.

Students may be aware of some of the work being done by researchers around the world on genetic manipulation. This is a topic which lends itself easily to the introduction and study of differing opinions regarding a particular topic in science and technology.

Students should investigate the “environment versus genetic” debate with regard to genetic changes within populations. Natural (solar radiation and radioactive gases) and human-made factors (chemicals and nuclear radiation) can be investigated in order to understand the ways in which genetic information can be altered within an individual and between generations. Students should be encouraged to identify current questions being debated with regard to this topic as well as their own. Some topics and/or issues that may be investigated and discussed or debated are drugs that affect genetic processes, such as thalidomide, mercury pollution, the use of X rays, and various types of radiation (nuclear and electromagnetic).

The topic of gene manipulation and engineering lends itself well to the critical investigation of a particular process or technology. Students should have opportunities to investigate and discuss the positions of various scientists, researchers, and organizations that work in or study the field of gene manipulation and/or gene technologies. Students should also have the opportunity to critically examine and evaluate sources of information by keeping in mind such things as the date of the publication, the type of audience for which the material was intended, and the author's intent. Students can explore and investigate the information from various groups and their positions regarding topics such as cloning, gene manipulation/therapy in people, and genetically modified foods.

Students can role-play or use debates to highlight the issues inherent in genetic manipulation. Recent events involving the cloning of various animals such as sheep, and the genetic research and technologies associated with foods and food quality can be used to help students appreciate the complex nature of the debate.

Development of wheat and potato varieties, cloning, and an investigation of companies that work in genetic engineering such as Aqua Bounty Farms in Newfoundland can provide contexts for these investigations. Breeding programs in the livestock industry as well as the development of the Macintosh apple, can be topics to be investigated.

## Genetic Changes

### Tasks for Instruction and/or Assessment

#### *Observation*

- Research various positions of scientists and others with regard to cloning of animals. Participate in a role play or debate on the subject. (210-8, 305-5)

#### *Paper and Pencil*

- Investigate and report on a company in your region or province that works within the field of genetic manipulation/selection. (112-12, 305-5)
- In an essay, outline two positions on the cloning of plants and animals. (209-5, 210-8)
- Research the positive and negative effects of mutations or changes in the genetic code; for example, curing/treating diseases (positive); organisms such as bacteria and some mosquitos developing resistance to pesticide. (305-5)

#### *Presentation*

- Prepare an oral report on gene therapy. (111-1, 113-10, 305-5)
- Investigate a factor that causes genetic changes, such as nuclear radiation or thalidomide, and prepare a report to present to the class. (209-5, 210-8, 305-5)
- Create a multimedia presentation on the work done to find a cure or treatment for genetically related conditions in humans. (111-1, 113-10)
- Prepare a visual representation of genetic technologies. (210-8)

### Resources/Notes

#### Science 9

- Pg 179 (Career Profiles- Cystic Fybrosis) (113-10)
- Pg 180-183 6.2 & 6.3 optional  
Pg 184-185 6.4 (305-5)
- Pg 144-147 5-3 (111-1)

#### AV

“Genetic Engineering” CANL #704834, VH (305-5, 209-5, 210-8, 111-1)



## ATOMS & ELEMENTS





**Unit 2**  
**Physical Science:**  
**Atoms and Elements**

# Atoms and Elements

## Introduction

Modern chemistry is founded on atomic theory and its associated findings. Building on past explorations using various substances and the particle model of matter, students should become familiar with the basic constituents of atoms and molecules, with chemical symbols themselves, and with common elements and compounds. A strong connection should develop between students' basic ideas about chemistry and related examples in their own lives.

## Focus and Context

This unit is primarily focussed on inquiry. Students should be exposed to activities that illustrate how knowledge and theories related to atoms and elements have been developed. This unit provides an excellent opportunity to distinguish between laws and theories in science.

## Science Curriculum Links

In entry to grade 3, students begin a cursory look at properties of objects and materials (physical properties). Also, a preliminary look at static electricity and magnetism occurs. By the end of grade 6, students have encountered and studied properties and changes in materials (properties of physical changes and chemical changes).

Students in Science 10 will be involved with a unit of work entitled "Chemical Reactions" in which they will learn to name and write formulas for some common ionic and molecular compounds, using the periodic table and a list of ions. In addition, students will classify substances such as acids, bases, or salts according to their characteristics, name, and formula. Students will learn to represent chemical reactions and the conservation of mass, using molecular models and balanced symbolic equations. Students will investigate how neutralization involves tempering the effects of an acid with a base, or vice versa. Finally, students will illustrate how factors such as heat, concentration, light, and surface area can affect chemical reactions.

In Chemistry 11 & 12, students will have the opportunity to further their studies in chemistry in which topics such as organic chemistry, acids and bases, bonding, electrochemistry, solutions, and stoichiometry and thermochemistry are addressed.

## Curriculum Outcomes

STSE	Skills	Knowledge
<p><i>Students will be expected to</i></p> <p><b>Nature of Science and Technology</b></p> <p><b>109-2</b> describe and explain the role of collecting evidence, finding relationships, proposing explanations, and imagination in the development of scientific knowledge</p> <p><b>109-13</b> explain the importance of choosing words that are scientifically or technologically appropriate</p> <p><b>109-14</b> explain the importance of using precise language in science and technology</p> <p><b>110-1</b> provide examples of ideas and theories used in the past to explain natural phenomena</p> <p><b>110-3</b> identify major shifts in scientific world views</p> <p><b>Relationships Between Science and Technology</b></p> <p><b>111-1</b> provide examples of scientific knowledge that have resulted in the development of technologies</p> <p><b>111-4</b> provide examples of technologies that have enhanced, promoted, or made possible scientific research</p> <p><b>Social and Environmental Contexts of Science and Technology</b></p> <p><b>112-3</b> explain how society's needs can lead to developments in science and technology</p> <p><b>112-8</b> provide examples to illustrate that scientific and technological activities take place in a variety of individual or group settings</p>	<p><i>Students will be expected to</i></p> <p><b>Performing and Recording</b></p> <p><b>209-7</b> demonstrate a knowledge of WHMIS standards by using proper techniques for handling and disposing of lab materials</p> <p><b>Analysing and Interpreting</b></p> <p><b>210-1</b> use or construct a classification key</p> <p><b>210-2</b> compile and display data, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, bar graphs, line graphs, and scatter plots</p> <p><b>210-11</b> state a conclusion, based on experimental data, and explain how evidence gathered supports or refutes an initial idea</p> <p><b>210-16</b> identify new questions and problems that arise from what was learned</p>	<p><i>Students will be expected to</i></p> <p><b>307-12</b> investigate materials and describe them in terms of their physical properties</p> <p><b>307-13</b> describe changes in the properties of materials that result from some common chemical reactions</p> <p><b>307-14</b> use models in describing the structure and components of atoms and molecules</p> <p><b>307-15</b> identify examples of common elements, and compare their characteristics and atomic structure</p> <p><b>307-16</b> identify and write chemical symbol or molecular formula of common elements or compounds</p>

## Safety Consideration and Physical Properties

### Outcomes

#### *Students will be expected to*

- compare earlier conceptions of the structure of matter with their conceptions (110-1)
- demonstrate a knowledge of WHMIS standards by using proper techniques for handling and disposing of lab materials (209-7)
- investigate materials and describe them in terms of their physical properties (307-12)
- compile and display data collected during an investigation of the physical properties of materials (210-2)

### Elaborations—Strategies for Learning and Teaching

This unit can begin with a What I Know-Want to Know-Learned (K-W-L) activity centred around the topic of matter. Questions such as “What is matter?,” “What do you think matter is made up of?” and “How small can matter be divided?” will allow for an assessment of students’ prior understanding and knowledge of matter. Students should explore earlier concepts of the nature of matter, such as those of Aristotle and the ancient Greeks, who believed matter to be composed of air, fire, and/or water. This investigation will illustrate that understanding of scientific ideas and phenomena evolve and change over time.

It is important that the teacher and students, collectively and collaboratively, develop a set of lab safety rules based on provincial safety guidelines. Rules should be discussed, agreed upon, and posted. Students may want to use a variety of media to communicate these rules. Art and creativity can be easily focussed upon here. Safety posters made by students can be displayed to illustrate these rules and remind students of their importance. Students should be introduced to the existence and use of WHMIS data sheets. Students will not be expected to understand all of the information presented in chemical data sheets but they should understand that these data sheets provide valuable information regarding the safe handling and disposal of the chemicals involved. Examples of these data sheets can be posted in the classroom or laboratory for students to read and examine.

To gain an appreciation of how physical properties can be used to identify materials, students may be asked to describe everyday objects in terms of their physical characteristics. Students can identify objects based on descriptions provided by other students, for example. If the list of objects is long enough, students may create and use a database to assist them in this activity. Physical properties are properties that do not involve the formation or creation of a new substance. Examples of physical properties include odour, colour, melting point, boiling point, solubility, malleability, and density.

The students can be supplied with a variety of materials of the same dimensions in order to test their strength, malleability, flexibility, and density. Some examples of materials to test are copper, aluminum, iron, plastic, and wooden strips.

Other physical properties that may be investigated are texture and colour. Testing and/or observations can be done on materials such as baking soda, salt, sugar, iron filings, and flour. Students should be encouraged to devise an efficient way to compile and display the data that they have collected from their investigations.

## Safety Consideration and Physical Properties

### Tasks for Instruction and/or Assessment

#### *Observation*

- **Self-Assessment** (210-2, 307-12)

My Physical Properties' Checklist	Yes	No
Did I understand the task?		
Have I developed a clear set of procedures to follow?		
Have I followed the procedures in my plan?		
Did I use the equipment safely and accurately?		
Have I recorded my observations in an organized way?		

#### *Journal*

- What do you think matter is composed of? How small can it be broken up? (110-1)
- Create an advertisement for a fictional substance that has just been created or discovered and highlight its physical properties. (307-12)

#### *Paper and Pencil*

- Write a story in which the characters are described with physical properties. (307-12)
- Research a particular substance to find out its physical properties. (307-12)
- Interview a member of a Waste Watch program to learn how WHMIS standards are used in the disposal of some dangerous or hazardous wastes. (209-7)

#### *Presentation*

- Prepare a poem or cartoon illustrating a safety feature or procedure in the laboratory. (209-7)
- Design and contribute to a bulletin-board display of physical properties of a variety of materials that display various aspects of the physical properties (for example, gold-malleable, diamond-not malleable). (307-12)
- Make a poster showing the relationship between a material (physical properties) and its uses. (307-12)
- Create a database file of physical properties of some common materials. (210-2)

### Resources/Notes

#### Science 9

- Pg 78-85 3.1 & 3.2 (110-1)
- Pg 14-15 1.1 (209-7)
- Pg 16-18 and 20-21 1.2 & 1.3 optional Pg 24-25 1.5 (307-12, 210-2)

#### AV

“Chemistry Essentials - Matter: Form and Substance...” Kinetic #705404, VH (307-12, 210-2)

## Chemical Changes/Reactions

### Outcomes

#### *Students will be expected to*

- describe changes that result from common chemical reactions:
  - energy change
  - change in colour
  - precipitate formed
  - gas formed
  - new chemical substance formed (307-13)
- determine, where possible, if the change in a material or object is physical or chemical on the basis of experimental data (210-11)
  
- identify new questions about physical and chemical changes that arise from investigations (210-16)

### Elaborations–Strategies for Learning and Teaching

Common substances should be exposed to changes such as dissolving and burning in order to investigate to see if a new substance has been created. A variety of activities and reactions will allow for classification of chemical and physical changes. At this point, discussion should focus on evidence which indicates physical versus chemical change. Students should understand that a chemical change involves the production of new substances with new properties. While there are particular types of evidence which can be used to support the inference of a chemical change (for example, bubbles being formed, change of colour, odour, temperature change), it is important that students understand that this is not conclusive evidence, since many physical changes may also fit these categorizations. Some changes, such as those in which a precipitate is formed, indicate a chemical change. Some changes such as dissolving are more difficult to classify. Dissolving is usually classified as physical, but many chemical interactions occur. Many chemical reactions are easily reversible (equilibrium reactions), while many physical changes are not easily reversible (shredding paper, sanding down wood).

Students can try to identify physical changes which involve evidence that may suggest chemical changes. For example, when a bottle of pop is opened, gas appears. This is a physical and not a chemical change. If an ice sculpture melts, the change is not easily reversible, yet it is a physical change. In the case of pH indicators, the colour change may be easily reversible, yet it is a chemical change. Some possible leading questions to initiate classroom discussion follow: “Are there examples of changes that are not easily identified as chemical or physical?” “What does it mean when you say a new substance is formed?” and “Can you always tell when a substance is different from the starting material?” Students should be aware that the theoretical definitions are more clear-cut than operational definitions in this case.

## Chemical Changes/Reactions

### Tasks for Instruction and/or Assessment

#### *Observation*

- Use a checklist to assess safety precautions and basic lab skills during chemical-change activity. (209-7, 210-11)
- Give the students the opportunity to investigate a number of safe, common chemical and physical changes. Use a scoring rubric to assess their ability to recognize and provide proof for the various changes. (210-11, 307-12, 307-13)

#### *Journal*

- When can the appearance of gas bubbles in a liquid be problematic when trying to determine if their appearance is due to a physical or a chemical change? (307-13)

#### *Paper and Pencil*

- Classify the following changes as chemical or physical: making of toothpicks, making pancakes, and so on. (307-12, 307-13)
- Interview a plumber or other tradesperson to find out which chemical or physical changes occur regularly in the course of the job. Make a list of these changes. (307-13)

#### *Interview*

- Describe a situation in which it would be difficult to ascertain if the change is physical or chemical and explain why. (210-16, 307-13)

#### *Presentation*

- Prepare a display containing possible indicators of a chemical change. (307-13)
- Prepare a brochure or bulletin-board display containing physical and chemical changes. Include pictures from everyday life. (210-11, 307-13)

#### *Portfolio*

- Note and record typical “changes” in your home and note whether they are physical or chemical changes. Give reasons for your choices. (307-12, 307-13)

### Resources/Notes

#### Science 9

- Pg 18-19 1.1 (307-13)
- Pg 26-30 1.6 & 1.7 and Pg 32-33 1.8 (307-13, 210-11, 210-16)

#### AV

“Chemistry Essentials - Reactions: The Chemistry of” Kinetic #705408, VH

## Atomic Theory

### Outcomes

#### *Students will be expected to*

- identify major changes in atomic theory up to and including the Bohr model (110-3)
  
- use models in describing the structure and the components of atoms and molecules, and explain the importance of choosing words that are scientifically appropriate:
  - determine the number of protons and electrons in the atom of an element, given its atomic number
  - determine the number of protons, electrons, and neutrons, given the mass number and atomic number
  - be able to write the appropriate symbol for an isotope, given the number of protons and neutrons (109-13, 307-14)

### Elaborations–Strategies for Learning and Teaching

Do research or view an appropriate video to learn more about the construction of atomic theory. A time line may be created and placed in class illustrating the names of people and the atomic theories associated with them. This type of activity provides an opportunity for students to see how scientific theories are constructed, modified, and at times discarded as new data and evidence are collected. Students can create models of atoms (mobiles, posters, for example), using historical atomic model conventions (for example, Dalton’s “billiard ball” model, Thomson’s “raisin bun” model, Bohr’s “planet” model). Students can correlate the time line on the discovery of elements with the development of atomic models from Dalton to Bohr. Some students may show an interest in other women and men, such as Robert Boyle, Joseph Priestley, Marie Curie, and Ernest Rutherford, who have made contributions to our knowledge and understanding of the atom.

The development of the atomic model is an important and worthwhile lesson in one aspect of the nature of science. Models form conceptual frameworks to organize complex phenomena into understandable forms. Even though it is now possible to view individual atoms of some elements, scientists still cannot see the structure of the atom itself, so they build useful models to explain observed behaviour.

Students will learn about the major component parts of atoms, including their basic characteristics. Students should be exposed to our current cloud theory or energy-level theory of atoms. Students should explore and be able to represent the different arrangements of electrons in the energy levels around the nucleus of the atom of the first eighteen elements of the period tables.

The use of videos and other visuals about atomic structure and theory appropriate to this grade level are highly recommended as the ideas and structures being investigated are fairly abstract.

Students can use charts to arrange the atomic number, mass number, number of protons, neutrons, and electrons of various elements.

Students can be assigned an element to research (abundance, extractions, forms, for example). They may then present their findings to the class in the form of an oral presentation, a poster display, or multi-media presentation.

continued...



## Atomic Theory

### Tasks for Instruction and/or Assessment

#### *Paper and Pencil*

- Represent the element sodium in a diagram which shows the arrangement of its electrons in energy levels. (109-13, 307-14)
- How is the atomic number of an element related to the mass number of the same element? (109-13, 307-14)
- Oxygen has the atomic number 8. How many protons and electrons would an atom of this element have? (109-13, 307-14)
- The atomic number of carbon is 6. The mass number of its most common form is 12. Determine the number of protons, neutrons, and electrons in the atom. (109-13, 307-14)
- There are three isotopes of hydrogen: hydrogen, deuterium, and tritium. Research how many protons and neutrons each isotope has. (109-13, 307-14)
- Given the mass number and atomic number of an element, determine the number of neutrons it has. (307-14)

#### *Interview*

- What is the essential difference between an element and a compound? (307-14)

#### *Presentation*

- Using coloured clothing or pinnies, devise a way to represent elements (like colours) or compounds (unlike colours). (109-13, 307-14)
- Create a bulletin-board display highlighting the evolution of our understanding of atomic structure and theory. (110-3)
- Create a model, using a variety of media and materials, of our present understanding of atomic structure. (307-14)
- Create a visual and animated representation of our present concept of atoms, using people to represent the components of an atom. (110-3, 307-14)
- Research and play the role of Rutherford to explain his contribution to our present atomic theory. (109-13, 110-3, 307-14)
- Create art displays of atomic models that illustrate how our conception of atomic structure has changed over the years. (110-3)

continued...

### Resources/Notes

#### Science 9

- Pg 78-85 3.1 & 3.2 and Pg 92-93 3.4 (110-3)
- Pg 87-89 3.3 and Pg 96-97 3.6 (109-13, 307-14)

#### AV

“Atoms and Molecules” CANL #704807, VH (109-13, 307-14)

## Atomic Theory (*continued*)

### Outcomes

*Students will be expected to*

- provide examples of technologies that have enhanced, promoted, or made possible scientific research in chemistry (111-4)
- provide examples to illustrate that scientific and technological activities related to atomic structure take place in a variety of individual and group settings (112-8)
- explain the importance of using the terms law and theory in science (109-14)

### Elaborations–Strategies for Learning and Teaching

Students should be aware that our understanding of atoms and atomic structure is largely based on evidence gathered from many physical and chemical explorations and activities. The individual components of atoms are too small to be viewed, but the atomic theory is based on evidence of their activities or relationships with matter and energy.

Students should be made aware of and note some technologies that have helped scientists explore and gain a better understanding of the atom and its composite parts. From the vacuum tube used by Crookes in the 19th century to atomic cyclotrons of today, technologies have helped further our understanding of the atomic world.

It is important that students appreciate that some activities related to chemistry take place in a variety of settings. The fact is that many of the scientists who helped to develop the various atomic models, such as Crookes, Thomson, and Rutherford, worked with others in university settings. They used the discoveries of others to help them in their experiments to develop their own theories. When examples such as cooking (individual) and the development of better metallic alloys (groups of chemical engineers) are used, students can better appreciate the variety of activities in which chemistry is involved. Students can investigate how scientists, working together, have used knowledge of atomic structure to build new technologies such as atomic micro-engines and investigate the atom even further.

This is an opportune time to introduce and formally discuss the difference between a law and a theory in science. Very often, students use the terms interchangeably. Sometimes students use the term “theory” to denote a hypothesis in an experiment. Students should understand that, in science, a law simply describes or summarizes what happens or is observed. The Periodic Law, for example, describes the periodic nature of elements with regard to how they behave chemically. A theory, on the other hand, is an imaginative way of explaining why something happens. The Atomic Theory, for example, is a creative way scientists have to try to explain structure and function at the atomic and sub-atomic level. Theories often change or are modified on the basis of new or conflicting evidence from experimental data or observations.

## Atomic Theory (*continued*)

### Tasks for Instruction and/or Assessment

#### *Journal*

- Keep a record of the individuals or groups you encounter in the study of this topic who work with chemical changes or chemistry-related activities. (112-8)
- What is the essential difference between a law and a theory in science? Give examples to illustrate. (109-14)

#### *Presentation*

- Prepare a multimedia presentation illustrating theories and understandings of atomic theory over the ages (for example, from Democritus to Bohr). (110-3, 111-4, 307-14)

### Resources/Notes

#### Science 9

Science 9 does not have any activities that address outcomes 111-4, 112-8 and 109-14.

Teachers will need to find other resources that

- show technology connections with major achievements in chemistry
- show comparison between a law and theory in science

#### AV

“Introduction to Chemistry”

NATGEOG  
#500783, MM  
(111-4, 112-8)

“What Is Chemistry” VEC

#705166, VH  
(111-4, 112-8)

## Periodic Law

### Outcomes

#### *Students will be expected to*

- identify examples of common elements, and compare their characteristics and atomic structure (307-15)
- describe and explain the role of collecting evidence, finding relationships, and proposing explanations in the development of the periodic table (109-2)
- use a periodic table to predict properties of a family of elements:
  - period
  - family
  - metals
  - metalloids
  - nonmetals (210-1)

### Elaborations–Strategies for Learning and Teaching

Students should be exposed to and observe appropriate non-toxic, non-corrosive safe elements such as C, Cu, Al, Fe, and Zn in order to compare and contrast some of the physical characteristics of these elements. Pictures, pictorial periodic tables, and videos of a variety of the common elements will provide students with the knowledge that individual elements exhibit physical properties that can be unique and yet similar in some cases to other elements.

Students should investigate how Dmitri Mendeleev found a pattern when he arranged the known elements of his day in order of increasing mass. He came to realize that there was a repeating pattern of the elements with regard to differences and similarities in their chemical characteristics. Students can develop a time line of the discovery of the elements that were found after Mendeleev and show how they fit into the proposed periodic table.

The introductory investigation of the periodic table and its uses should focus on the periodic nature of elements and the main organization of groups or elements owing to their similarities because of the periodicity of elements. Students should not memorize components of the periodic table. The focus should be on the use of the periodic table.

Students should be given the opportunity to research the physical and perhaps even some of the chemical properties of one or several common elements, using a variety of resources. The results of this research should be shared with the other students. Posters, oral presentations, and multimedia presentations can be used to communicate their findings. Students can be involved with activities involving a blank Periodic Table or early attempts to organize the elements according to their properties. Students can also develop a time line of discovery of the elements.

Students should use the Periodic table to derive information about the number of protons, neutrons, and electrons in the atoms of common elements. Activities should define the relationship between atomic number and mass number, and students should apply it for identifying isotopes. Learning activities designed to introduce and explore the Periodic Law should be developed. Students can make predictions about a certain element of a particular family of elements based on the characteristics of that family, and verify their predictions. Students can be asked to make inferences about the relationships between and among the various families of elements.

continued...

## Periodic Law

### Tasks for Instruction and/or Assessment

#### *Journal*

- Explain how the use of patterns helped in the development of the periodic table. (109-2)

#### *Paper and Pencil*

- Write an article on a particular element for the school paper. Note its date of discovery, symbol, and usage. (307-15)
- Given an incomplete Periodic Table, predict the atomic structure of missing elements in the first eighteen places. (210-1)
- Compare and contrast a helium atom with a sodium atom with regard to their numbers of protons, neutrons, and electrons. (307-15)
- Research the five most abundant components of air and earth, and create a circle graph to communicate their percentage distributions. (307-15)
- What physical properties would you predict the element chromium to have? (210-1)

#### *Interview*

- What would you predict about the chemical properties of potassium, given the fact that sodium is a very explosive/reactive element? (210-1)

### Resources/Notes

#### Science 9

- Quickly Review Pg 44-47 2.1  
Do Pg 48-49 2.2  
and  
Pg 94-95 3.5  
(307-15)
- Pg 104-119 4.1 up to 4.6  
(109-2, 210-1)

#### AV

“Atoms and Their Electrons - Periodic Table” C-Video  
#705259, VH  
(109-2, 210-1)

“Chemistry: Periodic Table”  
Magic  
#700542, VH  
(109-2, 210-1)

continued...

## Periodic Law (continued)

### Outcomes

#### *Students will be expected to*

- identify the elements and number of atoms, given a chemical formula (307-16)
- provide examples where knowledge of chemistry has resulted in the development of commercial materials (111-1)
- give and explain examples illustrating how limited resources have forced scientists and technologists to develop more efficient ways to extract elements and compounds from nature, or to find or develop appropriate substitutes (112-3)

### Elaborations—Strategies for Learning and Teaching

Students should learn what the component parts of relatively simple chemical formulas are. Students should come to understand that the molecules or compounds are represented in ratio form. For example, in one molecule of water ( $\text{H}_2\text{O}$ ) there are two atoms of hydrogen and one atom of oxygen. Other examples of appropriate chemical formulas to explore would be methane ( $\text{CH}_4$ ), carbon dioxide ( $\text{CO}_2$ ), calcium carbonate ( $\text{CaCO}_3$ ), propane ( $\text{C}_3\text{H}_8$ ), and sodium chloride ( $\text{NaCl}$ ). Students are not expected to learn how molecular and ionic compounds are formed. This will be addressed in grade 10.

Students should become aware of the ways in which our knowledge of chemistry has resulted in the development of the great variety of technologies that affect nearly every aspect of everyday life. Medicines, clothing and building materials, fertilizers and petrochemicals and their derivatives can be explored to see how we have been able to use our knowledge of elements and how they react with other elements and compounds to create a wide variety of chemical compounds.

Students can investigate how the research and development of more efficient and cost-effective ways to extract aluminum from various ores, for example, was precipitated by the accelerated need for lightweight metals in the transportation sector during this century. Other examples of elements and/or compounds that may be investigated are nylon and oil-based rubber.

## Periodic Law (*continued*)

### Tasks for Instruction and/or Assessment

#### *Paper and Pencil*

- Investigate how gold and iron ore are separated from the rocks in which they are formed and report on your findings. (112-3)
- Complete the following table. (307-16)

**Components of Chemical Compounds**

Name of Compound	Chemical Formula	Elements Present	Numbers of Atoms of Each Type
water	H <sub>2</sub> O	hydrogen, oxygen	2 atoms of H, 1 atom of O
carbon dioxide	CO <sub>2</sub>		
methane	CH <sub>4</sub>		
hydrogen gas	H <sub>2</sub>		
glucose	C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>		
vinegar	C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>		

#### *Presentations*

- Create a poster or bulletin-board of products or technologies that are developed because of our knowledge of chemistry. (111-1)
- Research how techniques for the extraction of aluminum from its ores have evolved over time. Create a multimedia presentation of your findings. (112-3)

### Resources/Notes

#### Science 9

- Carefully choose Pg 58-65 2.7 up to 2.10 (307-16)
- Pg 66-73  
Do either 2.11 or 2.12 (not both) (111-1, 112-3)





## ELECTRICITY



**Unit 3**  
**Physical Science:**  
**Characteristics of Electricity**

# Characteristics of Electricity

## Introduction

Technologies based on the principles of electricity are an important part of the students' world. An understanding of the essentials of electrostatics and electric circuits will enable students to connect their learning to everyday applications. Investigations help students to learn the laws of electrostatic charges and study some features and properties of electrostatics and electrical circuits.

Students should be given ample opportunity to plan, design, and construct a variety of circuits, as well as to explore and investigate the relationships that exist among voltage, resistance, and current. Students should gather and organize their findings, and communicate them in an efficient manner.

Students must also be given the chance to investigate the technologies that permit the use of electrical energy and evaluate both the technologies and their direct and indirect impacts on the environment and society in general.

## Focus and Context

The world of today's students is inundated with technology that is linked to and depends on electricity for its function. The focus of this unit is inquiry and the design process, with reference to technology and systems with which the students are familiar. The context revolves around electricity usage in and around the home.

## Science Curriculum Links

Students investigated and explored everyday materials to produce static charges in grade 2. In grade 6, students are involved in a unit of study entitled "Electricity." The conductivity of a variety of solids and liquids, as well as characteristics of static and current electricity, are explored. In this unit, students also investigate simple series and parallel circuits, switches, and the relationship between electricity and magnetism when an electromagnet is used. Various methods by which electricity can be generated are addressed, as well as different factors that can lead to a decrease in electrical energy consumption in school and at home.

In Physics 12, students have the opportunity to study electric field and Coulomb's Law. They will compare the way a motor and a generator function, using the principles of electromagnetism.

## Curriculum Outcomes

STSE	Skills	Knowledge
<p><i>Students will be expected to</i></p> <p><b>Nature of Science and Technology</b></p> <p><b>109-6</b> illustrate how technologies develop as a systematic trial-and-error process that is constrained by cost, the availability and properties of materials, and the laws of nature</p> <p><b>109-14</b> explain the importance of using precise language in science and technology</p> <p><b>110-9</b> compare examples of past and current technologies developed to meet a similar need</p> <p><b>Relationships Between Science and Technology</b></p> <p><b>111-1</b> provide examples of scientific knowledge that have resulted in the development of technologies</p> <p><b>Social and Environmental Contexts of Science and Technology</b></p> <p><b>112-7</b> provide examples of how science and technology affect their lives and their community</p> <p><b>112-10</b> provide examples of science- and technology-based careers in their province or territory</p> <p><b>113-6</b> evaluate the design of a technology and the way it functions on the basis of identified criteria such as cost and the impact on daily life and the environment</p> <p><b>113-9</b> make informed decisions about applications of science and technology, taking into account environmental and social advantages and disadvantages</p> <p><b>113-13</b> propose a course of action on social issues related to science and technology, taking into account human and environmental needs</p>	<p><i>Students will be expected to</i></p> <p><b>Initiating and Planning</b></p> <p><b>208-1</b> rephrase questions in a testable form and clearly define practical problems</p> <p><b>Performing and Recording</b></p> <p><b>209-3</b> use instruments effectively and accurately for collecting data</p> <p><b>Analysing and Interpreting</b></p> <p><b>210-5</b> identify the line of best fit on a scatter plot and interpolate or extrapolate on the basis of the line of best fit</p> <p><b>210-7</b> identify, and suggest explanations for, discrepancies in data</p> <p><b>210-8</b> apply given criteria for evaluating evidence and sources of information</p> <p><b>210-10</b> identify potential sources of error and determine the amount of error in measurement</p> <p><b>Communication and Teamwork</b></p> <p><b>211-2</b> communicate questions, ideas, intentions, plans, and results, using lists, notes in point form, sentences, data tables, graphs, drawings, oral language, and other means</p>	<p><i>Students will be expected to</i></p> <p><b>308-13</b> explain the production of static electrical charges in some common materials</p> <p><b>308-14</b> identify properties of static electrical charges</p> <p><b>308-15</b> compare qualitatively static electricity and electric current</p> <p><b>308-16</b> describe the flow of charge in an electrical circuit</p> <p><b>308-17</b> describe series and parallel circuits involving varying resistance, voltage, and current</p> <p><b>308-18</b> relate electrical energy to domestic power consumption costs</p> <p><b>308-19</b> determine quantitatively the efficiency of an electrical appliance that converts electrical energy to heat energy</p> <p><b>308-20</b> Describe the transfer and conversion of energy from a generating station to the home</p>

## Static Electricity

### Outcomes

#### *Students will be expected to*

- identify properties of static electrical charges:
  - like charges repel
  - unlike charges attract
  - induced charges (308-14)
- explain the production of static electrical charges in some common materials (308-13)
- provide examples of how knowledge of static electricity has resulted in the development of technologies (111-1, 112-7)
- provide examples of careers related to electricity in their community and province (112-10)

### Elaborations–Strategies for Learning and Teaching

Students have had opportunities in their daily life as well as formally in the primary and elementary grades to experience and investigate static electricity. Students may be asked to relate instances where they have encountered static electricity at home or at school. Students can also be asked what it is like when there are periods of no electricity at home or school in order to motivate discussion about its everyday uses and people's expectations of having it available.

Students have explored static charges in grade 3 and investigated static charges in grade 6 in order to define attraction, repulsion, electrons, positive charge, and negative charge. Students should be given opportunities to produce static electric charges with a variety of materials such as flannel, fur, wood, plastic, rubber, and metal. By creating static charges on suspended pith balls and/or balloons, students can further investigate the properties of static electricity with activities that involve attraction, repulsion, and the neutralizing of the static charge. This activity should eventually lead to the accepted scientific understanding and explanation of static charges. Students will be able to utilize what they have learned about the parts of atoms to create models to describe why some objects are considered to be neutral, positively charged, or negatively charged. Students should come to conceptualize and be able to explain the reasons for static electric charges through the transfer of electrons and inductions. Videos using animation to describe what is happening to the electrons are helpful.

Students should investigate technologies that use static electricity in a variety of ways to perform tasks. An investigation of how the school's photocopying machine functions can begin with an invitation to the sales/repair person to explain/demonstrate how static charges are used to create copies. Students can do research or interview a driver of a transport truck that carries flammable products to learn of the technologies and special tires used to reduce static build-up and thus prevent a potentially dangerous spark. Students can test the ability of various fabric softeners to reduce static cling by counting the number of puffed rice pieces a sock or other piece of clothing picks up. Electrostatic precipitators/air filters, electric eels, and lightning rods are other examples of technologies and living things that may be investigated.

Throughout the unit students should note and investigate some of the many careers that are related to electricity production and transfer. In addition, students should become aware of the many people and jobs associated with the production and maintenance of technologies using electricity.

## Static Electricity

### Tasks for Instruction and/or Assessment

#### *Performance/Presentation*

- Create a bulletin-board display of careers associated with electricity in your community and province. (112-9, 112-10)
- Have students demonstrate and explain the production of static charges by using a balloon, some fur and a glass rod. (308-13)
- Use the Internet to research Nikola Tesla and report on his contribution to our knowledge and understanding of static electricity. (308-13, 308-14)

#### *Paper and Pencil*

- Use a sketch or drawing to help you explain why a balloon “sticks” to a wall after it is rubbed on your hair. (308-13, 308-14)
- Interview a photocopy repair person to learn how static electricity plays a part in making copies of a document. Report your findings. (112-7, 308-13, 308-14)
- Interview a person who transports fuel oil or gasoline in a transport truck to learn about the technologies that are used to reduce the chances of static charges being created during the loading and transportation of the fuels. (111-1, 308-13)
- Research lightning rods and make a diagram to illustrate their function. (111-1, 112-7, 308-13)
- Research the Van der Graef generator and report how static charges are produced and used. (308-14)

#### *Interview*

- Explain how a charged balloon can cause an iron nail to have an induced charge without the transfer of electrons. (308-13, 308-14)

#### *Portfolio*

- Maintain a record in a scrapbook of current and past technologies that have utilized static electricity. (112-7)

### Resources/Notes

#### Science 9

- Pg 270-273 9.1 & 9.2 (308-14)
- Pg 274-279 9.3 up to 9.5 and Pg 285 9.8 optional and/or quickly cover Pg 280-285 288-291 (308-13)
- Pg 292-293 9.11 (111-1, 112-7)
- Career Profiles on Pages 284, 304, 355 and 379 will cover. (112-10)  
Choose carefully.

#### AV

- “Electricity” TV Ont #701356, VH (308-14, 308-13)

## Static Electricity and Electric Current

### Outcomes

*Students will be expected to*

- describe the flow of charge in an electrical circuit and describe the factors affecting the amount of resistance in a wire (length, diameter, type):
  - voltage
  - electric current
  - resistance  
(109-14, 308-16)
  
- compare qualitatively static electricity and electric current (308-15)

### Elaborations–Strategies for Learning and Teaching

Students should be exposed to learning situations which illustrate the difficulty of controlling static electricity along a conductor. Students have had the experience of walking across a carpeted floor and getting a “shock” from the transfer of electrons when they touched a doorknob. Students can see that the rapid movement of the electrons can even light a fluorescent light bulb if it is touched against the doorknob.

During this unit, students should have opportunities to explore and investigate, within the context of hands-on/minds-on activities, the notions of voltage (electromotive force), electric current (the flow of electric charge), ampere (rate of flow of electric charge), and resistance in electrical circuits and materials.

Students should be involved in activities where factors influencing resistance in a wire in an electric circuit are investigated. Students can compare and contrast the current in wires of various lengths and various diameters. Students can try blowing through straws of different lengths, diameters, and types in order to experience the varying amounts of force required to blow through the different types of straws. Students can also compare the resistance of various conductors such as copper and nichrome.

Students should be involved in designing and constructing simple circuits using direct current (DC) created with wet cells and dry cells. Students should be able to explain, using the motion of electrons, how a current is being produced. This should be compared and contrasted with static electricity. Potential difference or voltage can be addressed in various activities in which more powerful cells and batteries are used to illustrate the results of more volts. Students should be involved in activities in which the resistance of the circuit varies by increasing or decreasing the number of light bulbs in a circuit or using conducting wires with varying resistances. Commercial multirange meters can be used when doing quantitative evaluations.

Students can be challenged to design and construct a flashlight from a list of materials which meet the following criteria:

- working switch
- can operate with one hand
- durability
- has a replaceable battery or dry cell

Students can evaluate their designs and flashlights according to a number of predetermined criteria.



## Static Electricity and Electric Current

### Tasks for Instruction and/or Assessment

#### *Performance*

- Design a fair test to determine the resistance of a variety of wires in a circuit. (308-16)

#### *Paper and Pencil*

- Create simple circuit diagrams in which the flow of a direct current is indicated. (308-16)
- Compare and contrast electric current and resistance. (109-14)
- Personify an electric current in a short story in order to tell what happens to the current in its journey in a direct system (dry cell-wire-light bulb-wire-dry cell). (308-15, 308-16)
- Research how an electric fence functions and report on its operation, using the terms voltage, electric current, ampere, and resistance. (208-7, 308-16)

#### *Interview*

- What are the essential differences between static and current electricity. (308-15)

#### *Presentation*

- Using straws of various diameters, demonstrate the relationship between voltage and resistance. (308-16)

### Resources/Notes

#### Science 9

- Pg 298-303 and 305  
10.1 up to 10.4  
(109-14, 308-16)
- Pg 314-321 10.9 up to 10.11  
(109-14, 308-16, 308-15)

#### AV

- “Electricity” TV Ont  
#701356, VH  
(109-14, 308-16, 308-15)

## Series and Parallel Circuits

### Outcomes

#### *Students will be expected to*

- rephrase questions in a testable form related to series and parallel circuits (208-1)
- use an ammeter and a voltmeter to measure current and voltage in series and parallel circuits (209-3)
- identify potential sources of error in ammeter and voltmeter readings (210-10)
- identify and suggest explanations for discrepancies in data collected using an ammeter and a voltmeter (210-7)
- present graphically the data from investigation of voltage, current, and resistance in series and parallel circuits (210-5, 211-2)

### Elaborations–Strategies for Learning and Teaching

Students should be encouraged to identify questions and areas of exploration related to series and parallel circuits. Students should be able to transform their questions into a testable form. Students should have opportunities to construct a variety of series and parallel circuits and to test the amount of voltage, current, and resistance in each one, using appropriate ammeters, voltmeters, and/or multirange meters. Students should be encouraged to collect data regarding the voltage and current and present their findings in the form of a table or graph. Students should be asked to make predictions before making actual readings, and they should attempt to give possible reasons for these differences. Activities should be designed in order that students are able to derive the relationships in Ohms' Law.

Students should manipulate and change variables such as the amount of voltage and resistance in a circuit. Students can vary the number of dry cells used, the type of wire, and the number and placement of light bulbs in simple series and parallel circuits.

Students should become familiar with the ammeter as an instrument used to quantitatively measure current. An ammeter and a bulb can be connected in a series, and students can observe that, whenever the bulb is brighter, the ammeter reads a bigger current. A voltmeter can be added to the circuits so that students can measure the voltage of different batteries. Students will probably note that the data they collect from readings of ammeters and voltmeters vary owing to a number of factors. Students should try to identify reasons for these different readings and suggest reasons for their data differences. Students can "feel" the resistance of a circuit if a hand-held generator is available. By adding resistance (lamps), students will appreciate the extra energy it takes to maintain brightness.

Students can construct, or design on paper, various series and parallel circuits and challenge other groups of students to predict and determine the voltage, current, and resistance in the circuit, as well as the type of circuit constructed or designed. Lines of best fit can be determined in scatter plots that communicate the relationship between voltage and the number of resistance branches in parallel circuits, for example. Students can investigate Christmas tree lights that are in series, as well as those that are in parallel. Note and discuss the positive and negative aspects of each.

continued...

## Series and Parallel Circuits

### Tasks for Instruction and/or Assessment

#### *Performance*

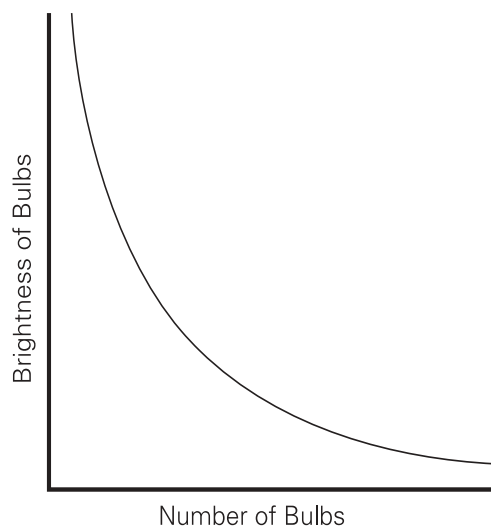
- Demonstrate the ability to accurately read an ammeter/voltmeter, using a constructed circuit. Ask why they may not be exact readings. (209-3, 210-10)

#### *Journal*

- List three potential sources of error when taking a voltage or amperage reading. (210-10)
- Something that I didn't realize before I explored different types of circuits was ... A question that I would like to investigate about series and parallel circuits is ... (208-1, 209-3)

#### *Paper and Pencil*

- In a lab report, graph the relationships between current and resistance of a number of circuits. (210-5, 211-2)
- Create a scatterplot graph of the data collected in class from voltage versus current activities. (210-5, 211-12)
- Use a sketch of your circuit to illustrate how one might get discrepant readings from a voltmeter. (210-7)
- Would the following graph illustrate what would happen in a series or parallel circuit? Explain your reasoning. (210-5, 211-2)



continued...

### Resources/Notes

#### Science 9

- Pg 314-327  
10.9 up to 10-13  
(208-1, 209-3, 210-10, 210-7, 210-5, 211-2)

#### AV

“Electric Circuits” Access

Film 1 “Current Electricity”  
#705545, VH

Film 2 “Ohm’s Law”  
#705546, VH

Film 3 “Series and Parallel”  
#705547, VH

These films will address a variety of electrical outcomes.

## Series and Parallel Circuits *(continued)*

### Outcomes

*Students will be expected to*

- describe series and parallel (maximum two resistors) circuits involving varying resistance, voltage, and current, using Ohms' Law:
  - draw circuit diagrams, using circuit symbols for a cell, switch, battery, lamp, resistor, multirange meter (308-17)

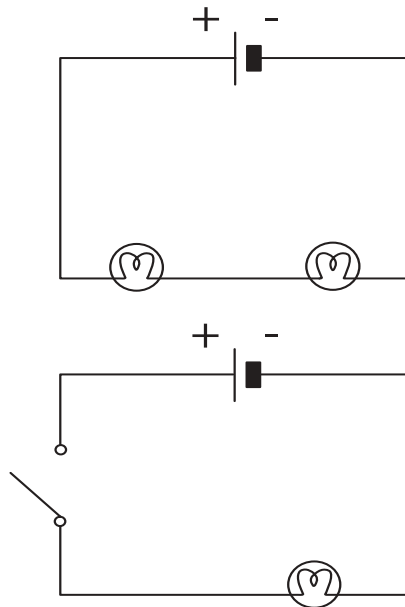
### Elaborations–Strategies for Learning and Teaching

Activities should demonstrate Ohms' Law quantitatively. After constructing a circuit that includes a battery, a resistor (for example, lamp), and an ammeter, students can investigate what happens to the current as other resistors (lamps) are added to the series circuit. Students can add batteries to the circuit to explore voltage and current readings in the circuit. Through a number of guided activities and explorations involving study of the relationships between current, voltage, and resistance, students should discover that the amount of current in a circuit is directly proportional to the voltage (number of dry cells) and is inversely proportional to the resistance of the circuit. This will lead to an understanding and appreciation of Ohm's law, which states that

$$\text{current} = \frac{\text{voltage}}{\text{resistance}} \quad \text{or} \quad \text{amperes} = \frac{\text{volts}}{\text{ohms}}$$

Measurements should include only those involving a single resistance. Investigation should only involve one resistance at a time. Students should not solve problems for an unknown resistance nor for multiple resistances.

### Series Circuit



## Series and Parallel Circuits (*continued*)

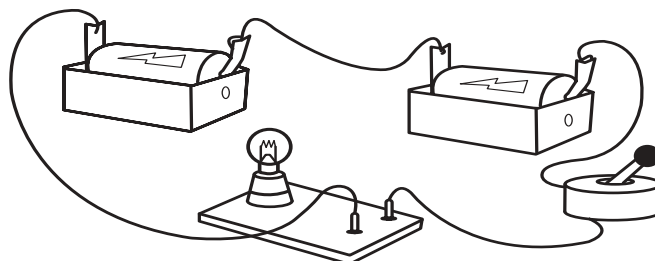
### Tasks for Instruction and/or Assessment

#### *Performance*

- Construct both parallel and series circuits, using provided materials, and explain the differences between them. (308-17)

#### *Paper and Pencil*

- Determine the resistance of a circuit, given the voltage and current in a dry cell and lightbulb circuit. (308-17)
- What is the resistance of an electrical appliance that draws 22 amperes when connected to a 220-volt circuit? (308-17)
- Illustrate in a series of drawings or sketches the relationships between amperage and resistance within a circuit when the voltage remains constant. (308-17)
- Investigate why the lights dim in homes with older wiring. (308-17)
- Draw a circuit diagram for the following: (308-17)



### Resources/Notes

#### Science 9

See Column 4, page 49.

## Use of Electrical Energy

### Outcomes

#### *Students will be expected to*

- relate electrical energy to domestic power consumption costs:
  - watt as a unit of power  
(1 W = 1 J/s) (308-18)
- explain that precise language is required to properly interpret Energuide labels and to understand a utility bill (109-14)
- compare examples of past and current technologies that used current electricity to meet similar needs (110-9)
- determine quantitatively the efficiency of an electrical appliance that converts electrical energy to heat energy (308-19)

### Elaborations–Strategies for Learning and Teaching

The study of the uses of electrical energy provides an appropriate context in which to explore and investigate the relationships among energy, work (joule = 1 newton x 1 metre), and power (1 watt = 1 J/s). Students ought to be given the chance to explore and experience a joule of work.

Explorations and discussions about the amounts of energy, work, and power required to operate electric technologies will help the students gain an understanding and appreciation of these concepts.

Students can be challenged to determine kWh, given an example of a large figure involving watts. Students should come to understand the reason for using kWh as a convenient way of expressing energy usage. Students should research and determine the energy consumption ratings of a variety of home appliances. In many cases, the energy consumption ratings are indicated on the “Energuide/kWh” labels. Students can compare and contrast various electrical appliances that convert electrical energy to heat energy. Students can compare and contrast old and new models of irons and toasters, for example, and suggest reasons for differences in efficiencies.

Students should come to understand that not all the electrical energy that is used to make a stove element hot is transferred directly to the water in a cooking pot. Some of the electrical energy is converted to heat energy, some is converted to other forms such as light energy, and some is lost to the surroundings. Students should be able to determine the efficiency of an electrical appliance, given the energy used and the energy of the system. For example, if an electric kettle uses 150,000 J or 150 kJ to bring the water to a boil, but the water itself has only a 140,000 J or 140 kJ of energy difference, students should be able to determine that the kettle is 93% efficient. Students should come to realize that energy exists in a variety of forms and can be converted to a variety of forms.

Some time should be allotted to the study and discussion of the design and efficiency of a number of common electrical appliances and how much it costs to operate them. Students can compare monthly electric utility bills and suggest reasons for differences in kWh used (season, types of appliances used, time appliances are used, for example). Students should associate the use and efficiency of electrical appliances with their impact on our environment and our way of life.

Students can carry out investigations involving fuses and breaker switches during their study of resistance in circuits.

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## Use of Electrical Energy

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### Tasks for Instruction and/or Assessment

#### *Paper and Pencil*

- Suggest alternative sources of electrical energy that might be less costly for your region. (308-18)
- Write a letter to your local electric utility company to inquire how your energy consumption rates are determined. (308-18)

#### *Interview*

- Ask, “What is the efficiency of an electric stove if it requires 30,000 kJ and only 25,000 kJ is used to heat a pot of water? What do you think happened to the rest of the energy?” (308-19)

#### *Presentation*

- Create a poster based on an Enersave label on one of the appliances in your home. Explain the terms found on the label. (109-14)
- Create a mural or poster that shows the development of electrical technologies, such as the washing machine or radio, from their discovery to present day. (110-9)

### Resources/Notes

#### Science 9

- Pg 332-339 11.1 up to 11.4 (308-18, 308-19)
- Pg 370-375 12.4 up to 12.6 (109-14, 308-19)
- Pg 376-378 12.7 (308.19)

Outcome 110-9 is not addressed in the text.

## Electricity and the Environment

### Outcomes

#### *Students will be expected to*

- describe the transfer and conversion of energy from a generating station to the home (308-20)
- evaluate evidence and sources of information when conducting research on electrical energy production and its impact on the environment (210-8)
- select recent data while conducting research on the environmental problems associated with various types of electrical energy production (113-6, 210-8)
- propose a course of action that reduces the consumption of electrical energy (113-9, 113-13)
- give examples of the development of alternative sources of energy (such as wind generators and solar energy) that are a result of cost and the availability and properties of materials (109-6)

### Elaborations–Strategies for Learning and Teaching

The electrical energy that is used by homes and industry originates in electric generators in which a revolving magnet generates the electrical energy. Students investigated the link between magnets and electricity in grade 6. Students have the chance to investigate this relationship further in senior high. At this level, students need only be aware that this relationship exists (generator-electricity, electricity-motor). Students are expected to be able to trace the path of energy conversion and transfer from source to use. For example: wind energy-windmill generator-utility lines-porch light.

Students should investigate how electrical energy is produced and transported to their community. If there are a number of ways electricity is generated, they can be compared and contrasted.

Students should examine and discuss the positions of groups who support, and groups that are against, certain technologies that produce electrical energy. The damming of rivers in Labrador and coal-fired generators in New Brunswick can be used, for example, to evaluate evidence from a variety of sources.

Students should identify and propose a course of action that reduces electrical energy consumption either at home or in society in general. Students should be able to substantiate their course of action with evidence gathered or constructed throughout the course of study of this unit. Note whether students modify their behaviour with regard to energy usage and consumption as this behaviour is related to the attitudinal outcome of stewardship.

Examples of alternative sources of energy, such as windmills, solar panels, and wood chips, can be highlighted and discussed when investigating and exploring sources of electrical energy. These sources can be compared and contrasted in terms of cost, efficiency, and impact on the environment. Students should come to realize that the availability of energy resources in a region usually dictates the types of energy used in that region.



## Electricity and the Environment

### Tasks for Instruction and/or Assessment

#### *Observation*

- Conduct a debate on the use of nuclear energy to generate electric energy. (111-6, 210-8)

#### *Journal*

- How would you contribute to a cleaner or healthier world by reducing your energy consumption? (113-9, 113-13)

#### *Paper and Pencil*

- Make note of all of the uses of electricity throughout the day and note where savings can be made. (113-13)
- Write to an electric utility to ask where their energy is generated and how it is transferred to a customer location. (308-20)
- Note ways in which your school can possibly reduce its use of electrical energy and make your proposal to the school administration. (113-13)
- Research alternative sources of energy production in your community or province and present a report on your findings. (109-6)
- Compare technologies (for example, appliances) that use electricity in industrialized countries with those that do not use electricity, for example, in non-industrialized countries. (113-9, 113-13)
- Compare and contrast a fan and an air-conditioner with regard to how much electric energy each requires, their costs, and their impact on the environment in terms of cooling or the energy needs to run the device. (113-6, 210-8)

#### *Presentation*

- Create a bulletin-board display of various technologies that require electrical energy and place them into categories on the basis of their cost and their impact on the environment. (113-6)
- Use a diagram or drawing, or picture poster to illustrate how the energy that your TV uses is generated and transferred to your location. (308-20)

### Resources/Notes

#### Science 9

- Pg 342-357  
Carefully select - Do not do all!  
11.6 up to 11-11  
(308-20, 210-8, 113-6, 109-6)
- Pg 380-385 12.8-12.10  
(113-9, 113-13)

#### AV

“Energy” THA  
#704133, VH  
(113-6, 109-6)







**Unit 4**  
**Earth and Space Science:**  
**Space Exploration**

# Space Exploration

## Introduction

Innovations and advancements in computers and other technologies related to astronomy in the past 20 years have enabled astronomers to collect new evidence about the nature of the universe. The study of space exploration is an opportunity for students to develop an understanding of the origin, evolution, and components of the solar system and the universe. As students become more aware of the solar system and the universe and understand them better, they develop a greater appreciation of them and how they function.

Students will continue their study of our solar system by exploring the various theories that exist to explain its formation. As well, students will learn about other parts of the universe such as galaxies, red giants, black holes, and quasars.

## Focus and Context

The focus of this unit is inquiry. In addition to learning more about space and what is in it, students should learn how we have come to know and understand the solar system and the rest of the universe.

## Science Curriculum Links

In the unit “Daily and Seasonal Changes” in primary science, students are introduced to the concept of daily and seasonal cycles. In grade 6, students describe the physical characteristics of components of the solar system—specifically, the sun, planets, moons, comets, asteroids, and meteors. They also investigate how the relative positions of the earth, the moon, and the sun are responsible for the moon phases, eclipses, and tides. Major constellations are investigated and identified.

Further in high school, students have the option of continuing their study of astronomy. They will continue to compare and contrast a variety of theories about the origin of the universe. Also, they will describe the life cycle of stars and compare the composition of stars at different stages of their life cycles.

## Curriculum Outcomes

STSE	Skills	Knowledge
<p><i>Students will be expected to</i></p> <p><b>Nature of Science and Technology</b></p> <p><b>109-3</b> describe and explain the role of experimentation, collecting evidence, finding relationships, proposing explanations, and imagination in the development of scientific knowledge</p> <p><b>109-11</b> relate personal activities and various scientific and technological endeavours to specific science disciplines and interdisciplinary study areas</p> <p><b>110-6</b> explain the need for new evidence in order to continually test existing theories</p> <p><b>Relationships Between Science and Technology</b></p> <p><b>111-5</b> describe the science underlying particular technologies designed to explore natural phenomena, extend human capabilities, or solve practical problems</p> <p><b>Social and Environmental Contexts of Science and Technology</b></p> <p><b>112-6</b> provide examples of how Canadian research projects in science and technology are supported</p> <p><b>112-11</b> describe examples of science- and technology-based careers in Canada, and relate these careers to their studies in science</p>	<p><i>Students will be expected to</i></p> <p><b>Initiating and Planning</b></p> <p><b>208-4</b> propose alternative solutions to a given practical problem, select one, and develop a plan</p> <p><b>Performing and Recording</b></p> <p><b>209-4</b> organize data, using a format that is appropriate to the task or experiment</p> <p><b>210-9</b> calculate theoretical values of a variable</p> <p><b>Analysing and Interpreting</b></p> <p><b>210-16</b> identify new questions and problems that arise from what was learned</p> <p><b>Communication and Teamwork</b></p> <p><b>211-1</b> receive, understand, and act on the ideas of others</p> <p><b>211-3</b> work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise</p> <p><b>211-5</b> defend a given position on an issue or problem, on the basis of their findings</p>	<p><i>Students will be expected to</i></p> <p><b>312-1</b> describe theories on the formation of the solar system</p> <p><b>312-2</b> describe and classify the major components of the universe</p> <p><b>312-3</b> describe theories on the origin and evolution of the universe</p> <p><b>312-4</b> describe and explain the apparent motion of celestial bodies</p> <p><b>312-5</b> describe the composition and characteristics of the components of the solar system</p> <p><b>312-6</b> describe the effects of solar phenomena on Earth</p>

## The Beginnings of the Solar System

### Outcomes

#### *Students will be expected to*

- describe and explain the apparent motion of celestial bodies:
  - moon
  - sun
  - planets
  - comets
  - asteroids (312-4)
  
- describe theories on the formation of the solar system (312-1)

### Elaborations–Strategies for Learning and Teaching

This unit can begin with an investigation into the planets that are visible at the time of year that this unit is being addressed. As well, students can be asked to identify any constellations that are obvious at this time of year. A “What I Know-Want to Know-Learned” (K-W-L) activity centred around this unit will indicate students’ awareness of concepts in astronomy, as well as provide a time for them to reflect on their understanding of what they have learned formally in grade 6 about the solar system and stars.

Students should investigate the moon, sun, and planets in order to describe their apparent motion. Students should be involved in activities that demonstrate rotation and revolution of planets and moons. Students should also be involved with activities that illustrate the paths or orbits of the planets and our moon. Students can use plastic cups to trace and compare circular and elliptical orbits. The orbits of comets and asteroids should be explored.

Students should understand that our understanding of Earth’s revolutionary motion around the sun is relatively recent (Copernicus, 1543). Through readings and videos, students can be exposed to the societal and scientific issues involved in the evolution of our understanding of the solar system. Particular attention should be paid to the contributions of Kepler and Galileo.

Students should investigate the major scientific theories that try to explain the formation and origin of the solar system. One must be sensitive to the fact that scientific and religious theories were, for most of recorded history, one and the same. Students should recognize the fact that evidence and data gathered from direct and indirect observation have led to the present theories that exist about the origin and formation of Earth and the rest of the solar system.

Students should understand that theories about the origin and formation of the solar system and the universe themselves change and evolve on the basis of evidence and ideas that bring new light to our understandings of these events.

It is generally accepted that our solar system is one-half to one-third as old as the universe. Most scientists believe that the parts of the present solar system were formed from a cosmic cloud about six billion years ago.



## The Beginnings of the Solar System

### Tasks for Instruction and/or Assessment

#### *Journal*

- On the basis of how we come to develop theories regarding the formation of the solar system, suggest improvements in technologies or new technologies which may refine our understanding of this topic. (312-1)
- What questions or problems might we have regarding the orbits of planets, comets, and asteroids? (312-4)

#### *Paper and Pencil*

- Investigate Ptolemy's theory of the motion of the planets and compare it to our present understanding. (312-4)
- Research and report upon the events that led to changes in the scientific theory that the earth was the centre of the universe. (312-1)

#### *Interview*

- Why might it be misleading to say that Pluto is the last planet in our solar system? (312-4)

#### *Presentation*

- Research and report upon the accepted view and understanding of a planetary movement during the time of Galileo. (312-4)
- Create a skit that demonstrates/illustrates the "apparent" movement of the sun as compared to the earth. (312-4)
- Make a drawing that compares and contrasts the orbits of a planet and a comet. (312-4)

### Resources/Notes

#### Science 9

- Pg 400-402 13.1  
Pg 418-433 13.10 up to 13.15  
(312-4)
- Pg 472-473 15.2  
(312-1)

#### AV

"Solar System" MAGIC  
#705388, VH  
(312-4, 312-1)

## Composition and Characteristics of the Solar System

### Outcomes

#### *Students will be expected to*

- describe the composition and characteristics of the following components of the solar system:
  - terrestrial and gas planets and Pluto
  - periodicity of comets
  - asteroids/meteors (312-5)

- explain the need for new evidence in order to continually test existing theories about the composition and origin of our solar system and galaxies (110-6)

### Elaborations–Strategies for Learning and Teaching

At this level, students should investigate and learn about the two main classes of planets in our solar system: terrestrial planets and the gaseous giant planets. Students should be able to compare and contrast the inner terrestrial planets (Mercury, Venus, Earth, and Mars) with the outer gaseous planets (Jupiter, Saturn, Uranus, and Neptune). In addition, Pluto should be investigated in order to determine its similarities and differences when compared with the other planets.

Students have been introduced to comets in grade 6. In grade 9, students should come to realize that comets have unique orbits around the sun and tend to follow a pattern with regard to their passage by Earth and the sun. Students may investigate a well-known comet such as Halley’s Comet in order to learn about its periodic nature and why it is easier to view during some pass-bys than during others. Asteroids and meteors should be explored in order to learn about their similarities and differences.

Students should come to understand that the main location for asteroids is between Mars and Jupiter and that most other asteroids have orbits similar to those of the planets. Students should come to understand that some asteroids have irregular orbits owing to collisions and gravitational attraction of the planets. Evidence on our planet, as well as on other planets, of meteor/asteroid impacts should be addressed.

Previously, students studied the physical characteristics of the various components (that is, comets, asteroids, meteors) of our solar system. Students should explore the nature of comets, asteroids and meteors at this level. Exploration of the periodicity of comets will provide an opportunity to learn how predictions are made regarding these part-time members of our solar system.

Students should explore the ways by which scientists gather information about our solar system. Earth-based telescopes, the Hubble telescope, and planetary space missions should be highlighted in this exploration.

Students can view pictures and/or videos of various components of the solar system taken from earth and from satellites and spacecraft in order to compare and contrast the quality of the two. In this way, students will learn how our understanding of the solar system has changed and improved with improved technologies. The “face” on Mars may be used as an example to illustrate how newer and more effective data-collecting technologies help reshape our thinking about certain theories.

continued...

## Composition and Characteristics of the Solar System

### Tasks for Instruction and/or Assessment

#### *Paper and Pencil*

- Given the recorded periodicity of a given comet, make a prediction concerning its next appearance close to Earth. (312-5)
- Research, in order to compare and contrast, the differences and similarities of Earth-based telescopes and the Hubble telescope. Prepare a written report or a pictorial report. (110-6, 210-3)
- Write a travel brochure that will advertise and promote a planet in our solar system. (312-5)
- Give one of the most distinguishing features for each planet and challenge your teacher/classmate to give the planet's name. (312-5)
- Determine how many times bigger or smaller each planet is than Earth. (312-5)
- Make-believe that you are planning a colony on another planet in our solar system. Pick the planet you would choose and tell why you choose that planet for the colony. (312-5)

#### *Interview*

- Why would images appear clearer from the Hubble telescope than from an earth-based telescope? (110-6)

#### *Presentation*

- Given a table containing the atmospheric composition of Earth's nearest planetary neighbours, create an appropriate graph to communicate the information. (312-5)
- Make posters that compare Earth's orbit with those of several other planets. (312-5)
- Create a table that illustrates the common features of the inner terrestrial planets and the outer gaseous planets. (312-5)

continued...

### Resources/Notes

#### Science 9

– Pg 418-433 13.10 up to 13.15  
(312-5, 110-6)

Further Pg 438-439 14.1  
and Pg 448-450 14.6 can be  
covered (optional) to help  
address 110-6

#### AV

“Space Science: Comets, Meteors  
and Asteroids” CORONET  
#701631, VH  
(312-5)

## Composition and Characteristics of the Solar System *(continued)*

### Outcomes

#### *Students will be expected to*

- provide examples of how the Canadian Government and/or Canadian Space Agency is involved in research projects about space (112-6)
- defend their position regarding societal support for space exploration (211-5)
  
- describe the effects of solar phenomena on Earth:
  - sunspots
  - solar flares
  - solar radiation (312-6)
  
- in small groups, design and describe a model space station on the basis of what they have learned about the sun's influences on Earth (208-4, 211-1)

### Elaborations–Strategies for Learning and Teaching

Students can research our country's involvement in and its contributions to space exploration and the understanding of our solar system. Students should research, discuss, and debate the “need” to explore the solar system and the financial costs associated with space exploration. Canada's role, primarily through the Canadian Space Agency or NASA, can be investigated. Students should also recognize factors, other than purely scientific, that have motivated the exploration of our solar system. Students should be asked to express and defend their position on the continued support for space exploration from the point of view of Canadians and world citizens. Note whether students recognize the potential conflicts of different points of view on the time, energy and resources allotted to space exploration.

In grade 6, students have observed and studied the relative positions of Earth, the moon, and the sun in order to explain how these are responsible for moon phases, eclipses, and tides. Students should become aware of the fact that the sun influences almost all natural phenomena on Earth. From being the source of energy for green plants to impacting upon communication systems, the sun's influence is ever present. Students already have had the chance to associate the sun's effect on weather on Earth, and will do this in greater detail in grade 10.

Students may request information from the Canadian Cancer Society to inquire how and why exposure to sunlight can be dangerous. Students should also research and identify various methods and technologies used to protect our bodies and eyes from harmful UV rays. Recent studies on the impact that UV rays have on plankton and fish fry in the ocean can be investigated.

The discovery of sunspots and their properties can be approached in this study of the sun, to illustrate how one discovery can lead to other discoveries. For example, the fact that the sunspots move indicate that the sun actually rotates. Students can investigate, co-operatively and collaboratively, the periodicity of sunspot activity on the sun and how some types of solar activity have influences on electromagnetic waves (radio, TV, for example) created on Earth. The “northern lights” or aurora borealis and the “southern lights” or aurora australis may be investigated to demonstrate another observable influence the sun has on earth.

Students should work in small groups to design a “space station” that will safeguard the occupants from the effects of solar phenomena. Students will also need to consider resources that they will require, as well as how these resources can be reused and/or recycled in such an environment. Students will then present or report, using visual aids, what their plan encompasses.

## Composition and Characteristics of the Solar System *(continued)*

### Tasks for Instruction and/or Assessment

#### *Performance*

- Work collaboratively to research and design a model space station. (208-4, 211-1)

#### *Paper and Pencil*

- Research and report on various sunscreens and sunblocks and why people use them. (312-6)

#### *Interview*

- Contact the Canadian Space Agency to find out its mandate and current activities (<http://apwww.stmarys.ca/space>). (112-6)

#### *Presentation*

- Make a poster/large drawing showing what happens to the Earth's magnetic field when it is affected by solar flares. (312-6)
- Make a model or drawing of the sun in which solar flares and sunspots are illustrated. (312-6)

#### *Portfolio*

- Write a summary of the most important/interesting thing you learned about our universe in this unit. (various)
- Predict what might happen to the Earth and life on Earth if the sun were one light-year away. (312-6)

### Resources/Notes

#### Science 9

- Pg 498-499 16.6 (112-6)
- Pg 511 16.12 (211-5)
- Pg 452-455 14.7 & 14.8 (312-6)
- Pg 498-503 16.6 & 16.7 (208-4, 211-1)

#### AV

“Taking the Sun’s Pulse” FILMW #705799, VH (312-6, 208-4, 211-1)

## Composition and Characteristics of the Universe

### Outcomes

#### *Students will be expected to*

- describe theories on the origin and evolution of the universe:
  - big bang theory
  - oscillating theory (312-3)
  
- describe and classify the major components of the universe:
  - nebulae
  - galaxies
  - giant stars
  - dwarf stars
  - quasars
  - black holes (312-2)
  
- calculate the travel time to a distant star at a given speed:
  - define and explain a light year (210-9)

### Elaborations–Strategies for Learning and Teaching

The generally accepted theory that stars form from large clouds of dust and gas called nebulae should be examined. An investigation of the type of light emitted by a star may lead to a discussion of spectra signature. This can naturally lead into the various types of stars known to exist in the universe. Students should become familiar with the current theories about the origin and evolution of the universe. The big bang theory suggests that, because of the evidence we have for an expanding universe, the universe must have been more compact at an earlier time. Scientists estimate that the present matter in the universe was compressed together into a hot, dense mass 15 to 20 billion years ago. This matter began to move outward after a massive explosion.

The oscillating theory suggests that the universe will expand to a certain point in time and then, because of the forces of gravitation among the stars and galaxies, contract. Some scientists believe that this will result in another big bang.

Students should be exposed to the types of galaxies known to exist in the universe. The main types are the elliptical galaxies, spiral galaxies, and irregular galaxies. Students should be challenged to calculate the travel time to a well-known star or galaxy at a given speed. The concept of the light-year could be addressed here.

Students can view videos of components of the universe such as galaxies, nebulae, and black holes. Students should come to realize that nebulae are the supposed birthplaces of stars and that most stars are found in groups called galaxies. Students should become aware of the fact that stars, including of course our sun, have a specific lifetime and go through various stages (types of stars) before expending their energy or collapsing upon themselves and becoming black holes.

Students should develop an introductory understanding of the unit light-year. A light-year is the distance light travels in space in one year. Light travels at 300 000 km/s or about 9.5 trillion km/year. Students may find it interesting to explore and determine how long it would take us to reach some of our nearest star neighbours at the speeds travelled by present space shuttles or probes.

continued...

## Composition and Characteristics of the Universe

### Tasks for Instruction and/or Assessment

#### *Journal*

- Given a flashlight and a powerful spotlight, explain how you can make both appear to be the same brightness. (312-2)

#### *Pencil and Paper*

- Write a narrative for a fictional radio/tv program in which theories of the formation and evolution of the universe are discussed. (312-3)
- Develop a concept map for the following terms: sun, nebula, galaxy, giant star, dwarf star, quasar, black hole. (312-2)
- Write a science-fiction story in which the following terms are used and explained: nebula, galaxy, giant star, dwarf star, quasar, black hole. (312-2)
- A given star is 6 light-years from Earth. Given that a particular space craft can travel at 14 km/s, determine how long it will take to reach the star. (210-9)

#### *Presentation*

- Create a bulletin board of technologies used to explore and investigate the universe and associate the science with each technology [for example, telescope (optics), radio telescope (physics)]. (109-3, 111-5, 112-11)

### Resources/Notes

#### Science 9

\*choose carefully\*

- Pg 438-439 14.1
- Pg 444-447 14.4 and 14.5
- Pg 456-463 14.9 up to 14.11
- Pg 468-471 15.1 (312-2, 210-9)
- Pg 475-481 15.3 up to 15.6 (312-3)

#### AV

“Universe: The Vast Frontier”  
KINECTIC  
#705411, VH  
(312-3, 312-2)

continued...

## Composition and Characteristics of the Universe *(continued)*

### Outcomes

#### *Students will be expected to*

- explain how data provided by technologies contribute to our knowledge of the universe (109-3)
- working collaboratively with group members, prepare a comparative data table on various stars, and design a model to represent some of these stars relative to our solar system (209-4, 211-1, 211-3)
- describe examples of science- and technology-based careers in Canada that are associated with space exploration (112-11)
- identify new questions and problems that arise from the study of space exploration (210-16)
- describe the science underlying three technologies designed to explore space (109-11, 111-5)

### Elaborations—Strategies for Learning and Teaching

Theories that try to explain the origin of the universe and what will happen to it are derived from direct and indirect evidence. This section provides a very good opportunity for students to learn how theories about the origin and evolution of the universe are developed through analysis of data obtained from light telescopes, spectrometers, and radio telescopes. Students should have the opportunity to investigate how these and other technologies have allowed scientists to collect data to share and compare, in order to prove or disprove theories about the origin and evolution of the universe.

Students can begin their study of the components of the universe by researching the constituent parts of galaxies: the various types of stars. Print, non-print, and electronic media may be used to research the location of the stars, their distance from Earth, their magnitude, size, and/or other similar information. Students should organize their information into a data table and use that information to create a model to demonstrate, for example, relative sizes of the stars. Posters or classroom models can be created to illustrate the diameters of various types of stars.

This section also provides an excellent opportunity to demonstrate and illustrate the wide variety of professions that work together when studying various aspects of the universe. Astrophysicists, computer programmers, electrical engineers, lens makers, and many others may be highlighted during the study of the unit. Students should be able to describe several technologies used to explore the universe and the sciences associated with them.

Students should be encouraged to identify questions and problems associated with theories and/or topics related to the universe such as “What are the limits of space travel?” “How old is the universe?” and “Are there other planetary systems similar to ours in the Universe?”

Students should be able to associate a variety of sciences with technologies designed to explore space. The Hubble telescope (optics and electromagnetic waves—physics), preserved food and propulsion (chemistry), and radio telescopes (physics) provide opportunities for investigation of sciences related to various technologies used to explore space.

Students should investigate the basic science of several technologies. Jet propulsion (chemical reaction and forces), reflecting and refracting telescopes (properties of light), and radio telescopes (electromagnetic radiation) are some of the technologies that may be explored.



## Composition and Characteristics of the Universe *(continued)*

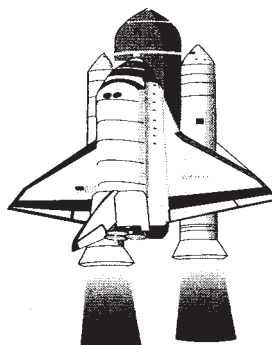
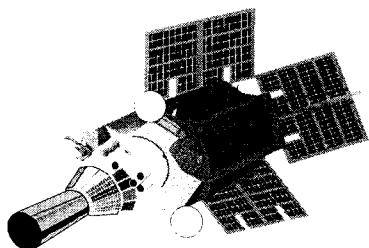
### Tasks for Instruction and/or Assessment

#### *Journal*

- A small child says that a bright star must be closer to earth than a less bright star. What can you do to illustrate that this is not always the case? (209-4, 211-1, 211-3, 210-9)
- Why may it be possible to leave for another star without realizing that it no longer exists? (210-9)

#### *Paper and Pencil*

- Given the travel speed of the space shuttle, calculate the time it would take to get to a particular star. (210-9)
- If an object explodes five light-years away, when did the explosion actually occur? (210-9)
- Using the two drawings below, identify and describe several technologies and the sciences associated with them. (109-11, 111-5)



#### *Interview*

- Why would light from a supernova be “old news”? (210-9)

#### *Presentation*

- Research and explain how we have come to understand the planetary motion/orbits and solar system with respect to our galaxy and other galaxies. (209-4, 211-1, 211-3)
- Prepare a model/poster of the various types of stars investigated in this unit. (312-2)

### Resources/Notes

#### Science 9

\*choose carefully\*

- Pg 480-483 15.6 and 15.7  
Pg 448-450 14.6  
(109-3)
- Pg 468-469 15.1  
(209-11, 211-1, 211-3)
- Career Profiles on Pg 429, 451,  
474 and 507  
(112-11)
- Pg 566 16.9  
(109-11, 111-5)
- Pg 508-510 16.10 and 16.11  
(210-16)

#### AV

“Space Stations Film Series”  
CANL

- Film 1 “Uses International”  
#702769, VH
- Film 2 “Today’s Reality”  
#702768, VH
- Film 3 “Zero Gravity”  
#704530, VH  
(112-11, 210-16, 109-11,  
111-5)







## Sample Pathways

This section contains Sample Pathways of resource material to be used by teachers as they work through the curriculum guide. These are provided as a suggested way to help cover as many outcomes as possible in an allotted time frame that spans approximately 20 class periods per unit. For example, if a teacher decides to follow the 16- 20 suggested lessons they will be assured of covering a vast majority of the prescribed outcomes listed in this curriculum guide. Tests and quizzes are not listed in the pathways but they must be part of a teacher's overall unit plan. Some teachers may have an opportunity to cover some of the alternative text sections if they feel those sections cover outcomes better.

Though the sample pathways provided are specific to a resource, teachers are always encouraged to use additional/alternative resources to help address a specific outcome. The blank Pathway sheets are provided so that teachers can photocopy and design their own "pathways" and lesson time-lines. A 4-5 week period is suggested to cover a particular unit of science content.

Teachers are encouraged to use the Pathways in order to allow time for Science Fairs, Science Olympics, and other science related activities that are an important component in helping students develop scientific literacy.



# Sample Unit 1

## Critical Pathway (Life Sciences: Reproduction – Science 9)

Lesson	Text Section(s)	OR	Alternative Text Section(s)	► Outcome(s)
1	5.2		5.1	305-1, 109-14
2	5.4			304-11
3	5.5			304-11, 109-14
4	5.6			305-1, 304-11, 109-14
5	5.7		5.11	210-2, 210-4, 210-9
6	5.8		5.9	305-2, 305-3
7	5.12			210-2, 210-4, 210-9, 304-11
8	6.1			305-1, 110-3
9	6.2		6.3	305-5, 113-10
10	6.4			209-5, 210-8, 305-5
11	6.6		6.7 or 6.8 or 6.9	111-1, 209-5, 210-8, 305-2
12	7.1			305-3
13	7.2			304-11, 109-14
14	7.3			208-2, 209-6, 211-2
15	7.4			208-2, 209-6, 211-2
16	7.10			209-5, 210-8
17	7.11			209-5, 210-8





# Sample Unit 2

## Critical Pathway (Physical Science: Atoms and Elements – Science 9)

Lesson	Text Section(s)	OR	Alternative Text Section(s)	► Outcome(s)
1	1.1			209-7, 307-13
2	1.2			307-12
3	1.3		1.5	307-12, 210-2
4	1.6			210-11, 210-16, 307-13
5	1.7		1.9	210-11, 210-16, 307-13
6	1.8			210-11, 210-16, 307-13
7	Review 2.1		2.2	307-15
8	2.7		2.8 or 2.9	307-16
9	2.10			307-16
10	2.12		2.11	111-1, 112-3
11	3.2		3.1	110-1, 110-3
12	3.3			109-13, 307-14
13	3.4		3.5	110-3
14	3.6			109-13, 307-14
15	4.1			109-2, 210-1
16	4.2			109-2, 210-1
17	4.3			109-2, 210-1
18	4.4			109-2, 210-1
19	4.5		4.6	109-2, 210-1



# Sample Unit 3

## Critical Pathway (Physical Science: Characteristics of Electricity – Science 9)

Lesson	Text Section(s)	OR	Alternative Text Section(s)	► Outcome(s)
1	9.1			308-14
2	9.2 / 9.3		9.4 or 9.5	308-14, 308-13
3	9.8			308-13
4	9.9			308-13
5	9.11			111-1, 112-7
6	10.1		10.2	109-14, 308-16
7	10.3			109-14, 308-16
8	10.9			308-15
9	10.10			109-14, 308-16
10	10.11			210-5, 211-2, 109-14, 308-16, 209-3, 210-10, 210-7
11	10.12		10.13	208-1, 209-3, 210-10, 210-7
12	11.2			308-18, 308-19
13	11.4		11.3	308-18, 308-19
14	11.8			308-20, 210-8, 113-6
15	11.9		Project on “Energy Generation” can address the remaining outcomes	308-20, 210-8, 113-6
16	12.6			109-14, 308-19
17	12.7			308-19
18	12.8			113-9, 113-13
19	12.9			113-9, 113-13



# Sample Unit 4

## Critical Pathway (Earth and Space Science: Space Exploration – Science 9)

Lesson	Text Section(s)	OR	Alternative Text Section(s)	► Outcome(s)
1	13.2		13.1	312-4
2	13.3			312-4
3	13.10		13.11	312-5
4	13.12		13.13	312-4, 110-6, 112-6, 210-3
5	13.14		Project for students to investigate	312-4, 312-5
6	13.15			312-5, 110-6, 210-3
7	14.1			110-6, 210-3
8	14.4		14.3 or 14.5	210-9
9	14.6			110-6, 210-3
10	14.7			312-6
11	14.8			312-6
12	15.1			312-2
13	15.2			312-1, 312-3
14	15.3			312-1, 312-3
15	15.4 / 15.5			312-1, 312-3
16	16.6			208-4, 211-1
17	16.12		16.7	112-6, 211-5
18	Challenge # 2, page 514			211-3, 208-4



Sample Unit \_\_\_\_\_

Critical Pathway ( \_\_\_\_\_ )

Lesson	Text Section(s)	OR Alternative Text Section(s)	► Outcome(s)
1			
2			
3			
4			
5			
6			
7			
8			
9			
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11			
12			
13			
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15			
16			
17			
18			
19			
20			