Senior 1 Science

A Foundation for Implementation

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SENIOR 1 SCIENCE

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NOTES

CONTENTS

INTRODUCTION

Background

The ***Senior 1 Science: Manitoba Curriculum Framework of Outcomes*** (2000) (hereinafter referred to as the *Science Framework*) and ***Senior 1 Science: A Foundation for Implementation*** (2000) present student learning outcomes for Senior 1 science. These learning outcomes are the same for students in English, French Immersion, Français, and Senior Years Technology Education programs and result from a partnership involving two divisions of Manitoba Education and Training: School Programs and Bureau de l'éducation française. Manitoba's science student learning outcomes are based on those found within the *Common Framework of Science Learning Outcomes K to 12* (Council of Ministers of Education, Canada, 1997). The latter, commonly referred to as the *Pan-Canadian Science Framework*, was initiated under the Pan-Canadian Protocol for Collaboration on School Curriculum (1995), and was developed by educators from Manitoba, Saskatchewan, Alberta, British Columbia, the Northwest Territories, the Yukon Territory, Ontario, and the Atlantic Provinces.

> Student learning outcomes are concise descriptions of the knowledge and skills [and attitudes] that students are expected to learn in a course or grade level in a subject area.
> *(A Foundation for Excellence,* 1995)

The *Science Framework* provides the basis for teaching, learning, and assessing science. It also serves as a starting point for future development of curriculum documents, support materials, learning resources, assessment tools, and professional learning for teachers. *Senior 1 Science: A Foundation for Implementation* (2000) complements the *Science Framework*, providing support for its implementation, including suggestions for instruction and assessment.

Vision for Scientific Literacy

Global interdependence; rapid scientific and technological innovation; the need for a sustainable environment, economy, and society; and the pervasiveness of science and technology in daily life reinforce the importance of scientific literacy. Scientifically literate individuals can more effectively interpret information, solve problems, make informed decisions, accommodate change, and achieve new understandings. Science education is a key environment for developing **scientific literacy** and in building a strong future for Canada's young people.

The *Science Framework* and *Senior 1 Science: A Foundation for Implementation* are designed to support and promote the vision for scientific literacy as articulated in the *Pan-Canadian Science Framework.*

> The [Pan-Canadian Science] Framework is guided by the vision that all Canadian students, regardless of gender or cultural background, will have an opportunity 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.
>
> Diverse learning experiences based on the [Pan-Canadian Science] Framework will provide students with many opportunities to explore, analyze, evaluate, synthesize, appreciate, and understand the interrelationships among science, technology, society, and the environment that will affect their personal lives, careers, and their future. (*Common Framework of Science Learning Outcomes K to 12*, 1997)

Goals for Canadian Science Education

Several goals promoting scientific literacy within Canadian science education were developed as part of the *Pan-Canadian Science Framework*. These goals are addressed through Manitoba science curricula.

Science education will...

- encourage students at all grades to develop a critical sense of wonder and curiosity about scientific and technological endeavours
- enable students to use science and technology to acquire new knowledge and solve problems, so that they may improve the quality of their own lives and the lives of others
- prepare students to critically address science-related societal, economic, ethical, and environmental issues
- provide students with a proficiency in science that creates opportunities for them to pursue progressively higher levels of study, prepares them for science-related occupations, and engages them in science-related hobbies appropriate to their interests and abilities
- develop in students of varying aptitudes and interests a knowledge of the wide variety of careers related to science, technology, and the environment

Beliefs About Learning, Teaching, and Assessing Science

To promote scientific literacy among future citizens, it is crucial to recognize how students learn, how science can best be taught, and how learning can be assessed. Students are curious, active learners who have individual interests, abilities, and needs. They come to school with various personal and cultural experiences and prior knowledge that generate a range of attitudes and beliefs about science and life.

Students learn most effectively when their study of science is rooted in concrete learning experiences related to a particular context or situation, and applied to their world where appropriate. Ideas and understandings that students develop should be progressively extended and reconstructed as students grow in their experiences and in their ability to conceptualize. Learning involves the process of linking newly constructed understandings with prior knowledge and adding new contexts and experiences to current understandings.

Changing Emphases in Science Education Content Delivery*

The *National Science Education Standards* envision change throughout the system. The science content standards [or student learning outcomes] encompass the following changes in emphases:

LESS EMPHASIS ON	MORE EMPHASIS ON
Knowing scientific facts and information	Understanding scientific concepts and developing abilities of inquiry
Studying subject matter disciplines (physical, life, earth sciences) for their own sake	Learning subject matter disciplines in the context of inquiry, technology, science in personal and social perspectives, and history and nature of science
Separating science knowledge and science process	Integrating all aspects of science content
Covering many science topics	Studying a few fundamental science concepts
Implementing inquiry as a set of processes	Implementing inquiry as instructional strategies, abilities, and ideas to be learned

Changing Emphases to Promote Inquiry

LESS EMPHASIS ON	MORE EMPHASIS ON
Activities that demonstrate and verify science content	Activities that investigate and analyze science questions
Investigations confined to one class period	Investigations over extended periods of time
Process skills out of context	Process skills in context
Emphasis on individual process skills such as observation or inference	Using multiple process skills—manipulation, cognitive, procedural
Getting an answer	Using evidence and strategies for developing or revising an explanation
Science as exploration and experiment	Science as argument and explanation
Providing answers to questions about science content	Communicating science explanations
Individuals and groups of students analyzing and synthesizing data without defending a conclusion	Groups of students often analyzing and synthesizing data after defending conclusions
Doing few investigations in order to leave time to cover large amounts of content	Doing more investigations in order to develop understanding, ability, values of inquiry and knowledge of science content
Concluding inquiries with the result of the experiment	Applying the results of experiments to scientific arguments and explanations
Management of materials and equipment	Management of ideas and information
Private communication of student ideas and conclusions to teacher	Public communication of student ideas and work to classmates

* Source: *National Science Education Standards*, p. 113. © 1996 by The National Academy of Sciences. Reproduced with permission of the National Academy Press.

Development of scientific literacy is supported by instructional environments that engage students in the following processes:

- **scientific inquiry:** students address questions about natural phenomena, involving broad explorations as well as focussed investigations
- **technological problem solving (design process):** students seek answers to practical problems requiring the application of their science knowledge in various ways
- **decision making:** students identify issues and pursue science knowledge that will inform their decisions

It is through these processes that students discover the significance of science in their lives and come to appreciate the interrelatedness of science, technology, society, and the environment.

Each of these processes can be a starting point for science learning. These may encompass the exploration of new ideas, the development of specific investigations, and the application of the ideas that are learned.

To achieve the vision of scientific literacy, students must become increasingly engaged in the planning, development, and evaluation of their own learning experiences. They should have the opportunity to work cooperatively with other students, to initiate investigations, to communicate their findings, and to complete projects that demonstrate their learning.

At the beginning of instructional design, teachers and students should identify expected student learning outcomes and establish performance criteria. It is important that these criteria correspond with provincial student learning outcomes. This communication between students and teachers helps to identify clearly what needs to be accomplished, thereby assisting in the learning process.

When students are aware of expected outcomes, they will be more focussed on the learning and more likely to assess their own progress. Furthermore, they can participate in creating appropriate assessment and evaluation criteria. Assessment methods must be valid, reliable, and fair to students.

MANITOBA FOUNDATIONS FOR SCIENTIFIC LITERACY

The Five Foundations

To develop scientifically literate students, Manitoba science curricula are built upon five foundations for scientific literacy that have been adapted from the *Pan-Canadian Science Framework* to address the needs of Manitoba students and include:

A. Nature of Science and Technology

B. Science, Technology, Society, and the Environment (STSE)

C. Scientific and Technological Skills and Attitudes

D. Essential Science Knowledge

E. Unifying Concepts

In the following pages, each foundation is described and accompanied by general learning outcomes, which further define expectations for student learning. These general learning outcomes represent the goals of science learning in Kindergarten to Senior 4.

A. Nature of Science and Technology

Students must learn that science and technology are creative human activities with long histories in all cultures.

Science is a way of learning about the universe. This learning stems from curiosity, creativity, imagination, intuition, exploration, observation, replication of experiments, interpretation of evidence, and debate over that evidence and its interpretations. Scientific activity involves predicting, interpreting, and explaining natural and human-made phenomena. Many historians, sociologists, and philosophers of science argue that there is no set procedure for conducting a scientific investigation. Rather, they see science as driven by a combination of theories, knowledge, experiments, and processes anchored in the physical world.

> Producing science knowledge is an intrinsically collective endeavour. There is no such thing as stand-alone science. Scientists submit models and solutions to the assessment of their peers who judge their logical and experimental soundness by reference to the body of existing knowledge. (*Larochelle, M. and J. Désautels*, 1992)

Scientific theories are being tested, modified, and refined continuously as new knowledge and theories supersede existing ones. Scientific debate on new observations and hypotheses that challenge accepted knowledge involves many participants with diverse backgrounds. This highly complex interplay, which has occurred throughout history, is fuelled by theoretical discussions, experimentation, social, cultural, economic, and political influences, personal biases, and the need for peer recognition and acceptance. Students will realize that while some of our understandings about how the world works are due to revolutionary scientific developments, many of our understandings result from the steady and gradual accumulation of knowledge.

Technology results mainly from proposing solutions to problems arising from attempts by humans to adapt to the environment. Technology may be regarded as "...a tool or machine; a process, system, environment, epistemology, and ethic; the systematic application of knowledge, materials, tools, and skills to extend human capabilities...." (*Technology As a Foundation Skill Area: A Journey Toward Information Technology Literacy*, 1998). Technology refers to much more than the knowledge and skills related to computers and their applications. Technology is based on the knowledge of concepts and skills from other disciplines (including science) and is the application of this knowledge to meet an identified need or solve a problem using materials, energy, and tools (including computers). Technology also has an impact on processes and systems, on society, and on the ways people think, perceive, and define their world.

The *Science Framework* and *Foundation for Implementation* are designed to emphasize both the distinctions and relationships between science and technology. Figure 1 illustrates how science and technology differ in purpose, procedure, and product, while at the same time relating to each other.

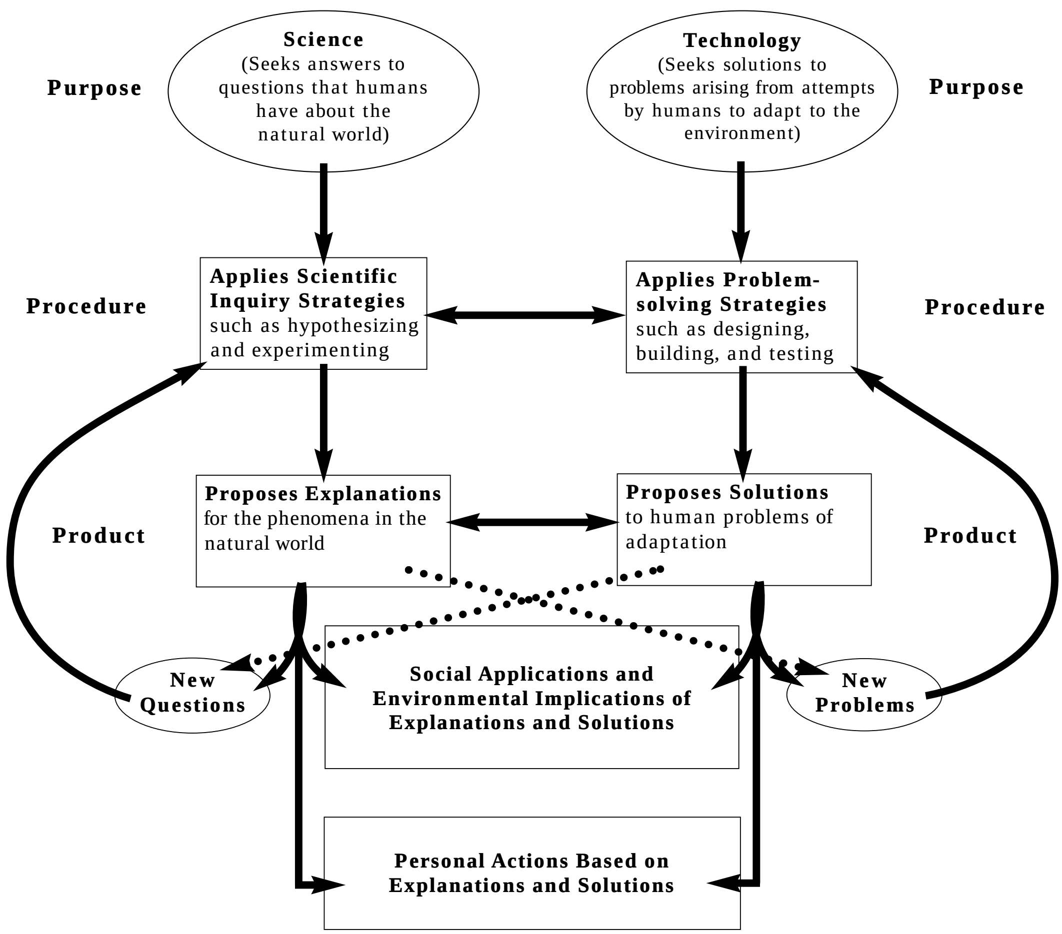

Figure 1: Science and Technology: Their Nature and Interrelationships

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Adapted with permission from Bybee, Rodger W. *Science and Technology Education for the Elementary Years: Frameworks for Curriculum and Instruction.* ©The NETWORK, Inc.

The following general learning outcomes (GLOs) have been developed to further define expectations related to this foundation area. (For a complete listing of Science GLOs, see Appendix 5.1.)

Nature of Science and Technology General Learning Outcomes

As a result of their Early, Middle, and Senior Years science education, students will...

A1. recognize both the power and limitations of science as a way of answering questions about the world and explaining natural phenomena

A2. recognize that scientific knowledge is based on evidence, models, and explanations, and evolves as new evidence appears and new conceptualizations develop

A3. distinguish critically between science and technology in terms of their respective contexts, goals, methods, products, and values

A4. identify and appreciate contributions made by women and men from many societies and cultural backgrounds towards increasing our understanding of the world and in bringing about technological innovations

A5. recognize that science and technology interact with and advance one another

B. Science, Technology, Society, and the Environment (STSE)

Understanding STSE is an essential component of scientific literacy. By studying the historical context, students come to appreciate ways in which cultural and intellectual traditions have influenced the questions and methodologies of science, and how science, in turn, has influenced the wider world of ideas.

Today, most scientists work in industry, where projects are more often driven by societal and environmental needs than by pure research. Many technological solutions have evoked complex social and environmental issues. Students, as future citizens, must recognize the potential of scientific literacy to inform and empower decision making of individuals, communities, and society as a whole.

Scientific knowledge is necessary, but is not sufficient for understanding the relationships among science, technology, society, and the environment. To understand these relationships fully, it is essential that students consider the values related to science, technology, society, and the environment.

To achieve scientific literacy, students must also develop an appreciation for the importance of sustainable development. To this end, the *Science Framework* and *Senior 1 Science: A Foundation for Implementation* integrate the Sustainable Development Strategy developed by the Province of Manitoba (See Figure 2).

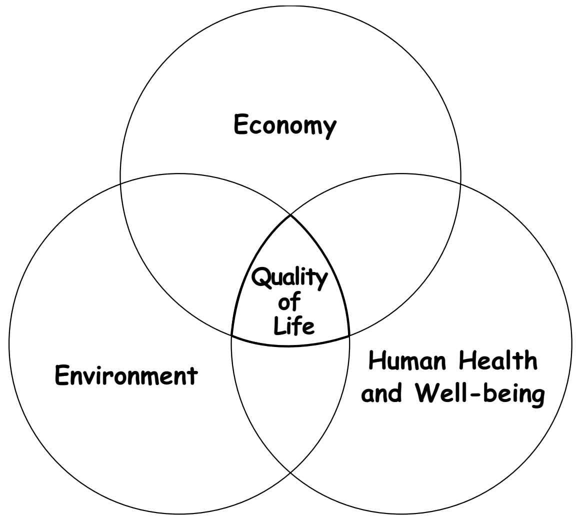


Figure 2: Sustainable Development

Sustainable development is a decision-making model that considers the needs of both present and future generations, and integrates and balances the **impact of economic activities**, the **environment**, and the **health and well-being of the community**.

> There can be no greater contribution or more essential element to long-term environmental strategies leading to sustainable development that respects the environment…than the education of future generations in matters relating to the environment. (*UNESCO*, 1988)
>
> Public awareness and understanding of the concept of sustainable development and its practices are essential. If we are to change our way of life we must equip present and future generations with the knowledge and training to put sustainable development into effect. (*Sustainable Development Strategy for Manitoba,* 1994)

As students advance from grade to grade, they identify STSE interrelationships and apply decision-making skills in increasingly demanding contexts, as shown below:

- **complexity of understanding** — from simple, concrete ideas to abstract ideas; from limited knowledge of science to more in-depth and broader knowledge of science and the world
- **applications in context** — from contexts that are local and personal to those that are societal and global
- **consideration of variables and perspectives** — from one or two that are simple to many that are complex
- **critical judgement** — from simple right or wrong assessments to complex evaluations
- **decision making** — from decisions based on limited knowledge, made with the teacher's guidance, to decisions based on extensive research, involving personal judgment and made independently

The following general learning outcomes (GLOs) have been developed to further define expectations related to this foundation area. (For a complete listing of Manitoba's science GLOs, see Appendix 5.1.)

Science, Technology, Society, and the Environment (STSE) General Learning Outcomes

As a result of their Early, Middle, and Senior Years science education, students will...

B1. describe scientific and technological developments, past and present, and appreciate their impact on individuals, societies, and the environment, both locally and globally

B2. recognize that scientific and technological endeavours have been and continue to be influenced by human needs and the societal context of the time

B3. identify the factors that affect health, and explain the relationships among personal habits, lifestyle choices, and human health, both individual and social

B4. demonstrate a knowledge of and personal consideration for a range of possible science- and technology-related interests, hobbies, and careers

B5. identify and demonstrate actions that promote a sustainable environment, society, and economy, both locally and globally

C. Scientific and Technological Skills and Attitudes

A science education that strives for scientific literacy must engage students in answering questions, solving problems, and making decisions. These processes are referred to as Scientific Inquiry, Technological Problem Solving (Design Process), and Decision Making (see Figure 3). While the skills and attitudes involved in these processes are not unique to science, they play an important role in the development of scientific understandings and in the application of science and technology to new situations.

	Scientific Inquiry	**Technological Problem Solving (Design Process)**	**Decision Making**
Purpose:	Satisfying curiosity about events and phenomena in the natural world.	Coping with everyday life, practices, and human needs.	Identifying different views or perspectives based on varying information.
Procedure:	What do we know? What do we want to know?	How can we do it? Will it work?	What are the alternatives or consequences? Which choice is best at this time?
Product:	Knowledge about events and phenomena in the natural world.	An effective and efficient way to accomplish a task or meet a need.	A defensible decision in a particular circumstance.

	Scientific Question	**Technological Problem**	**STSE Issue**
Example:	Why does my coffee cool so quickly?	How can I keep my coffee hot?	Should we use styrofoam cups or ceramic mugs for our meeting?
	An Answer: Heat energy is transferred by conduction, convection, and radiation, to the surrounding environment.	*A Solution:* A styrofoam cup will keep liquids warm for a long time. So will an insulated cup.	*A Decision:* Since we must use disposable cups for the meeting, a biodegradable type will be chosen.

Figure 3: Processes for Science Education

Adapted with permission of the Minister of Education, Province of Alberta, Canada, 1999.

Each of these *processes* is described below. *Attitudes*, an important element of each process, are also examined.

Scientific Inquiry

Scientific inquiry is a way of learning about the universe. It involves posing questions and searching for explanations of phenomena. Although no single "scientific method" exists, students require certain skills to participate in science-related experiences.

Skills such as questioning, observing, inferring, predicting, measuring, hypothesizing, classifying, designing experiments, and collecting, analyzing, and interpreting data are fundamental to scientific inquiry; as are attitudes such as curiosity, skepticism, and creativity. These skills are often represented as a cycle. This cycle involves posing questions, generating possible explanations, and collecting and analyzing evidence to determine which of these explanations is most useful and accurate in accounting for the phenomena under investigation. New questions may arise to re-ignite the cycle. It must be noted, however, that many scientific inquiries, past and present, do not necessarily follow a set sequence of steps nor do they always start at the "beginning" of the cycle: scientists can be creative and responsive to scientific challenges as they arise.

Technological Problem Solving

Technological problem solving seeks solutions to problems arising from attempts by humans to adapt to or change the environment. In Kindergarten to Grade 8 science, students have been developing these skills using a cycle of steps called the design process. This design process includes the proposing, creating, and testing of prototypes, products, and techniques in an attempt to reach an optimal solution to a given problem. Feedback and evaluation are built into this cycle. In Senior Years science, these technological problem-solving skills are incorporated into a decision-making process.

STSE Issues and Decision Making

Students, as individuals and global citizens, are required to make decisions. Increasingly, the type of issues they face demand an ability to apply scientific and technological knowledge processes, and products to the decisions they make related to Science, Technology, Society, and the Environment (STSE). The decision-making process involves a series of steps which may include:

- clarification of the issue
- critical evaluation of all available research
- generating possible courses of action
- making a thoughtful decision
- examining the impact of the decision
- reflecting on the process

Students should be actively involved in decision-making situations as they progress through their science education. Not only are decision-making situations important in their own right, but they also provide a relevant context for engaging in scientific inquiry, problem solving, and the study of STSE relationships (See Figure 4).

Decision-Making Model for STSE Issues

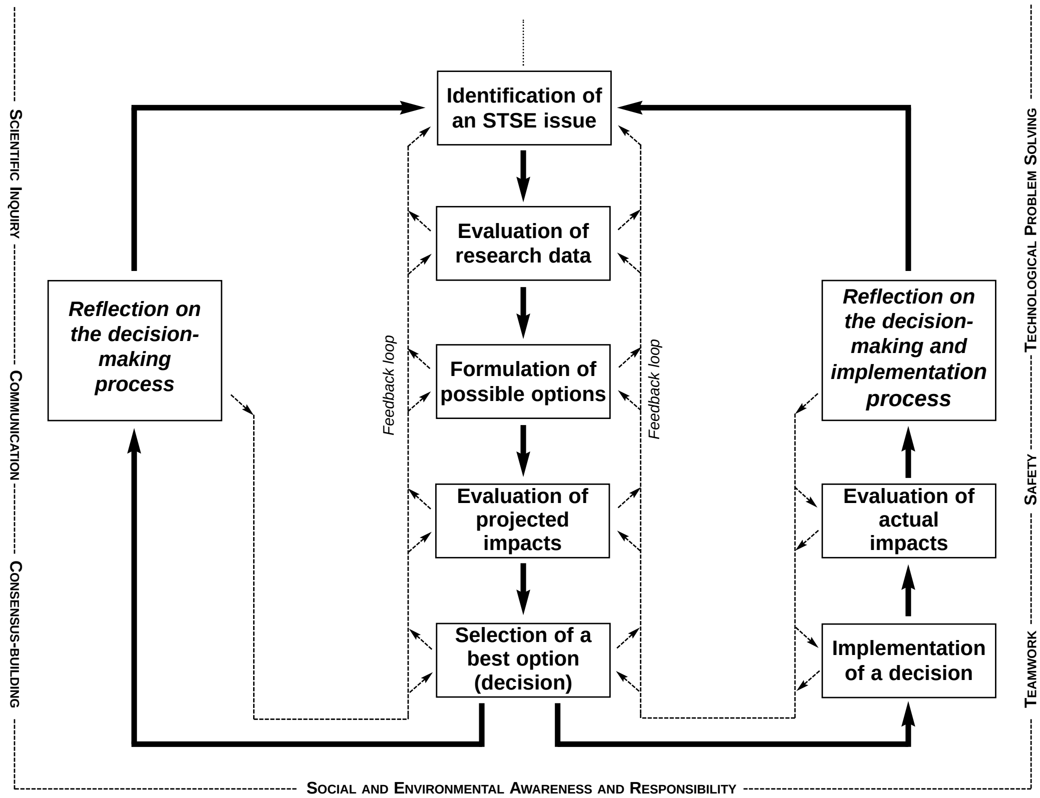


Figure 4: Decision-Making Model for STSE Issues

Attitudes

Attitudes refer to generalized aspects of behaviour that are modelled for students. Attitudes are not acquired in the same way as skills and knowledge. They cannot be observed at any particular moment, but are evidenced by regular, unprompted manifestations over time. Development of attitudes is a lifelong process that involves the home, the school, the community, and society at large. The development of positive attitudes plays an important role in students' growth, affecting their intellectual development and creating a readiness for responsible application of what they learn.

The following General Learning Outcomes (GLOs) have been developed to further define expectations related to this foundation area. (For a complete listing of Manitoba's science GLOs, see Appendix 5.1.)

Scientific and Technological Skills and Attitudes General Learning Outcomes

As a result of their Early, Middle, and Senior Years science education, students will...

C1. recognize safety symbols and practices related to scientific and technological activities and to their daily lives, and apply this knowledge in appropriate situations

C2. demonstrate appropriate scientific inquiry skills when seeking answers to questions

C3. demonstrate appropriate problem-solving skills while seeking solutions to technological challenges

C4. demonstrate appropriate critical thinking and decision-making skills when choosing a course of action based on scientific and technological information

C5. demonstrate curiosity, skepticism, creativity, open-mindedness, accuracy, precision, honesty, and persistence, and appreciate their importance as scientific and technological habits of mind

C6. employ effective communication skills and utilize information technology to gather and share scientific and technological ideas and data

C7. work cooperatively and value the ideas and contributions of others while carrying out scientific and technological activities

C8. evaluate, from a scientific perspective, information and ideas encountered during investigations and in daily life

D. Essential Science Knowledge

The subject matter of science includes theories, models, concepts, and principles that are essential to an understanding of life science, physical science, and Earth and space science. While the *Science Framework* and the *Senior 1 Science: A Foundation for Implementation* are not strictly aligned with these disciplines, the learning outcomes are intended to help develop important concepts from each of these areas.

Life science deals with the growth and interactions of life forms within their environment in ways that reflect their uniqueness, diversity, genetic continuity, and changing nature. Life science includes the study of organisms (including humans and cells), ecosystems, biodiversity, biochemistry, and biotechnology, to name a few.

Physical science, which encompasses chemistry and physics, deals with matter, energy, and forces. Matter has structure and interactions exist among its components. Energy links matter to gravitational, electromagnetic, and nuclear forces of the universe. The laws of conservation of mass and energy, momentum, and charge are addressed by physical science.

Earth and space science brings local, global, and universal perspectives to students' knowledge. The Earth exhibits form, structure, and patterns of change, as does our surrounding solar system and the physical universe beyond. Earth and space science includes fields of study such as geology, hydrology, meteorology, and astronomy.

The following General Learning Outcomes (GLOs) have been developed to further define expectations related to this foundation area. (For a complete listing of Manitoba's science GLOs, see Appendix 5.1.)

Essential Science Knowledge General Learning Outcomes

As a result of their Early, Middle, and Senior Years science education, students will...

D1. understand essential life structures and processes pertaining to a wide variety of organisms, including humans

D2. understand various biotic and abiotic components of ecosystems, as well as their interaction and interdependence within ecosystems and within the biosphere as a whole

D3. understand the properties and structures of matter as well as various common manifestations and applications of the actions and interactions of matter

D4. understand how stability, motion, forces, and energy transfers and transformations play a role in a wide range of natural and constructed contexts

D5. understand the composition of the Earth’s atmosphere, hydrosphere, and lithosphere, as well as the processes involved within and among them

D6. understand the composition of the universe, the interactions within it, and the impacts of humankind’s continued attempts to understand and explore it

E. Unifying Concepts

An effective way to create linkages within and among science disciplines is to use unifying concepts, the key ideas that underlie and integrate all science knowledge and extend into areas such as mathematics and social studies. Unifying concepts help students to construct a holistic understanding of science and its role in society. The following four unifying concepts were used in the development of the *Science Framework* and *Senior 1 Science: A Foundation for Implementation*.

Similarity and Diversity

The concepts of similarity and diversity provide tools for organizing our experiences with the world. Beginning with informal experiences, students learn to recognize attributes of materials, organisms, and events that help to make useful distinctions between and among them. Over time, students adopt accepted procedures and protocols for describing and classifying objects, organisms, and events they encounter, thus enabling them to share ideas with others and to reflect on their own experiences.

Systems and Interactions

An important part of understanding and interpreting the world is the ability to think about the whole in terms of its parts and, alternately, about parts in terms of how they relate to one another and to the whole. A system is a collection of components that interact with one another so that the overall effect is often different than that of the individual parts, even when these are considered together. Students will study both natural and technological systems.

Change, Constancy, and Equilibrium

The concepts of constancy and change underlie most understandings of the natural and technological world. Through observations, students learn that some characteristics of living things, materials, and systems remain constant over time, whereas others change. Through formal and informal studies, students develop an understanding of the processes and conditions in which change, constancy, and equilibrium take place.

Energy

The concept of energy provides a conceptual tool that brings together many understandings about natural phenomena, materials, and the processes of change. Energy, whether transmitted or transformed, is the driving force of both movement and change. Students learn to describe energy in terms of its effects and, over time, develop a concept of energy as something inherent within the interactions of materials, the processes of life, and the functioning of systems.

The following General Learning Outcomes (GLOs) have been developed to further define expectations related to this foundation area. (For a complete listing of Manitoba’s science GLOs, see Appendix 5.1.)

Unifying Concepts General Learning Outcomes

As a result of their Early, Middle, and Senior Years science education, students will...

E1. describe and appreciate the similarity and diversity of forms, functions, and patterns within the natural and constructed world

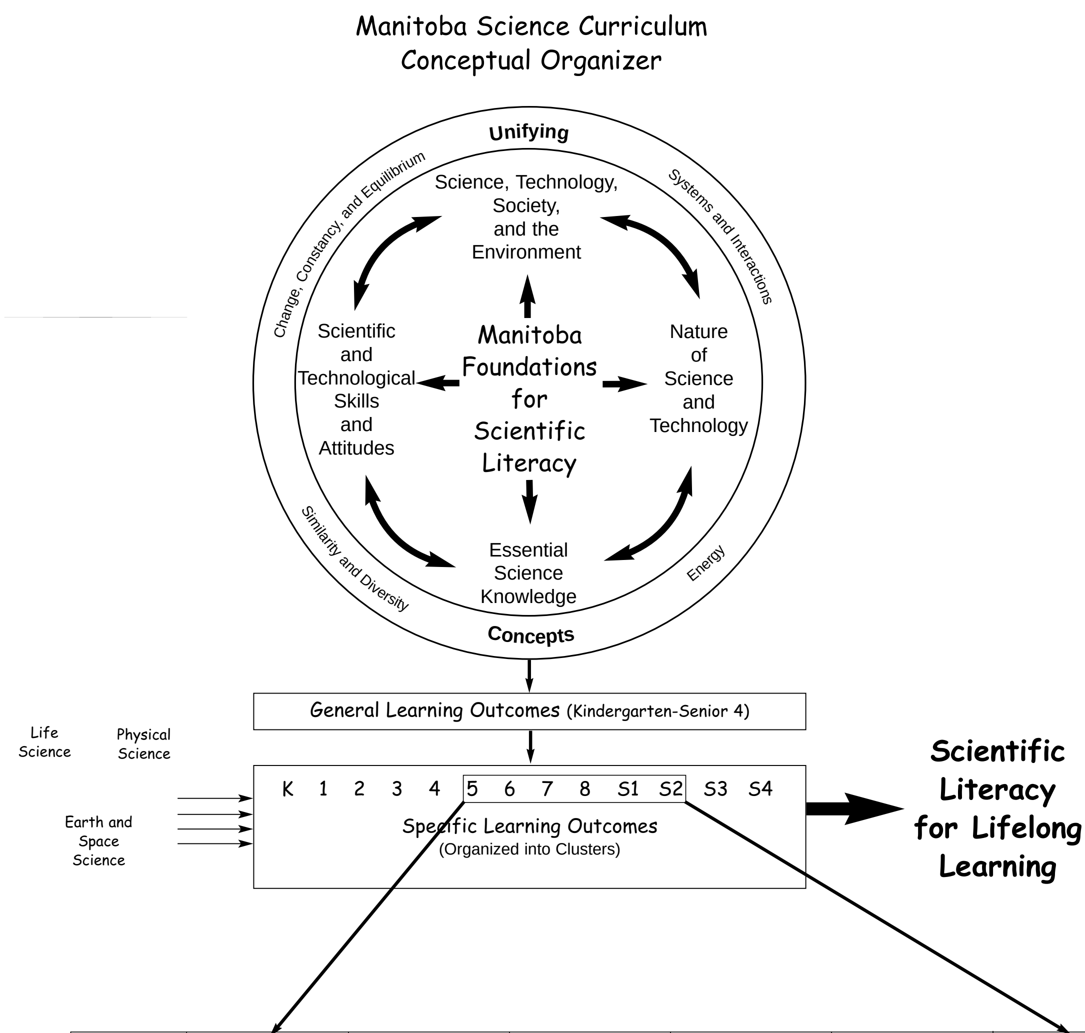
E2. describe and appreciate how the natural and constructed world is made up of systems and how interactions take place within and among these systems

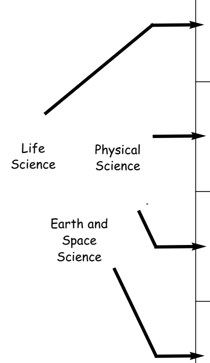
E3. recognize that characteristics of materials and systems can remain constant or change over time, and describe the conditions and processes involved

E4. recognize that energy, whether transmitted or transformed, is the driving force of both movement and change, and is inherent within materials and in the interactions among them

Conceptual Organizer

The following Conceptual Organizer on the facing page (Figure 5) provides a graphic representation of the different components of the science curriculum. It summarizes the relationships among the Manitoba Foundations for Scientific Literacy, and shows how they helped to develop the general and specific student learning outcomes in Kindergarten to Senior 4. The detail of the thematic clusters in Grades 5 to Senior 2 appears in the exploded view.





Grades / Clusters	Grade 5	Grade 6	Grade 7	Grade 8	Senior 1	Senior 2 (under development)
Cluster 0	Overall Skills and Attitudes (to be integrated into Clusters 1 to 4)					
Cluster 1	Maintaining a Healthy Body	Diversity of Living Things	Interactions Within Ecosystems	Cells and Systems	**Reproduction**	Dynamics of Ecosystems
Cluster 2	Properties of and Changes in Substances	Flight	Particle Theory of Matter	Optics	**Atoms and Elements**	Chemicals in Action
Cluster 3	Forces and Simple Machines	Electricity	Forces and Structures	Fluids	**Nature of Electricity**	In Motion
Cluster 4	Weather	Exploring the Solar System	Earth's Crust	Water Systems	**Exploring the Universe**	Weather Dynamics

Figure 5: Manitoba Science Curriculum Conceptual Organizer and Details of Cluster Titles, Grades 5 to Senior 2 Science

NOTES

IMPLEMENTATION OF SENIOR 1 SCIENCE

Diversity in the Classroom

Students come from a variety of backgrounds and have distinct learning requirements, learning and thinking approaches, and prior knowledge and experiences. Their depth of prior knowledge varies, reflecting their experiences inside and outside the classroom. Some entry-level knowledge held by students may be limited or incorrect, impeding new learning. For new learning to occur, it is important for teachers to activate prior knowledge, correct misconceptions, and encourage students to relate new information to prior experiences.

Manitoba's cultural diversity provides opportunities for embracing a wealth of culturally significant references and learning resources in the Senior Years science classroom. Students from various backgrounds bring socially constructed meanings, references, and values to science learning experiences, as well as their unique learning approaches. As noted in the *Senior Years Science Teacher's Handbook (SYSTH)*, "To be effective, the classroom must reflect, accommodate, and embrace the cultural diversity of its students" (1997, p. 7.13).

Toward this end, *Senior 1 Science: A Foundation for Implementation* acknowledges and supports cultural diversity. Included in this document are a range of instructional strategies and conceptual links to appropriate communities and their resources (e.g., Aboriginal communities, agricultural communities). Teachers are encouraged to utilize the community and the surrounding natural habitats as these relate to particular science learning outcomes, as they afford opportunities to enrich the learning experience. The careful selection of learning resources that acknowledge cultural, racial, and gender differences will allow students to affirm and strengthen their unique social, cultural, and individual identities. A meaningful learning environment for all requires that teachers be sensitive to the role that diversity plays in the Senior Years classroom.

Instructional Philosophy

The science program should employ a variety of instructional strategies that include the collection and analysis of data from both laboratory and outdoor observations (especially in the case of the astronomical component), field work, the use of living organisms in a caring manner, group and individual instruction, a diversity of questioning techniques, a focus on current major issues, and a resource-based approach to learning. Senior 1 science programming should foster critical thinking skills and promote the integration of knowledge and application of facts to real-life situations.

In general, science should be taught as a way of thinking that has rules for judging the validity of answers applicable to everyday life. Science should be portrayed as intense human activity, full of trial and error, that is influenced by cultural priorities and perspectives. The myth of total objectivity that often permeates scientific dialogue also needs to be exposed. Truth should be placed in the context of something always to be sought, but we must realize that the goal can never be reached in absolute terms.

Students should be encouraged to make distinctions between what is observable and testable, as well as the abstract deductions, models, and themes that flow from evolving scientific research and thinking.

Conceptual knowledge in science must also be integrated with principles from other disciplines. Social, historical, and political implications must be included, with an opportunity for students to develop a facility to communicate ideas effectively through verbal and written expression. Finally, students should be provided with an opportunity to develop an awareness of the options available to them for careers and vocations in the wide diversity of sciences.

Ethical Issues

For many students and teachers, the study of scientific concepts may lead to issues and questions that go beyond the traditional curriculum. For example, the technological application of biological principles in areas such as genetic engineering, human reproduction, and medical technology obviously raises questions of ethics and values. The search for extra-terrestrial life has spiritual and religious implications. The environmental consequences of the industrial applications of chemistry or production of electric power raise issues of considerable merit. Due to the fact that these issues are derived from the study of science, they should be addressed, but it must be made clear to students that science only provides the background for what is hoped will be informed personal and social decisions. Teachers must handle these questions with sensitivity and clarity of purpose.

Concerns may be expressed by some students and parents because the evolutionary perspective of modern life science conflicts with personal beliefs. These individuals have a right to expect that science and the educational system will respect those beliefs. Teachers should explain to students that science is only one way of learning about the universe and our unique place embedded in it, and that other explanations have been put forth besides those of the traditional, Western sciences.

In some cases, individual teachers may choose to discuss various alternative viewpoints on these matters with their science classes. However, because these viewpoints are not derived from the disciplines of science, they are not addressed directly in the science curriculum.

The Responsible Use of Animals in the Science Classroom

The curriculum encourages science teachers to foster a respect for life and to teach about the interrelationship and interdependency of all living things. Furthermore, a stewardship approach emphasizes that humans must care for the fragile web of life that exists on this planet.

The use of live animals and the dissection of animals is a well-established place in the teaching of life sciences in particular. Well-constructed learning activities conducted by thoughtful teachers can illustrate important and enduring principles in the life sciences. However, teachers must carefully consider the educational objectives and available alternatives before using animals in the classroom. Justification on the grounds that “we have always done this” is unacceptable.

Interactive multimedia materials such as computer simulations, tutorials, videodiscs, and videotapes can substitute for the use of animals in the classroom. However, these alternatives must satisfy the objectives of teaching scientific methodology and fundamental biological concepts. If, in the judgment of the teacher, available alternatives do not meet these objectives, dissection may be used, provided that no student is forced to participate. In the event that a student chooses not to participate in a dissection, s/he is to be given assignments of comparable complexity and rigour. In outcome-based education, time is the variable.

Implementing alternative methods does not mean excluding animals from the classroom. Certain instructional strategies allow for the continued use of animals but with a modified approach, e.g., observation in behavior studies and experimentation with invertebrates. In these cases, prudent and responsible use of these animals is recommended.

Learning Resources

Traditionally, the teaching of science at Senior Years has been largely a textbook-centred exercise. The use of a single textbook as the sole resource for the teaching and learning of science severely restricts the development of knowledge, skills, and attitudes that are critical for today's students. Furthermore, it promotes the idea that all answers are enshrined in a textbook. The successful implementation of Senior 1 Science (10F) depends on a resource-based learning approach, in which textbooks are used only as one of many reference sources. Research suggests that we should provide a wide range of learning resources for structuring teaching and learning experiences. These include human resources, textbooks, magazines/periodicals, films, audio and video recordings, computer-based multimedia resources, the Internet, and other materials. While a teacher may choose to use a particular text as a primary resource, we encourage teachers to model the use of a multitude of resources for their students.

Resources referenced in this curriculum include two suggested textbooks, student learning activities outlined in a set of appendices, multimedia learning resources, and other print reference material such as the *Senior Years Science Teachers' Handbook: A Teaching Resource* (1997) and *Science Safety: A Kindergarten to Senior 4 Resource Manual for Teachers, Schools, and School Divisions* (1997). Approved learning resources for Senior 1 science are listed in the Grades 5 to Senior 1 Science Learning Resources: Annotated Bibliography available through MTBB (stock number 80382) or online at <http://www.edu.gov.mb.ca/metks4/curricul/learnres/mr-1.html>.

The choice of textbook or textbooks will depend on the local situation, reading level of the students, background of the teacher, community resources, and availability of other materials. A concerted effort should be made to utilize appropriate learning resources from a wide variety of sources. Not all curricular outcomes can be achieved by using any one text as some topics require using other references or supports.

The choice of multimedia learning resources, including video, software, CD-ROMs, microcomputer-based laboratory (MBL) probeware, calculator-based laboratory (CBL) probeware, and the Internet, will also depend on the local situation: availability of hardware, school technology budgets, teacher background and preference, community resources, and availability of other materials. The multimedia resources listed in this document in the Suggested Learning Resources column will be available for purchase through the Manitoba Text Book Bureau.

Using This Curriculum Document

This curriculum, consisting of four thematic clusters and one skills and attitudes cluster, is designed to build on what students know and are able to do as a result of their studies in Grades K-8 science.

Teachers are asked to be sensitive to the varying backgrounds of their students and to adapt instruction as necessary. Clusters do not need to be taught in the same sequence as they appear in the document. For example, it may by advantageous to make celestial observations throughout the year or perform electrostatic experiments in the winter when humidity is low. Teachers should use their own discretion. There are opportunities to achieve learning outcomes in contexts different from the way they are presented in this curriculum document. In all cases, however, the foundations, themes, and the interdisciplinary nature of science should be emphasized.

Senior 1 Science (10F) provides a solid foundation for further study in Senior 2 Science (20F) and has a multi-disciplinary focus. Accordingly, the curriculum includes only those topics that are deemed to be of relevance to students' needs and interests or are prerequisites to the further study of science at the Senior Years level.

Senior 1 Science (10F) assumes 110 hours of instructional time (see Scope, Sequence, and Time Allotments that appear with each Specific Learning Outcome or cluster of outcomes). Some time may need to be allocated to reviewing material from the appropriate sections of the grades 5–8 curricula, but formal review of previous years' work is to be avoided. Teachers need to use a variety of strategies for activating prior knowledge to determine appropriate learning strategies for their students.

Preparing a Lesson

The format of the *Senior 1 Science: A Foundation for Implementation* document allows teachers to view the four major columns, namely *Prescribed Learning Outcomes*, *Suggestions for Instruction*, *Suggestions for Assessment*, and *Suggested Learning Resources*. The learning outcomes in the first column should guide the teacher to make relevant decisions as to instruction, assessment/evaluation, and appropriate learning resources. The document also contains Cluster 0 outcomes in the *Prescribed Learning Outcomes* column. These are listed based on the suggestions made for instruction. The *Suggestions for Instruction* column provides possible avenues or actions for student learning. Teachers should use their own professional judgment regarding which strategies to use. It is NOT intended for teachers to use all of the suggested strategies. *Suggestions for Assessment* outlines a number of possible strategies beyond simple pencil and paper testing. Resources to support the prescribed outcomes are detailed in the final column, *Suggested Learning Resources*. It is hoped that this format provides a useful "map" for teachers. i.e., a clear indication of what students are to know and be able to do, as well as a resource for strategies and materials to help students achieve these outcomes.

Science curricula in the past have been primarily focussed on a wide variety of knowledge, i.e., a large amount of content material. This curriculum continues to be concerned with students acquiring relevant knowledge, but is equally concerned with the development of skills (context-based process skills, decision-making skills, problem-solving skills, laboratory experimental skills, critical thinking skills, independent learning skills), and with effecting a change of attitude. In broad terms, these learning outcomes should describe what we expect students to know and be able to do as a result of their studies.

Many of the Suggestions for Instruction columns begin by describing the probable *Entry Level Knowledge* of students based on previous studies using Manitoba's science curricula. Teachers are encouraged to determine student entry levels and select or develop approaches and materials to enable each student to achieve success. Many educators believe that time spent at this task has the greatest effect on student learning.

Senior 1 Science (10F) is driven by learning outcomes and process rather than by a text book. This design empowers teachers to plan appropriate learning experiences based on the nature of their students, school, and community. We encourage teachers to seek their own comfort level with the new curriculum, to share approaches and experiences with colleagues, and to use it to develop and extend student experiences and understandings in new ways.

Differentiating Instruction

How can Senior Years science teachers meet each student's learning requirements and still make learning experiences challenging and meaningful for all? One way to help all students achieve the prescribed student learning outcomes is to differentiate the instructional strategies. (See *Success for All Learners*: *A Handbook on Differentiating Instruction, 1996.*) Through differentiating instruction, teachers can

- activate students' prior knowledge
- accommodate multiple intelligences and the variety of learning and thinking approaches
- help students interpret, apply, and integrate information
- facilitate the transfer of knowledge, skills, and attitudes to students' daily lives
- challenge students to realize academic and personal progress and achievement

Differentiating instruction does not mean offering a different program to each student. Classroom experiences can be differentiated by offering students choices and by varying instructional and assessment strategies to provide challenging and effective learning experiences for all.

Learning Phases

Differentiated instructional strategies can be used in relation to the three learning phases:

- activating (preparing for learning)
- acquiring (integrating and processing learning)
- applying (consolidating learning)

These phases of learning are not entirely linear, nor are they discrete; rather, they provide teachers with a useful way of thinking and planning.

- The activating phase helps identify students' prior knowledge.
- The acquiring phase helps students to integrate new information with what they already know, adding or revising their previous knowledge as needed. Teachers help students make meaning of new information.
- The applying phase allows students to reflect on what they have learned, apply their learning in new situations, and extend their learning by drawing connections to other subject areas.

For a discussion of these three learning phases, see *Success for All Learners,* Chapter 6.

Senior 1 Science: A Foundation for Implementation includes cross-references to *Success for All Learners: A Handbook on Differentiating Instruction* (1996) and *Senior Years Science Teachers' Handbook* (1997). Teachers can refer to these documents for further information. Strategies that can be used effectively in the Senior Years science classroom include graphic organizers (such as mind maps), knowledge charts that utilize students' prior knowledge, collaborative activities in brainstorming for solutions to design problems, information-processing strategies, science learning logs, and many others. A detailed listing of the instructional strategies recommended throughout *Senior 1 Science: A Foundation for Implementation* follows:

Instruction

- **Entry-Level Knowledge —** Entry-level knowledge summarizes prior content knowledge that students may have obtained in earlier grades, other courses, or through personal experiences. Activating this knowledge can be a powerful tool, as students organize and make meaning of new ideas, experiences, and information in connection with their prior knowledge.
- **Notes for Instruction** — Notes for instruction outlines the depth and breadth to which learning outcomes are to be addressed. Definitions, safety concerns, and teaching/learning suggestions may also be included.
- **Student Learning Activities —** A number of instructional strategies involving student engagement with learning materials are available for each learning outcome. Deciding which learning activities to use is an important part of a teacher's initial planning. Teachers need to make deliberate, informed decisions about the best tools to use for each learning task to successfully reach each learning outcome of the curriculum, given the particular needs and characteristics of their students.
- **Journal Writing —** Science journal writing allows students to explore and record all aspects of their science class experiences. By sorting out their thoughts on paper or thinking about their learning (metacognition), students process more deeply what they are learning.
- **Class Discussion —** Discussions can be used in a variety of ways. They can spark interest in a topic or learning outcome, activate prior knowledge by inviting speculation on why certain events occur, or generate ideas for solutions to problems.
- **Prior Knowledge Activities —** Students learn best when they can relate new knowledge to what they already know. Brainstorming, KWL charts, and Listen-Think-Pair-Share are just a few of the strategies that can be used to activate and assess students' prior knowledge.
- **Student Research/Reports —** Learning projects that involve student research are one of the most effective ways to individualize instruction in a diverse classroom. These learning activities provide students with the opportunity to develop their research skills as they gather, process, and evaluate information.
- **Teacher Demonstration —** Demonstrations can arouse student interest and allow for visualization of phenomena. For instance, discrepant events can be a powerful tool. Demonstrations can activate prior knowledge and generate discussion around learning outcomes.
- **Visual Displays —** When students create visual displays, they make their thinking visible. Generating diagrams, posters, or models provides students with the opportunity to represent abstract information in a more concrete form.

- **Collaborative Teamwork —** Instructional strategies, such as the Jigsaw or Roundtable, encourage students to learn from one another and develop teamwork skills. The use of cooperative learning activities can lead to increased understanding of content and improved thinking skills.
- **Laboratory Activities —** Laboratory activities, whether student- or teacher- designed, provide students with the opportunity to apply their scientific knowledge and skills related to a group of learning outcomes. Students appreciate the hands-on experience of doing science.
- **Debates —** Debates draw upon students' own positions on STSE issues. When carefully structured, debates can be used to encourage students' consideration of societal concerns and the opinions of others, and improve their communication and research skills.

Assessment

Assessment is "the systemic process of gathering information about what a student knows, is able to do, and is learning to do" (*Reporting on Student Progress and Achievement*, 1997, p. 38). Assessment involves collecting, interpreting, and communicating results related to students' progress and achievement.

In Senior Years science, as in other subject areas, effective assessment is

- an integral part of instruction and learning
- continuous and ongoing
- authentic and reflective of meaningful science-learning processes and contexts
- a collaborative and reflective process
- multi-dimensional, incorporating a variety of tasks
- developmentally and culturally appropriate
- focussed on students' strengths
- based on how students learn
- supportive of learning by offering clear performance targets to students

(Adapted from *Senior 1 English Language Arts: Manitoba Curriculum Framework of Outcomes* and *Senior 1 Standards*, 1996, p. 53.)

This view of effective assessment in science for Manitoba is reflective of changes in emphases in science education at the national level and is congruent with international changes in science education. The following chart summarizes, at a glance, some of the changes in the area of assessment.

Changing Emphases in Assessment of Student Learning*

The *National Science Education Standards* envision change throughout the system.
The assessment standards encompass the following changes in emphases:

LESS EMPHASIS ON	MORE EMPHASIS ON
Assessing what is easily measured	Assessing what is most highly valued
Assessing discrete knowledge	Assessing rich, well-structured knowledge
Assessing scientific knowledge	Assessing scientific understanding and reasoning
Assessing to learn what students do not know	Assessing to learn what students do understand
Assessing only achievement	Assessing achievement and opportunity to learn
End of term assessments by teachers	Students engaged in ongoing assessment of their work and that of others
Development of external assessments by measurement experts alone	Teachers involved in the development of external assessments

Formative and Summative Assessment

Assessment can be formative or summative.

- **Formative assessment** is based on data collected before an instructional sequence is completed. Its purpose is to improve instruction and learning by
  - providing students and teachers with information about students' progress in accomplishing prescribed learning outcomes
  - evaluating the effectiveness of instructional programming content, methods, sequence, and pace
- **Summative assessment** (evaluation) is based on an interpretation of the assessment information collected. It helps determine the extent of each student's achievement of prescribed learning outcomes. Evaluation should be based on a variety of assessment information. Summative assessment is used primarily to
  - measure student achievement
  - report to parent(s)/guardian(s), students, and other stakeholders
  - measure the effectiveness of instructional programming

Senior 1 Science: A Foundation for Implementation suggests a range of assessment strategies. The same strategy can be used for both formative and summative assessment, depending on the purpose of the assessment.

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* Source: *National Science Education Standards*, p. 100. © 1996 by The National Academy of Sciences. Reproduced with permission of the National Academy Press.

A detailed discussion of the suggested assessment strategies included in this document follows:

- **Observation —** Observation of students is an integral part of the assessment process. It is most effective when focussed on skills, concepts, and attitudes. Without record keeping, however, observations and conversations can easily be forgotten. Making brief notes on index cards, self-stick notes, or grids, as well as keeping checklists, helps teachers maintain records of continuous progress and achievement.
- **Interviews —** Interviews allow teachers to assess an individual's understanding and achievement of the prescribed student learning outcome(s). Interviews provide students with opportunities to model and explain their understandings.

  Interviews may be both formal and informal. Posing science-related questions during planned interviews enables teachers to focus on individual student skills and attitudes. Questioning students about how they solved problems or answered science questions reveals their thinking processes and their use of skills. Using a prepared set of questions ensures that all interviews follow a similar structure. It is important to keep a record of student responses and/or understandings.
- **Group/Peer Assessment —** Group assessment gives students opportunities to assess how well they work within a group. Peer assessment gives them opportunities to reflect on one another's work, according to clearly established criteria. During the peer assessment process, students must reflect on their own understanding in order to evaluate the performance of another student.
- **Self-Assessment —** Self-assessment is vital to all learning and, therefore, integral to the assessment process. Each student should be encouraged to assess her/his own work. Students apply known criteria and expectations to their work and reflect on results to determine their progress toward the mastery of a prescribed learning outcome. Participation in setting self-assessment criteria and expectations helps students to see themselves as scientists and problem solvers. It is important that the teacher model the self-assessment process before expecting students to assess themselves.
- **Performance Assessment/Student Demonstration —** Performance tasks provide students with opportunities to demonstrate their knowledge, thinking processes, and skill development. The tasks require the application of knowledge and skills related to a group of student learning outcomes. Performance-based tests do not test the information that students possess, but the way their understanding of a subject has been deepened, and their ability to apply their learning in a simulated performance. A scoring rubric that includes a scale for the performance of the task helps organize and interpret evidence. Rubrics allow for a continuum of performance levels associated with the task being assessed.
- **Science Journal/Learning Log Entries —** Science journal writing and learning log entries provide opportunities for students to reflect on their learning and to demonstrate their understanding using pictures, labelled drawings, and words. They can be powerful tools of formative assessment, allowing teachers to gauge a student's depth of understanding. In this document, direct questions/scenarios frame the science journal suggestions.

- **Rubrics/Checklists** — Rubrics and checklists are tools that identify the criteria upon which student processes, performances, or products will be assessed. They also describe the qualities of work at various levels of proficiency for each criterion. Rubrics and checklists may be developed in collaboration with students.
- **Visual Displays** — When students or groups of students prepare visual displays, they are involved in processing information and producing a knowledge framework. The completed poster, concept map, diagram, etc., is the product with which teachers can determine what their students are thinking.
- **Laboratory Report** — Laboratory reports allow teachers to gauge the ability of students to observe, record, and interpret experimental results. These tools can aid teachers in determining how well students understand the content.
- **Written Quiz/Test** — Quizzes can be used as discrete assessment tools, and tests can be larger assessment experiences. These written tasks may include items such as multiple choice questions, completion of a drawing or labelled diagram, problem solving, or long answer questions.
- **Research Report/Presentation** — Research projects allow students to reach the learning outcomes in individual ways. Assessment should be built into the project at every stage, from planning, to researching, to presenting the finished product.

The foregoing assessment suggestions are not meant to be limiting. Teachers are strongly encouraged to develop their own assessment for Senior Years science based on their students' learning requirements and the prescribed student learning outcomes. *Reporting on Student Progress and Achievement: A Policy Handbook for Teachers, Administrators, and Parents* (1997) contains further information related to reporting on student progress.

DOCUMENT ORGANIZATION

The prescribed learning outcomes and the suggestions for instruction, assessment, and learning resources contained within *Senior 1 Science: A Foundation for Implementation* provide teacher educators with a plan for achieving the student learning outcomes identified in *Senior 1 Science: Manitoba Curriculum Framework of Outcomes* (2000). The document is organized by clusters; Cluster 0: Overall Skills and Attitudes is followed by the four “thematic” clusters. In addition, the appendices comprise Student Learning Activities, Teacher Support Materials, and Blackline Masters. These complementary materials are designed to support, facilitate, and enhance student learning and assessment by being closely linked to the learning outcomes and the skills and attitudes.

Guide to Reading the Specific Learning Outcomes and the Four-Column Format

- The Prescribed Learning Outcomes identified in column one outline the intended learning to be achieved by the student by the end of the course of instruction. They include the specific learning outcomes related to the thematic cluster in addition to the learning outcomes related to Cluster 0: Overall Skills and Attitudes selected to correspond to the Suggestions for Instruction.

- Column two contains Suggestions for Instruction directly related to the achievement of the specific learning outcomes contained in the first column.

- Column three assists teachers with Suggestions for Assessment of the specific learning outcomes.

- Column four cites suggested approved Learning Resources intended to guide and support instruction, the learning process, and student assessment.

- Teacher Background information provides planning hints, special interest material, and depth of treatment on certain issues related to the learning outcomes. These are incorporated as text boxes in either column two or three.

The pages that follow provide detailed clarification on reading the four-column format.

The Four-Column Format

Prescribed learning outcome statements that define what students are expected to achieve at the end of each grade

Suggestions for student learning experiences directly related to the attainment of specific learning outcomes

Suggested time for instruction

Learning outcomes related to thematic clusters

Learning outcomes related to Cluster 0, Overall Skills and Attitudes, selected to correspond to Suggestions for Instruction

Senior 1 Science: A Foundation for Implementation

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-1-03 Describe various types of asexual reproduction that occur in plant and animal species.

Examples: fission, budding, sporulation, vegetative propagation, regeneration…

GLO: D1, E1

Skills and Attitudes Outcomes

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6;
TFS: 2.3.1, 4.3.4

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia.
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

SUGGESTIONS FOR INSTRUCTION
(2 HOURS)

➢ **Entry-Level Knowledge**

Students have studied the difference between unicellular and multicellular organisms in Grade 8, but have not examined reproduction.

➢ **Notes for Instruction**

Most students will have some life experience with asexual reproduction. Encourage them to share their experience with the class through guided discussion or question and answer. Different methods of vegetative reproduction will be studied in greater detail in outcome S1-1-04.

➢ **Student Learning Activities**

Collaborative Teamwork S1-0-4e

Students use a Jigsaw or Roundtable to learn about the various types of asexual reproduction.

Expert Groups: Each student group investigates one form of asexual reproduction (regeneration, budding, sporulation, fission, vegetative propagation), and then shares its findings with the rest of the class. (See *Success for All Learners*, Chapter 5)

Visual Displays S1-0-2c, 5c

Students draw diagrams or create posters describing various types of asexual reproduction. (See Appendix 1.3)

Students complete Three-Point Approach frames to demonstrate their understanding of vocabulary. (See *SYSTH*, page 10.9)

Journal Writing S1-0-7e

Students reflect on ways in which the process of regeneration may be useful to humans. (See *SYSTH*, Chapter 13)

Students prepare a glossary of new words and their meanings for quick reference.

Students reflect and respond to the following questions:

- How has your understanding of reproduction changed since the beginning of this unit?
- What new questions do you have about reproduction?
- What new discoveries in this cluster surprise you?

1.6

Suggestions for assessing specific learning outcome(s)

Suggestions for learning resources including print and information technology resources

References to blackline masters (BLM) and Teacher Support Materials (TSM) in print resources

Background information and/or definitions for teachers, often beyond what students are required to know; safety information

Senior 1, Cluster 1: Reproduction

SUGGESTIONS FOR ASSESSMENT

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students

- identify examples of asexual reproduction based on their observations of microscope slides, pictures, or diagrams.
- describe different types of asexual reproduction.
- differentiate among alternative forms of asexual reproduction.
- explain why cutting individual starfish into pieces will increase the starfish population.

Visual Displays S1-0-2c, 5c

Students or student groups prepare visual displays of the various types of asexual reproduction. The displays may include:

- posters
- diagrams
- information technology presentations

Journals

Assess journal entries using a Journal Evaluation rubric. (See *SYSTH*, page 13.21)

Teacher Background

Some examples of organisms that use various methods of asexual reproduction include:

- *regeneration:* starfish, planaria
- *budding:* sponges, hydra
- *sporulation:* bread mould, wheat rust
- *fission:* amoebas, bacteria
- *vegetative propagation:* poplars, strawberries

Note: Reproduction refers to the processes by which a new generation of cells or multicelled individuals is produced. Sexual reproduction requires meiosis, formation of gametes, and fertilization (with the exception of parthenogenesis. Asexual reproduction refers to the production of new individuals by any mode that does not involve formation of gametes.

SUGGESTED LEARNING RESOURCES

Science 9

5.4 The Importance of Cell Division, p. 148

5.8 Reproduction and Cell Division, p. 159

6.5 Regeneration, p. 186

6.9 Cloning, p. 194

TSM-3 Cooperative Learning

Sciencepower 9

1.3 The Cell Cycle in Your Body, p. 24

1.4 Asexual Reproduction In Bacteria, Protists, Fungi, and Animals, p. 29
Investigation 1-D: Be a Biologist: Assess Asexual Reproduction, pp. 31–36

1.5 Asexual Reproduction In Plants, pp. 24–25

BLM 1-23 Investigation 1-D: Be a Biologist: Assess Asexual Reproduction

BLM 1-24 Mitosis and Cell Division in an Amoeba

BLM 1-25 Asexual Reproduction Crossword

Appendices

1.3 Blackline Master Types of Asexual Reproduction

SYSTH

3.7 Cooperative Learning and Science

10.9 Building a Scientific Vocabulary

13 Writing to Learn Science

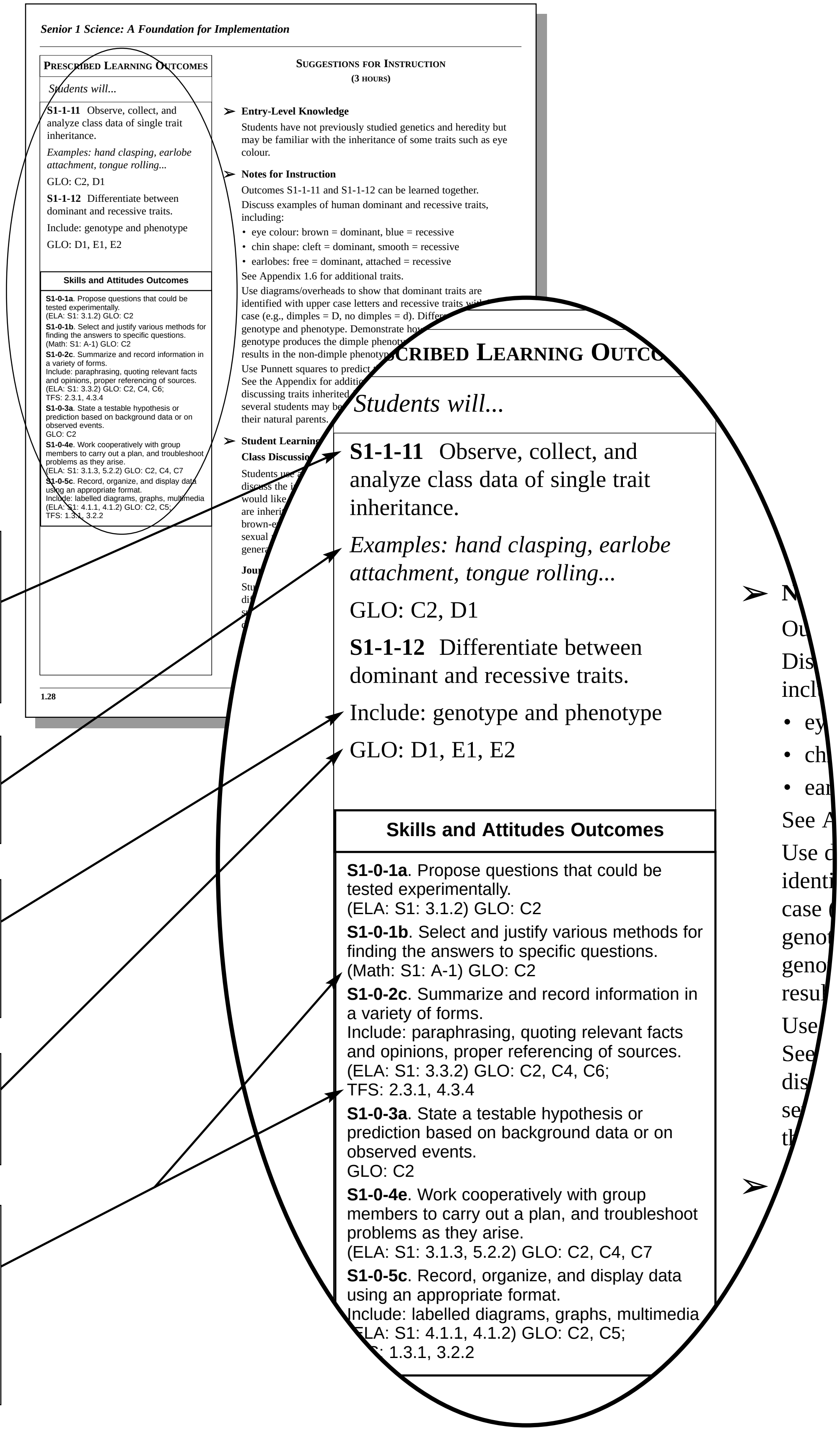
Success for All Learners

5 Flexible Grouping

5.3 Individual, Small-Group, and Whole-Class Work

1.7

Guide to Reading Specific Learning Outcomes



First digit indicates grade; second digit indicates cluster number; third digit(s) indicates specific learning outcome number

Example: Provides ideas of what could be included (non-mandatory)

Include: Indicates a mandatory component of the specific learning outcome

Cross-reference to general learning outcomes. (See Appendix)

Cross-reference to other areas: mathematics (Math), English language arts (ELA), Technology as a Foundation Skill Area (TFS)

Senior 1

Cluster 0: Overall Skills and Attitudes

Overview

Cluster 0 comprises nine categories of specific learning outcomes that describe the skills and attitudes* involved in scientific inquiry and the decision-making process for STSE issues. In Grades 5 to 8, students develop scientific inquiry through the development of an hypothesis/ prediction, the identification and treatment of variables, and the formation of conclusions. Students begin to make decisions based on scientific facts and refine their decision-making skills as they progress through the grades, gradually becoming more independent. Students also acquire key attitudes, an initial awareness of the nature of science, and other skills related to research, communication, the use of information technology, and cooperative learning.

In Senior 1, students continue to use scientific inquiry as an important process in their science learning, but also recognize that STSE issues require a more sophisticated treatment through the decision-making process. This process has been delineated in the Cluster 0 specific learning outcomes.

Teachers should select appropriate contexts to introduce and reinforce scientific inquiry, the decision-making process, and positive attitudes within the thematic clusters (Clusters 1 to 4) over the course of the school year. For example, students will use the decision-making process as they examine a current biotechnology issue in Cluster 1. To assist in planning and to facilitate curricular integration, many specific learning outcomes within this cluster are accompanied by links to specific learning outcomes in other subject areas, specifically English language arts (ELA) and mathematics (Math). There are also links to *Technology As a Foundation Skill Area* (TFS).

Students will...

	Scientific Inquiry	STSE Issues
Initiating	**S1-0-1a Propose questions that could be tested experimentally.** **GLO: C2** **(ELA: S1: 3.1.2)** **S1-0-1b Select and justify various methods for finding the answers to specific questions.** **GLO: C2** **(Math: S1: A-1)**	**S1-0-1c Identify STSE issues which could be addressed.** **GLO: C4** **S1-0-1d Identify stakeholders and initiate research related to an STSE issue.** **GLO: C4** **(ELA: S1: 3.1.4, 4.4.1)**

* Cluster 0, Overall Skills and Attitudes, specific learning outcomes for this grade are presented as a chart (separate attachment). The purpose of this chart is to provide a full grade overview of skills and attitudes that need to be achieved.

	Scientific Inquiry	STSE Issues
Researching	**S1-0-2a Select and integrate information obtained from a variety of sources. Include: print and electronic sources, specialists, and other resource people.** **GLO: C2, C4, C6 TFS: 1.3.2, 4.3.4** **(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1)**	
	S1-0-2b Evaluate the reliability, bias, and usefulness of information. **GLO: C2, C4, C5, C8 TFS: 2.2.2, 4.3.4 (ELA: S1: 3.2.3, 3.3.3)**	
	S1-0-2c Summarize and record information in a variety of forms. Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources. **GLO: C2, C4, C6 TFS: 2.3.1, 4.3.4 (ELA: S1: 3.3.2)**	
		S1-0-2d Review effects of past decisions and various perspectives related to an STSE issue. ***Examples: governments', public, environmentalists', and First Nations' positions on hydroelectric development; religious, social, and medical views on genetic screening...*** **GLO: B1, C4 TFS: 1.3.2, 4.3.4** **(ELA: S1: 3.2.2)**

	Scientific Inquiry	STSE Issues
Planning	**S1-0-3a State a testable hypothesis or prediction based on background data or on observed events.** **GLO: C2**	**S1-0-3d Summarize relevant data and consolidate existing arguments and positions related to an STSE issue.** **GLO: C4** **TFS: 2.3.1, 4.3.4** **(ELA: S1: 1.2.1, 3.3.1, 3.3.2)**
	S1-0-3b Identify probable mathematical relationships between variables. ***Examples: relationship between current and resistance...*** **GLO: C2**	**S1-0-3e Determine criteria for the evaluation of an STSE decision.** ***Examples: scientific merit; technological feasibility; social, cultural, economic, and political factors; safety; cost; sustainability...*** **GLO: B5, C1, C3, C4**
	S1-0-3c Plan an investigation to answer a specific scientific question. **Include: materials, variables, controls, methods, safety considerations.** **GLO: C1, C2**	**S1-0-3f Formulate and develop options which could lead to an STSE decision.** **GLO: C4**

	Scientific Inquiry	STSE Issues
Implementing a Plan	**S1-0-4a Carry out procedures that comprise a fair test.** **Include: controlling variables, repeating experiments to increase accuracy and reliability of results.** **GLO: C1, C2** **TFS: 1.3.1** **S1-0-4b Demonstrate work habits that ensure personal safety, the safety of others, as well as consideration for the environment.** **Include: knowledge and use of relevant safety precautions, WHMIS regulations, emergency equipment.** **GLO: B3, B5, C1, C2** **S1-0-4c Interpret relevant WHMIS regulations.** **Include: symbols, labels, Material Safety Data Sheet(s) (MSDS).** **GLO: C1, C2**	**S1-0-4d Use various methods for anticipating the impacts of different options.** ***Examples: test run, partial implementation, simulation, debate...*** **GLO: C4, C5, C6, C7**
	S1-0-4e Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise. **GLO: C2, C4, C7** **(ELA: S1: 3.1.3, 5.2.2)** **S1-0-4f Assume the responsiblities of various roles within a group and evaluate which roles are most appropriate for given tasks.** **GLO: C2, C4, C7** **(ELA: S1: 5.2.2)**	

	Scientific Inquiry	STSE Issues
Observing, Measuring, Recording	**S1-0-5a Select and use appropriate methods and tools for collecting data or information.** **GLO: C2** **TFS: 1.3.1** **S1-0-5b Estimate and measure accurately using Système International (SI) and other standard units.** **Include: SI conversions.** **GLO: C2** **S1-0-5c Record, organize, and display data using an appropriate format.** **Include: labelled diagrams, graphs, information technology.** **GLO: C2, C5** **TFS: 1.3.1, 3.2.2** **(ELA: S1: 4.1.1, 4.1.2)**	**S1-0-5d Evaluate, using pre-determined criteria, different STSE options leading to a possible decision.** **Include: scientific merit; technological feasibility; social, cultural, economic, and political factors; safety; cost; sustainability.** **GLO: B5, C1, C3, C4** **TFS: 1.3.2, 3.2.3** **(ELA: S1: 3.3.3)**

	Scientific Inquiry	STSE Issues
Analyzing and Interpreting	**S1-0-6a Interpret patterns and trends in data, and infer and explain relationships.** **GLO: C2, C5** **TFS: 1.3.1, 3.3.1** **(ELA: S1: 3.3.1)** **S1-0-6b Identify and suggest explanations for discrepancies in data.** ***Examples: sources of error...*** **GLO: C2** **(ELA: S1: 3.3.3)** **S1-0-6c Evaluate the original plan for an investigation and suggest improvements.** ***Examples: identify strengths and weaknesses of data collection methods used...*** **GLO: C2, C5**	**S1-0-6d Adjust STSE options as required once their potential effects become evident.** **GLO: C3, C4, C5, C8**

	Scientific Inquiry	STSE Issues
Concluding and Applying	**S1-0-7a Draw a conclusion that explains the results of an investigation.** **Include: cause and effect relationships, alternative explanations, supporting or rejecting the hypothesis or prediction.** **GLO: C2, C5, C8** **(ELA: S1: 3.3.4)**	**S1-0-7b Select the best option and determine a course of action to implement an STSE decision.** **GLO: B5, C4** **S1-0-7c Implement an STSE decision and evaluate its effects.** **GLO: B5, C4, C5, C8** **S1-0-7d Reflect on the process used to arrive at or to implement an STSE decision, and suggest improvements.** **GLO: C4, C5** **(ELA: S1: 5.2.4)**
	S1-0-7e Reflect on prior knowledge and experiences to develop new understanding. **GLO: C2, C3, C4** **(ELA: S1: 4.2.1)**	

Reflecting on Science and Technology

Scientific Inquiry	STSE Issues
S1-0-8a Distinguish between science and technology. **Include: purpose, procedures, products.** **GLO: A3** **S1-0-8b Explain the importance of using precise language in science and technology.** **GLO: A2, A3, C2, C3** **(ELA: S1: 4.4.2)** **S1-0-8c Describe examples of how scientific knowledge has evolved in light of new evidence, and the role of technology in this evolution.** **GLO: A2, A5** **S1-0-8d Describe examples of how technologies have evolved in response to changing needs and scientific advances.** **GLO: A5** **S1-0-8e Discuss how peoples of various cultures have contributed to the development of science and technology.** **GLO: A4, A5** **S1-0-8f Relate personal activities and possible career choices to specific science disciplines.** **GLO: B4** **S1-0-8g Discuss social and environmental effects of past scientific and technological endeavours.** **Include: major shifts in scientific world views, unintended consequences.** **GLO: B1**	

Demonstrating Scientific and Technological Attitudes and Habits of Mind

Scientific Inquiry	STSE Issues
S1-0-9a Appreciate and respect that science and technology have evolved from different views held by women and men from a variety of societies and cultural backgrounds. **GLO: A4** **S1-0-9b Express interest in a broad scope of science- and technology-related fields and issues.** **GLO: B4** **S1-0-9c Demonstrate confidence in their ability to carry out investigations in science and to address STSE issues.** **GLO: C2, C4, C5** **S1-0-9d Value skepticism, honesty, accuracy, precision, perseverance, and open-mindedness as scientific and technological habits of mind.** **GLO: C2, C3, C4, C5** **S1-0-9e Be sensitive and responsible in maintaining a balance between the needs of humans and a sustainable environment.** **GLO: B5, C4** **S1-0-9f Demonstrate personal involvement and be proactive with respect to STSE issues.** **GLO: B5, C4**	

Senior 1

Cluster 1: Reproduction

Overview

Reproduction is an essential biological mechanism for the continuity and diversity of species. In this cluster, students

- compare sexual and asexual methods of reproduction.
- learn how the human reproductive system functions.
- describe the major stages of human development from conception to birth.
- recognize that the nucleus of a cell contains genetic information and is responsible for the transmission of traits from one generation to the next.
- analyze single trait inheritance in humans
- discuss factors that may change a cell's genetic information, including environmental factors.
- address a current biotechnology issue using the knowledge they have gained.

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-1-01 Illustrate and explain the process of mitotic cell division in plants and animals.

Include: chromosomes, mitosis, cytoplasmic division, cell cycle.

GLO: D1, E1, E2

S1-1-02 Observe and explain the dynamic nature of cell division.

GLO: C2, D1, E3

Skills and Attitudes Outcomes

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6;
TFS: 2.3.1, 4.3.4

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
GLO: C2, C5, C8 (ELA: S1: 3.3.4)

S1-0-5a. Select and use appropriate methods and tools for collecting data or information.
GLO: C2; TFS: 1.3.1

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia.
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

S1-0-6a. Interpret patterns and trends in data, and infer and explain relationships.
(ELA: S1: 3.3.1) GLO: C2, C5;
TFS: 1.3.1, 3.3.1

SUGGESTIONS FOR INSTRUCTION

(2-1/2 HOURS)

➢ Entry-Level Knowledge

Students have studied cells in Grade 8, and should be familiar with

- the following vocabulary: cell membrane, nucleus, cell wall, chromosomes.
- the use of microscopes to observe and compare the general structure and function of plant and animal cells.

➢ Notes for Instruction

Explain how cell division occurs in single plant and animal cells. Be sure to identify and explain the role of the chromosomes, cell membrane, cell wall, cytoplasm, and nucleus in the process. Use models, diagrams, or videos to demonstrate the process of cell division.

Caution: Students are NOT to memorize the names of the stages of mitosis (i.e., interphase, prophase, metaphase, anaphase, telophase), but should understand that it is a continuous, dynamic process.

➢ Student Learning Activities

Laboratory Activity S1-0-2c, 5a, 5c

Students complete a lab activity involving observation of plant and/or animal cell division.

Visual Displays S1-0-5c

Students use a variety of charts, videos, overheads, CD-ROMs, and websites to illustrate cell division. (See Appendix 1.1)

Teacher Demonstration S1-0-6a

Set up a series of slides showing a variety of stages of cell division. Students

- observe structures that are included in the stages (i.e., chromosomes, nuclei, nuclear membrane, cell wall [in plant cells], cell membrane [in animal cells]).
- describe the differences among the structures in the slides.

Collaborative Teamwork S1-0-4e

Students work in small groups to write mitosis limericks.
For example:

There once was a cell named Tigger,
Who said "I can't get any bigger.
My growth has to quit.
It is time to split.
So the new cells can grow with vigour."

(continued)

SUGGESTIONS FOR ASSESSMENT

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students

- place pictures of single cells in various stages of cell division in the correct order.
- complete a Compare and Contrast or Concept Relationship frame listing the similarities and/or differences between cell division in plant and animal cells.
- write a description of the events of cell division.
- draw diagrams outlining the events of cell division.

Laboratory Report S1-0-2c, 5a, 5c

Students prepare a report outlining the events of cell division, and the similarities and differences between cell division in plant and animal cells. (See Appendices 5.5 and 5.6)

(continued)

SUGGESTED LEARNING RESOURCES

Science 9

5.5 Cell Division, p. 150

5.6 Activity: Observing Cell Division, pp. 154–55

BLM 5.5a Phases of Cell Division

TSM-3 Cooperative Learning

TSM-6 Graphic Organizers

Sciencepower 9

1.2 Understanding the Cell Cycle, p. 17
Investigation 1-C: Observing Mitosis in Plant and Animal Cells, pp. 20–21

BLM 1-14 Steps of Mitosis

BLM 1-15 Typical Cell Cycle

BLM 1-16 Cell Growth And Division

Appendices

1.1 Blackline Master
Mitotic Cell Division

1.2 Blackline Master
Meiotic Cell Division

5.5 Lab Report Assessment

5.6 Observation Checklist — Scientific Inquiry

PRESCRIBED LEARNING OUTCOMES

Students will...

(continued)

S1-1-01 Illustrate and explain the process of mitotic cell division in plants and animals.

Include: chromosomes, mitosis, cytoplasmic division, cell cycle.

GLO: D1, E1, E2

S1-1-02 Observe and explain the dynamic nature of cell division.

GLO: C2, D1, E3

SUGGESTIONS FOR INSTRUCTION

(2-1/2 HOURS)

➢ **Student Learning Activities (continued)**

Journal Writing S1-0-2c, 7e

Students imagine that they are miniaturized to microscopic size. They hitchhike a ride on a chromosome in a cell that divides, and describe what they see during the process.

Students propose events or circumstances that could affect the rate of cell division (e.g., poor nutrition, cancer).

Students use a Compare and Contrast or Concept Relationship frame to distinguish between cell division in plant and animal cells. (See *SYSTH*, pages 10.15, 13.5)

Visual Displays S1-0-2c, 5c

Students work individually or in small teams to draw and/or label diagrams or create posters, concept maps, information technology presentations, or models showing the events of cell division.

Students draw their own reference cell, labelling the components they know are involved in cell division.

SUGGESTIONS FOR ASSESSMENT

Visual Displays S1-0-2c, 5c

Students work individually or in small teams to prepare visual displays of the events of cell division or the similarities and differences between plant and animal cell division.

The displays may include:

- posters
- diagrams
- information technology presentations
- concept maps
- models

Journals

Assess journal entries using a Journal Evaluation form. (See Senior Years Science Teachers' Handbook [*SYSTH*], page 13.21)

Student Demonstration S1-0-2a, 2e, 7e

Students choose objects to demonstrate the process of mitosis (e.g., pieces of wool, coloured marshmallows, pieces of pipe cleaner, or anything they find useful for the activity), and present their demonstration to the class. (See Appendix 5.2)

SUGGESTED LEARNING RESOURCES

SYSTH

10.15 Building a Scientific Vocabulary

11.20 Developing Scientific Concepts Using Graphic Displays

11.26 Laboratory Report Online

13.5 Writing to Learn Science

13.21 Writing to Learn Science

Laboratory Safety

Science Safety: A K–S4 Resource Manual for Teachers, Schools, and School Divisions, Manitoba Education and Training, 1997
Available online @
www.edu.gov.mb.ca/metks4/docs/support/scisafe

Be safe! A health and safety reference for Science and Technology Curriculum, Science Teachers' Association of Ontario, 1998
Available online @
http://www.stao.org/

Appendices

5.2 Rubric for the Assessment of Class Presentations

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-1-03 Describe various types of asexual reproduction that occur in plant and animal species.

Examples: fission, budding, sporulation, vegetative propagation, regeneration…

GLO: D1, E1

Skills and Attitudes Outcomes

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6;
TFS: 2.3.1, 4.3.4

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia.
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

SUGGESTIONS FOR INSTRUCTION
(2 HOURS)

➢ Entry-Level Knowledge

Students have studied the difference between unicellular and multicellular organisms in Grade 8, but have not examined reproduction.

➢ Notes for Instruction

Most students will have some life experience with asexual reproduction. Encourage them to share their experience with the class through guided discussion or question and answer.

Different methods of vegetative reproduction will be studied in greater detail in outcome S1-1-04.

➢ Student Learning Activities

Collaborative Teamwork S1-0-4e

Students use a Jigsaw or Roundtable to learn about the various types of asexual reproduction.

Expert Groups: Each student group investigates one form of asexual reproduction (regeneration, budding, sporulation, fission, vegetative propagation), and then shares its findings with the rest of the class. (See *Success for All Learners*, Chapter 5)

Visual Displays S1-0-2c, 5c

Students draw diagrams or create posters describing various types of asexual reproduction. (See Appendix 1.3)

Students complete Three-Point Approach frames to demonstrate their understanding of vocabulary. (See *SYSTH*, page 10.9)

Journal Writing S1-0-7e

Students reflect on ways in which the process of regeneration may be useful to humans. (See *SYSTH*, Chapter 13)

Students prepare a glossary of new words and their meanings for quick reference.

Students reflect and respond to the following questions:

- How has your understanding of reproduction changed since the beginning of this unit?
- What new questions do you have about reproduction?
- What new discoveries in this cluster surprise you?

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students

- identify examples of asexual reproduction based on their observations of microscope slides, pictures, or diagrams.
- describe different types of asexual reproduction.
- differentiate among alternative forms of asexual reproduction.
- explain why cutting individual starfish into pieces will increase the starfish population.

Visual Displays S1-0-2c, 5c

Students or student groups prepare visual displays of the various types of asexual reproduction. The displays may include:

- posters
- diagrams
- information technology presentations

Journals

Assess journal entries using a Journal Evaluation rubric. (See *SYSTH*, page 13.21)

Teacher Background

Some examples of organisms that use various methods of asexual reproduction include:

- *regeneration:* starfish, planaria
- *budding:* sponges, hydra
- *sporulation:* bread mould, wheat rust
- *fission:* amoebas, bacteria
- *vegetative propagation:* poplars, strawberries

Note: Reproduction refers to the processes by which a new generation of cells or multicelled individuals is produced. Sexual reproduction requires meiosis, formation of gametes, and fertilization (with the exception of parthenogenesis. Asexual reproduction refers to the production of new individuals by any mode that does not involve formation of gametes.

Suggested Learning Resources

Science 9

5.4 The Importance of Cell Division, p. 148

5.8 Reproduction and Cell Division, p. 159

6.5 Regeneration, p. 186

6.9 Cloning, p. 194

TSM-3 Cooperative Learning

Sciencepower 9

1.3 The Cell Cycle in Your Body, p. 24

1.4 Asexual Reproduction In Bacteria, Protists, Fungi, and Animals, p. 29

Investigation 1-D: Be a Biologist: Assess Asexual Reproduction, pp. 31–36

1.5 Asexual Reproduction In Plants, pp. 24–25

BLM 1-23 Investigation 1-D: Be a Biologist: Assess Asexual Reproduction

BLM 1-24 Mitosis and Cell Division in an Amoeba

BLM 1-25 Asexual Reproduction Crossword

Appendices

1.3 Blackline Master Types of Asexual Reproduction

SYSTH

3.7 Cooperative Learning and Science

10.9 Building a Scientific Vocabulary

13 Writing to Learn Science

Success for All Learners

5 Flexible Grouping

5.3 Individual, Small-Group, and Whole-Class Work

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-1-04 Investigate and describe agricultural applications of asexual reproduction.

Examples: cloning, cuttings, grafting, bulbs…

GLO: A5, B1, B2, D1

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print and electronic sources, specialists, and other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 1.3.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.3.1, 4.3.4

S1-0-4b. Demonstrate work habits that ensure personal safety of others, as well as consideration for the environment.
Include: knowledge and use of relevant safety precautions, WHMIS regulations, emergency equipment.
GLO: B3, B5, C1, C2

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5a. Select and use appropriate methods and tools for collecting data or information.
GLO: C2 TFS: 1.3.1

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia.
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2

S1-0-7a. Draw a conclusion that explains the results of an investigation.
Include: cause and effect relationships, alternative explanations, supporting or rejecting the hypothesis or prediction.
(ELA: S1: 3.3.4) GLO: C2, C5, C8

SUGGESTIONS FOR INSTRUCTION
(2 HOURS)

➢ Notes for Instruction

Students will have varying degrees of experience with the applications of asexual reproduction. Research projects and group presentations could be used to expose students to a wide variety of agricultural applications.

➢ Student Learning Activities

Guest Speaker: Invite a local gardener, greenhouse or nursery worker, or agricultural research station employee to give a presentation and/or demonstration on this topic. Students prepare questions in advance of the visit. Questions may include:

- What background/experience/education is required to do the presenter’s job?
- What is a “day-in-the-life” of a gardener, greenhouse worker, or agricultural research station employee like?
- What applications of asexual reproduction does the presenter utilize? Why?

Laboratory Activity S1-0-2c, 4b, 5a, 5c

Students perform a lab in which they clone plants using a variety of methods.

Field Trip: Visit a local greenhouse, nursery, or agricultural research station for a tour related to this topic. Students discuss how they will prepare for the tour. Preparations may include:

- obtaining a still camera and film or video camera to record sights seen during the tour.
- preparing a list of questions to ask the tour guide.

Student Research S1-0-2a, 2c, 5c

Students or student groups research the agricultural applications of asexual reproduction, including

- grafting
- runners
- cloning
- bulbs
- cuttings
- tubers
- tissue culture

Collaborative Teamwork S1-0-4e

Students use a Jigsaw or Roundtable to learn about the various agricultural applications of asexual reproduction. (See *Success for All Learners*, Chapter 5)

(continued)

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students

- differentiate among the various methods of vegetative propagation (i.e., cuttings, grafting, etc.).
- identify when each method of propagation is used.
- describe, with the use of examples, agricultural applications of asexual reproduction.
- predict reasons why a farmer would use vegetative propagation instead of sexual reproduction with seeds.

Laboratory Report S1-0-2c, 5a, 5c, 7a

Students prepare a report outlining the methods used to clone plants and their success or failure. (See Appendices 5.5 and 5.6)

Research Report S1-0-2a, 2c, 5c

Working individually or in small groups, students investigate an agricultural application of asexual reproduction, and prepare

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations

(See Appendix 5.3)

(continued)

Suggested Learning Resources

Science 9

6.7 Producing Plants Without Seeds, p. 190

6.8 Investigation: Cloning from Plant Cuttings, pp. 192–93

6.9 Cloning, p. 94

BLM 6.7 Plant Reproduction: Concept Map

TSM-3 Cooperative Learning

Sciencepower 9

1.5 Asexual Reproduction in Plants, p. 36
Investigation 1-E: Clone a Plant, pp. 37–40

BLM 1-26 New Plants from Cuttings

BLM 1-28 New Plants from Roots

BLM 1-29 New Plants from Stems

BLM 1-30 New Plants from Layering

BLM 1-31 New Plants from Grafting

Success for All Learners

Chapter 5 Flexible Grouping

SYSTH

11.26 Laboratory Report Outline

Appendices

5.3 Rubric for the Assessment of a Research Project

5.5 Lab Report Assessment

5.6 Observation Checklist — Scientific Inquiry

(continued)

PRESCRIBED LEARNING OUTCOMES

Students will...

(continued)

S1-1-04 Investigate and describe agricultural applications of asexual reproduction.

Examples: cloning, cuttings, grafting, bulbs…

GLO: A5, B1, B2, D1

SUGGESTIONS FOR INSTRUCTION
(2 HOURS)

➢ **Student Learning Activities (continued)**

Journal Writing

Students reflect on and respond to the following questions:

- What are the possible risks associated with the agricultural applications discussed in this unit?
- Do you think farmers and gardeners will have a broader choice of plants and animals to grow/raise in the future? Explain.
- What are the advantages of asexual reproduction applications for the food industry? For medicine? For the horticulture industry?

Class Discussion: Discuss the ethical issues arising from cloning and grafting. (See *Success for All Learners*, page 7.3)

Suggestions for Assessment

Journals

Assess journal entries using an assessment rubric such as the template in *SYSTH*, page 13.21.

Teacher Background

Some examples of asexual reproduction used in agricultural applications include:

- *cuttings:* African violets, geraniums, begonias, grapes
- *grafting:* apple trees, rose bushes. Grafting consists of joining a portion of the plant you wish to increase (the scion) to the chosen root system (the stock). The join is bound with tape to allow adhesion.
- *bulbs:* garlic, onions, gladiolas
- *runners:* strawberries, spider plants
- *tubers:* potatoes, dahlias
- *cloning:* plants (seedless watermelons and oranges) A new plant produced by cloning has chromosomes identical to those of the parent plant from which it came. Cloning plants is quite easy and is now done on a large scale in a lab by using a technique called *tissue culture*.

Asexual reproduction of plants is also called vegetative propagation.

Suggested Learning Resources

Success for All Learners

7.3 Structuring Whole-Class Discussions

SYSTH

13.21 Writing to Learn Science

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-1-05 Illustrate and explain the production of male and female gametes by meiosis in plants and animals.

GLO: D1, E1, E2

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print and electronic sources, specialists, and other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 1.3.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.3.1, 4.3.4

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

SUGGESTIONS FOR INSTRUCTION
(1-1/2 HOURS)

➢ Entry-Level Knowledge

In Grade 8, students were exposed to the use of microscopes and the structure and function of some cell parts, such as the cell membrane, cytoplasm, nucleus, and chromosomes.

➢ Notes for Instruction

Emphasize that meiosis involves chromosome number reduction prior to sexual reproduction so that the chromosome number of the species is maintained. Review the following terms: meiosis, diploid, homologous, haploid, gametes, and zygote.

Caution: Students are not expected to memorize the names of the stages of meiosis. It is important that they understand the purpose and products only.

➢ Student Learning Activities

Class Discussion S1-0-7e

Students speculate why meiosis is important, and what would happen if meiosis did not occur prior to sexual reproduction.

Visual Displays S1-0-2a, 2c, 5c

Students label diagrams or create posters illustrating the production of male and female gametes by meiosis. (See Appendix 1.2)

Information Technology: A variety of charts, video, overheads, websites, and CD-ROMs can be used to illustrate meiosis.

Journal Writing S1-0-2c

Students read a description of sexual reproduction for one specific plant species and for one specific animal species and compare the two processes using a tabular format.

Have students complete a Concept Frame or Concept Overview to aid in their understanding of meiosis.

Student Research S1-0-2a, 2c, 5c

Students research the advantages and disadvantages of parthenogenesis (the development of an unfertilized egg into an adult animal without fusion with sperm). Parthenogenesis occurs in many insects, such as bees, wasps, aphids, lice, some ants, and other microscopic animals. See *SYSTH*, pages 14.7–14.15, for strategies and format suggestions.

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students

- place pictures of single cells in various stages of meiosis in the correct order.
- write a description of the events of meiosis.
- draw diagrams outlining the events of meiosis.

Visual Displays S1-0-2c, 5c

Students or student groups work to prepare visual displays of the events of meiosis. The displays may include:

- posters
- diagrams
- information technology presentations
- concept maps
- models

Students choose from five different sets of objects to represent the process of meiosis (e.g., plastic building blocks, pipe cleaner pieces, bingo chips, pieces of coloured wool) and present the process to the class. (See Appendix 5.2)

Journals

Assess Journal Entries using an assessment rubric similar to that in *SYSTH*, page 13.21.

Suggested Learning Resources

Science 9

7.2 Meiosis, p. 206

BLM 7.2 Stages of Meiosis

TSM-6 Graphic Organizers

Sciencepower 9

2.1 Understanding the Basis of Sexual Reproduction, p. 46

Investigation 2-A: Meiosis: The Power of Reduction, pp. 48–50

BLM 2-9 How Do the Number of Chromosomes in Body Cells and Sex Cells Compare?

BLM 2-0 Sex Cells — A Different Story

BLM 2-11 Key Events in Meiosis

BLM 2-12 The Steps of Meiosis

BLM 2-15 Formation of Sperm and Egg

BLM 2-16 Sex Cell Summary

Appendices

1.1 Blackline Master Mitotic Cell Division

1.2 Blackline Master Meiotic Cell Division

5.2 Rubric for the Assessment of Class Presentations

SYSTH

11.20 Developing Scientific Concepts Using Graphic Displays

13.21 Writing to Learn Science

14.7 Technical Writing in Science

Prescribed Learning Outcomes

Students will...

S1-1-06 Compare and contrast the function of mitosis to that of meiosis.

Include: diploid cells, haploid cells.

GLO: D1, E1

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print and electronic sources, specialists, and other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 1.3.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.3.1, 4.3.4

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2

Suggestions for Instruction

(1 hour)

➢ **Notes for Instruction**

Emphasize that mitosis is for the purpose of asexual reproduction, growth, and tissue repair. Meiosis involves chromosome number reduction prior to sexual reproduction so that the chromosome number of the species is maintained. (See Appendices 1.1 and 1.2)

➢ **Student Learning Activities**

Journal Writing S1-0-2c

Students complete a Compare and Contrast or Concept Relationship frame outlining the similarities and/or differences between the functions and processes of mitosis and meiosis. (See *SYSTH*, pages 10.15, 11.19)

Visual Displays S1-0-2a, 5c

Students draw the life cycle of their favourite animal, illustrating which parts of the cycle come from meiosis and which parts come from mitosis. (See *SYSTH*, page 11.37)

Collaborative Teamwork S1-0-4e

Students use a Think-Pair-Share or Roundtable to compare and contrast meiosis and mitosis. (See *SYSTH*, pages 9.5, 10.6)

Debate: Students debate whether meiosis or mitosis is more efficient and advantageous. Divide the class into two — one half to defend each process. Stress the importance of basing arguments on scientific facts rather than personal opinion. (See *SYSTH*, page 4.19)

You may wish to distribute copies of Appendix 1.4 to students in advance of the debate.

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students

- complete a Compare and Contrast frame outlining the similarities and differences between the functions and processes of mitosis and meiosis.
- explain the difference between haploid and diploid cells. A Concept Relationship frame could be used.

Visual Displays S1-0-2c, 5c

Students draw the life cycle of their favourite animal, identifying which parts of the cycle come from meiosis and which parts come from mitosis. The displays may include:

- posters
- diagrams
- information technology presentations

Discussion and/or Journals: Encourage reflection and discussion on the debate. Use the following questions to inspire participation:

- What surprising points were raised during the debate?
- Do you think there is a right or wrong answer to the question? Explain.
- What valid facts were used to support their arguments?
- Summarize the arguments given by each team.

Suggested Learning Resources

Science 9

7.2 Meiosis, p. 206

TSM-3 Cooperative Learning

Sciencepower 9

2.1 Understanding the Basis of Sexual Reproduction, p. 46

BLM 2-3 How Is Meiosis Different from Mitosis?

BLM 2-14 Compare Mitosis and Meiosis

Appendices

1.1 Blackline Master Mitotic Cell Division

1.2 Blackline Master Meiotic Cell Division

1.4 Blackline Master Advantages and Disadvantages of Sexual and Asexual Reproduction

SYSTH

4.19 Science — Technology — Society — Environment Connections

9.5 Tapping into Prior Knowledge

10.6 Building a Scientific Vocabulary

10.15 Building a Scientific Vocabulary

11.19 Developing Scientific Concepts Using Graphic Displays

11.20 Developing Scientific Concepts Using Graphic Displays

11.37 Developing Scientific Concepts Using Graphic Displays

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-1-07 Compare sexual and asexual reproduction in terms of their advantages and disadvantages for plant and animal species.

GLO: D1, E1

Skills and Attitudes Outcomes

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6;
TFS: 2.3.1, 4.3.4

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

SUGGESTIONS FOR INSTRUCTION
(1 HOUR)

➢ **Entry-Level Knowledge**

In Grade 8, students were made aware that reproduction is a characteristic of all living things. They also have an understanding of the differences between sexual and asexual reproduction from previous learning outcomes in the unit.

➢ **Notes for Instruction**

Students suggest reasons why organisms may use one method of reproduction or the other and attempt to explain the rationale for their choice. Appendix 1.4 may be used for background information.

➢ **Student Learning Activities**

Journal Writing S1-0-7e

Students predict the effects of a new disease that affects all seedless and seeded varieties of oranges.

Students complete a Compare and Contrast or Concept Relationship frame comparing the advantages and disadvantages of sexual and asexual reproduction. Students may also prepare a Concept Map illustrating the relationship between sexual and asexual reproduction. (See *SYSTH*, pages 10.15, 10.22, 10.24, 11.19)

Collaborative Teamwork S1-0-4e

Students work in small teams to identify situations in which one form of reproduction may be more advantageous than another. A Listen-Think-Pair-Share format could be used. (See *SYSTH*, page 10.6)

Case Study (S1-0-2c): Students investigate organisms that can reproduce sexually and asexually (e.g., the jellyfish, poplar tree, etc.), and discuss findings using the following questions:

- What are the advantages of a jellyfish being able to use either method of reproduction?
- Which method of reproduction would be most advantageous for a lone poplar tree in a field? Explain.
- Which method of reproduction would be most advantageous for a poplar tree in a dense forest? Explain.
- Name other organisms that are capable of reproducing sexually and asexually, and comment on the environments in which they live.

SUGGESTIONS FOR ASSESSMENT

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students

- complete a Compare and Contrast or Concept Relationship frame comparing asexual and sexual reproduction in terms of their advantages and disadvantages for plant and animal species.
- describe situations in which one form of reproduction is more advantageous than others.
- prepare a Concept Map illustrating the relationship between sexual and asexual reproduction.
- determine whether given examples represent asexual reproduction or sexual reproduction.

Debate/Discussion/Journals

Divide the class into two — one half representing sexual reproduction, and one half representing asexual reproduction. Debate the advantages and disadvantages associated with each type of reproduction. Stress the importance of using scientific facts and not personal opinion. (See *SYSTH*, page 4.19)

Discuss the outcome of the debate. Students then summarize the arguments presented by both teams and reflect on any new information that they learned from the debate in their journals.

Journals

Assess journal entries using *SYSTH*, page 13.21.

Teacher Background

Sexual reproduction results in genetic variation within a species, whereas asexual reproduction produces genetically identical offspring. The Potato Famine in Ireland in the 1840s occurred when a fungus attacked the potato, a primary food source. Because the potato plants were clones, the lack of genetic variation rendered them all susceptible to the blight. As a result, millions of Irish starved to death, while others fled to Canada, the United States, and Australia.

SUGGESTED LEARNING RESOURCES

Science 9

7.1 Reproductive Strategies, p. 202

7.5 Reproduction of Plants for Food, p. 212

TSM-3 Cooperative Learning

TSM-6 Graphic Organizers

Sciencepower 9

2.2 Sexual Reproduction in Animals, p. 51

2.3 Sexual Reproduction in Plants, p. 60

Appendices

1.4 Blackline Master: Advantages and Disadvantages of Sexual and Asexual Reproduction

SYSTH

4.19 Science — Technology — Society — Environment Connections

10.6 Building a Scientific Vocabulary

10.15 Building a Scientific Vocabulary

10.22 Building a Scientific Vocabulary

10.24 Building a Scientific Vocabulary

11.19 Developing Scientific Concepts Using Graphic Displays

11.20 Developing Scientific Concepts Using Graphic Displays

13.21 Writing to Learn Science

Success for All Learners

7.3 Structuring Whole-Class Discussions

Prescribed Learning Outcomes

Students will...

S1-1-08 Investigate and explain adaptations of plant and animal species which enhance reproductive success.

Examples: appearance, behaviour, number of gametes or offspring, chemical cues…

GLO: D2, E1, E2

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print and electronic sources, specialists, and other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 1.3.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.3.1, 4.3.4

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

Suggestions for Instruction
(2 hours)

➢ Notes for Instruction

A wide variety of adaptations exist, ranging from mating patterns and methods of fertilization/pollination to increase the chance of survival of offspring. Students should be made aware of some of the adaptations (e.g., appearances, behaviour, chemical cues, etc.).

➢ Student Learning Activities

Class Discussion S1-0-7e

Students use a Roundtable format to identify ways in which plants and animals increase their chance of reproductive success. Initial examples, such as insects that produce many eggs, may need to be provided. (See *Success for All Learners*, page 7.3)

Field Trip: Students visit a park, wildlife refuge, or wilderness area to identify ways in which plant and animal species enhance their reproductive success. Students discuss ways in which they will make observations, note locations, gather and record findings, etc.

Guest Speaker: Invite a local hunter, conservation officer, or zoologist to give a presentation on this topic. Students prepare questions in advance of the visit. Questions may include:

- What adaptations are you aware of that improve reproductive success?
- What strategies are used to maintain plant and animal populations in this area?
- What effect does captivity have on reproductive success?

(continued)

Suggestions for Assessment

Written Quiz/Test

Students

- complete a matching quiz where one column contains the names of organisms, and the other column contains a list of reproductive strategies.
- explain how courtship behaviours and mating calls could aid in species recognition.
- describe adaptations of plant and animal species that enhance reproductive success.

The review questions generated by the students could be used for the quiz/test.

(continued)

Suggested Learning Resources

Science 9

7.1 Reproductive Strategies, p. 202

8.1 Survival and Development of Organisms, p. 232

BLM 7.4 Ontario — A Pollen Paradise

TSM-3 Cooperative Learning

Sciencepower 9

2.2 Sexual Reproduction in Animals, p. 51

2.3 Sexual Reproduction in Plants, p. 60

2.4 The Value of Variation, p. 92

Success for All Learners

5.1 Flexible Grouping

7.3 Questioning and Discussion Strategies

Prescribed Learning Outcomes

Students will...

(continued)

S1-1-08 Investigate and explain adaptations of plant and animal species which enhance reproductive success.

Examples: appearance, behaviour, number of gametes or offspring, chemical cues…

GLO: D2, E1, E2

Suggestions for Instruction

(2 hours)

➢ **Student Learning Activities (continued)**

Student Research S1-0-2a, 2c, 5c

Students research adaptations that enhance reproductive success, such as

- behaviour (e.g., parental care of offspring)
- appearance (e.g., flower or bird colours)
- mating calls (e.g., elk bugling)
- chemical cues (e.g., flower scents, pheromones)
- courtship behaviour (e.g., ruffed grouse)
- number of offspring produced (e.g., insects)
- number of gametes produced (e.g., fish)

A variety of sources, including the Internet, can be used to gather information. Word processing and desktop publishing software can be used for report writing.

Collaborative Teamwork S1-0-4e

Students use a Jigsaw to learn about the adaptations of plant and animal species that enhance reproductive success. (See *Success for All Learners*, page 5.9, and *SYSTH*, pages 3.19, 3.20)

Class Discussion

The following question could be used to initiate a class discussion:

Which reproductive strategy do you think is the most efficient?

Journal Writing

Students reflect and respond to the following questions:

- Why is reproduction essential to life?
- Which reproductive strategy did you find most interesting, and why?
- Which reproductive strategy did you find to be most efficient, and why?

Students generate and share a list of review questions with their peers.

Suggestions for Assessment

Research Report S1-0-2a, 2c, 5c

Students or student groups investigate a specific adaptation and prepare

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- dramatic presentations
- multimedia presentations

(See Appendix 5.2)

Journals

Assess journal entries using *SYSTH*, page 13.21.

Suggested Learning Resources

SYSTH

3.19 Cooperative Learning and Science

3.20 Cooperative Learning and Science

13.21 Writing to Learn Science

Success for All Learners

5.9 Jigsaw: A Cooperative Learning Strategy

Appendices

5.2 Rubric for the Assessment of Class Presentations

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-1-09 Describe the structure and function of the male and female human reproductive systems.

Include: role of hormones.

GLO: D1, E1, E2

Skills and Attitudes Outcomes

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6;
TFS: 2.3.1, 4.3.4

S1-0-3b. Identify probable mathematical relationships between variables.
Examples: relationship between current and resistance...
GLO: C2

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

S1-0-6a. Interpret patterns and trends in data, and infer and explain relationships.
(ELA: S1: 3.3.1) GLO: C2, C5;
TFS: 1.3.1, 3.3.1

S1-0-7a. Draw a conclusion that explains the results of an investigation.
Include: cause and effect relationships, alternative explanations, supporting or rejecting the hypothesis or prediction.
(ELA: S1: 3.3.4) GLO: C2, C5, C8

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

SUGGESTIONS FOR INSTRUCTION

(3 HOURS)

➢ Entry-Level Knowledge

Students have not studied the structure and function of the male and female reproductive systems in previous science courses; however, some students may have been introduced to this topic in Health Education classes. Consult with a teacher responsible for Physical Education/Health Education to plan instruction.

➢ Notes for Instruction

Check for prior knowledge, noting emerging student conceptions and comfort levels. Use a Question Box to accept anonymous requests for clarification or information and answer these questions in class. Consult with a teacher responsible for Physical Education/Health Education on how to approach these questions.

Note: Approach the topic from an anatomical and physiological perspective only. Stress the use of the correct terminology. Use a Sort and Predict activity as a vocabulary warm-up/review.

➢ Student Learning Activities

Prior Knowledge Activity: From a diagram of the male and the female reproductive systems, students identify as many structures as they can.

Class Discussion S1-0-7e

Students discuss the importance of reproduction and speculate about the necessity of the survival of an individual or a species.

Students discuss the differences and similarities between human males and females. A KWL frame could be used. (See *SYSTH*, page 9.8)

Visual Displays S1-0-2c, 5c

Students label diagrams or create posters showing the locations of the male and female reproductive structures. Students can also draw diagrams illustrating how hormones regulate the male and female reproductive systems.

Collaborative Teamwork S1-0-4e

Students use a Jigsaw to learn about the male and female structures and functions. (See *Success for All Learners*, page 5.3)

(continued)

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students
- label diagrams including the functions of the parts of the male and female reproductive systems.
- describe how the male and female reproductive systems are regulated by hormones.
- create and/or complete crossword puzzles of terms related to the topic.
- interpret graphs to determine the role of hormones in regulating the menstrual cycle.

(continued)

Suggested Learning Resources

Science 9

7.6 Sex Cell Development in Males, p. 214

7.7 Sex Cell Development in Females, p. 216

7.8 Case Study: Hormones and the Reproductive Cycle, pp. 220–21

BLM 7.7 Cross-Section of Female Reproductive System

TSM-3 Cooperative Learning

TSM-6 Graphic Organizers

Sciencepower 9

3.1 Reproductive Systems, p. 80

Investigation 3-A: How Do We Know What Ovarian Hormones Do?, p. 87

Investigation 3-D: Interpreting Hormonal Cycles, pp. 102–04

BLM 3-3 Does the Canada Lynx Go Through Puberty?

BLM 3-4 Effects of Testosterone on Target Tissues

BLM 3-5 Sperm Development

BLM 3-6 Egg Development in the Ovary

BLM 3-7 Effects of Hormones During Stages of the Menstrual Cycle

BLM 3-9 Female Hormone Levels

BLM 3-10 Investigating Amenorrhea

BLM 3-11 Review Key Terms

BLM 3-12 What Happens after Menopause?

(continued)

PRESCRIBED LEARNING OUTCOMES

Students will...

(continued)

S1-1-09 Describe the structure and function of the male and female human reproductive systems.

Include: role of hormones.

GLO: D1, E1, E2

SUGGESTIONS FOR INSTRUCTION

(3 HOURS)

➢ **Student Learning Activities (continued)**

Journal Writing S1-0-2c

Students complete Concept Frames, Concept Overviews, Compare and Contrast charts, a Word Cycle, or Three-Point Approach to demonstrate their understanding of the concepts and vocabulary. (See *SYSTH*, pages 10.9, 10.15, 10.21, 11.23)

Visual Displays

Students use a variety of charts, videos, overheads, and CD-ROMs to illustrate the male and female reproductive system, and the role that hormones play in their regulation.

Laboratory Activity S1-0-5c, 6a, 7a

Students interpret the role of hormones in the menstrual cycle.

Journal Writing

Students reflect on and respond to the following questions:

- What are the major differences between the male and female reproductive systems?
- What did you learn that was completely new to you?
- What new findings were most surprising to you and why?
- What questions do you still have regarding the reproductive system?

Article Analysis: Students use an Article Analysis frame to analyze texts that discuss new advances in reproduction technology. (See *SYSTH*, pages 11.30, 11.41)

Suggestions for Assessment

Visual Displays S1-0-2c,5c

Working individually or in small groups, students prepare visual displays of the parts of the male and female reproductive systems, their functions, and hormonal control. The displays may include:

- posters
- diagrams
- information technology presentations
- concept maps

Laboratory Report S1-0-3b, 5c, 6a, 7a

Students prepare a report about the role of hormones in the menstrual cycle. Word processing, spreadsheet, and desktop publishing software can be used.

Journals

Assess journal entries using a Journal Evaluation form. (See *SYSTH*, page 13.19)

Suggested Learning Resources

SYSTH

9.8 Tapping into Prior Knowledge

10.9 Building a Scientific Vocabulary

10.15 Building a Scientific Vocabulary

10.21 Building a Scientific Vocabulary

11.20 Developing Scientific Concepts Using Graphic Displays

11.23 Developing Scientific Concepts Using Graphic Displays

11.30 Developing Scientific Concepts Using Graphic Displays

11.41 Developing Scientific Concepts Using Graphic Displays

13.21 Writing to Learn Science

Success for All Learners

5.3 Individual, Small-Group, and Whole-Class Work

6.20 Prior Knowledge Strategies

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-1-10 Outline human development from conception through birth.

Include: X and Y chromosomes, zygote, embryo, fetus.

GLO: D1, E1, E2, E3

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print and electronic sources, specialists, and other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 1.3.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.3.1, 4.3.4

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2

S1-0-6a. Interpret patterns and trends in data, and infer and explain relationships.
(ELA: S1: 3.3.1) GLO: C2, C5; TFS: 1.3.1, 3.3.1

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

SUGGESTIONS FOR INSTRUCTION
(1-1/2 HOURS)

➢ Entry-Level Knowledge

Students have not studied human development from conception to birth in previous science courses; however, students may have been introduced to this topic in Health Education classes. Consult with a teacher responsible for Physical Education/Health Education.

➢ Student Learning Activities

Visual Displays S1-0-2a, 2c

Students label diagrams or create posters outlining human development. A timeline can also be created to show events from the fertilization of an egg to birth. Students can develop their own personal timeline of development by working backward from their birthdate.

Students use a variety of charts, videos, overheads, and CD-ROMs to illustrate human development.

Journal Writing S1-0-2c

Students use a Word Cycle or Three-Point Approach to develop an understanding of concepts and vocabulary. Students use a KWL framework to describe what they know, want to know, and have learned. (See *SYSTH*, pages 10.21, 10.22, 9.24)

Guest Speaker: Invite a public health nurse to give a presentation on this topic. Students prepare questions in advance of the visit. Questions may include:

- What education/experience/background is required to do your job?
- What sorts of tasks do you perform in the course of your workday?
- How would you explain human development to a client?

Collaborative Teamwork S1-0-4e

Students use a Jigsaw to learn about the stages of human development from conception to birth. Student groups research the developmental changes that an embryo undergoes during one of each of the nine months or during one of the trimesters. Following the investigation, students share their findings with the class.

Laboratory Activity S1-0-5c, 6a

Students complete an activity on fetal/embryonic development. (See Appendix 1.5)

Journal Writing S1-0-7e

Students prepare a glossary of new words for quick reference.

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students
- create a timeline outlining the stages of human development.
- differentiate among the terms zygote, embryo, and fetus.
- label diagrams of the stages of human development.
- write an essay describing the events of human development.

Visual Displays S1-0-2a, 2c, 5c

Students or student groups prepare visual displays of human development from conception to birth. The displays may include:
- posters
- diagrams
- information technology presentations
- concept maps
- models
- timelines
- events chain

Laboratory Report S1-0-5c, 6a

Students prepare a lab report about fetal/embryonic development. Word processing, spreadsheet, and desktop publishing software can be used.

Journals

Assess journal entries using a Journal Evaluation form. (See *SYSTH*, pages 9.9, 9.24, 11.26, 11.33, 14.11)

Teacher Background

Teachers should focus on outlining the major events of human development. An exhaustive treatment of the learning outcome is not required. Review the following prior to teaching this section: zygote, diploid, cleavage, as well as the developmental stages of an embryo.

Suggested Learning Resources

Science 9

8.4 Activity: Eggs and Embryonic Development, pp. 240–41

8.5 Human Conception And Pregnancy, p. 242

8.8 The Human Embryo, p. 250

8.10 Birth, p. 254

BLM 8.5 Path of a Fertilized Egg

BLM 8.10a Four Stages of Labour

Sciencepower 9

3.2 Pregnancy, p. 91

3.3 Differentiation and Birth, p. 95
Investigation 3-C:
Fetal Development, p. 99

BLM 2-19 Development of the Human Embryo

BLM 3-13 Inner Space Is the Limit

BLM 3-15 Early Stages of Human Development

BLM 3-16 Investigation 3-C

BLM 3-17 Critical Periods

BLM 3-19 Create a Human

Appendices

1.5 Blackline Master
Human Development

SYSTH

9.9, 9.24 Tapping into Prior Knowledge

10.21, 10.22 Building a Scientific Vocabulary

11.26, 11.33 Developing Scientific Concepts Using Graphic Displays

14.11 Technical Writing in Science

Success for All Learners

5.3 Flexible Grouping

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-1-11 Observe, collect, and analyze class data of single trait inheritance.

Examples: hand clasping, earlobe attachment, tongue rolling...

GLO: C2, D1

S1-1-12 Differentiate between dominant and recessive traits.

Include: genotype and phenotype

GLO: D1, E1, E2

Skills and Attitudes Outcomes

S1-0-1a. Propose questions that could be tested experimentally.
(ELA: S1: 3.1.2) GLO: C2

S1-0-1b. Select and justify various methods for finding the answers to specific questions.
(Math: S1: A-1) GLO: C2

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6;
TFS: 2.3.1, 4.3.4

S1-0-3a. State a testable hypothesis or prediction based on background data or on observed events.
GLO: C2

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

SUGGESTIONS FOR INSTRUCTION
(3 HOURS)

➢ Entry-Level Knowledge

Students have not previously studied genetics and heredity but may be familiar with the inheritance of some traits such as eye colour.

➢ Notes for Instruction

Outcomes S1-1-11 and S1-1-12 can be learned together.

Discuss examples of human dominant and recessive traits, including:

- eye colour: brown = dominant, blue = recessive
- chin shape: cleft = dominant, smooth = recessive
- earlobes: free = dominant, attached = recessive

See Appendix 1.6 for additional traits.

Use diagrams/overheads to show that dominant traits are identified with upper case letters and recessive traits with lower case (e.g., dimples = D, no dimples = d). Differentiate between genotype and phenotype. Demonstrate how the DD or Dd genotype produces the dimple phenotype, and the dd genotype results in the non-dimple phenotype.

Use Punnett squares to predict the results of single trait crosses. See the Appendix for additional activities. Be sensitive when discussing traits inherited from biological parents, because several students may be adopted or may not have contact with their natural parents.

➢ Student Learning Activities

Class Discussion S1-0-7e

Students use a KWL chart to activate prior knowledge. Students discuss the importance of the study of genetics and what they would like to learn about genetics. Students discuss how traits are inherited from parents (e.g., Are traits "blended," or can brown-eyed parents have a blue-eyed child? What is the role of sexual reproduction in the process? Why do some traits "skip a generation?"). (See *SYSTH*, Chapter 9)

Journal Writing S1-0-6a

Students list the traits they have that closely resemble and/or differ from those of their siblings or other relatives. Students speculate on why some traits are similar while others are different.

(continued)

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students

- complete a Compare and Contrast or Concept Relationship frame to demonstrate their understanding of the terms genotype and phenotype, dominant and recessive. (See *SYSTH*, pages 10.24, 11.20)
- solve genetics problems using Punnett squares (e.g., if both parents and one son can roll their tongues [a dominant trait], why is it that their daughter cannot roll her tongue [a recessive trait]?).
- complete a Word Cycle relating the terms: DNA, chromosomes, genes, genotype, traits, dominant, recessive, and phenotype. Assess the logic of the relationships between the terms in the cycle.
- describe the resulting offspring by completing a Punnett Square indicating the phenotype of both parents.
- consider each example from a list of traits and characteristics and classify it as being either acquired, innate, or innate AND acquired.

(continued)

Suggested Learning Resources

Science 9

TSM-3 Cooperative Learning

TSM-6 Graphic Organizers

Sciencepower 9

Ask an Expert, pp. 144–45

Project: Secret Faces, p. 147

BLM 2-1 Observing Human Characteristics

BLM 2-2 Which Traits are Most Common?

BLM 2-3 How Organisms Get Their Traits

BLM 2-4 All in the Family

BLM 2-5 Mendel’s Work with Peas

BLM 2-6 Albino Offspring in Plants

BLM 2-7 Explaining Mendel’s Work

BLM 2-8 Concept Mapping Heredity

Appendices

1.6 Blackline Master Human Traits — Punnett Squares

SYSTH

Chapter 9 Tapping into Prior Knowledge

10.24 Building a Scientific Vocabulary

11.20 Developing Scientific Concepts Using Graphic Displays

PRESCRIBED LEARNING OUTCOMES

Students will...

(continued)

S1-1-11 Observe, collect, and analyze class data of single trait inheritance.

Examples: hand clasping, earlobe attachment, tongue rolling...

GLO: C2, D1

S1-1-12 Differentiate between dominant and recessive traits.

Include: genotype and phenotype

GLO: D1, E1, E2

Skills and Attitudes Outcomes

S1-0-6a. Interpret patterns and trends in data, and infer and explain relationships.
(ELA: S1: 3.3.1) GLO: C2, C5;
TFS: 1.3.1, 3.3.1

S1-0-6b. Identify and suggest explanations for discrepancies in data.
Examples: sources of error...
(ELA: S1: 3.3.3) GLO: C2

S1-0-6c. Evaluate the original plan for an investigation and suggest improvements.
Examples: identify strengths and weaknesses of data collection methods used...
GLO: C2, C5

S1-0-7a. Draw a conclusion that explains the results of an investigation.
Include: cause and effect relationships, alternative explanations, supporting or rejecting the hypothesis or prediction.
(ELA: S1: 3.3.4) GLO: C2, C5, C8

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

SUGGESTIONS FOR INSTRUCTION

(3 HOURS)

➢ **Student Learning Activities (continued)**

Laboratory Activity S1-0-4e, 5c, 6a, 6b, 6c

From a list of dominant and recessive traits in humans, students observe and record selective traits in classmates and determine their genetic expression.

Using a prepared list of dominant and recessive facial features, students flip two coins to derive the genotypes of the traits. Students then determine the phenotype expression of each trait, and draw the portrait of their “baby.” Have students analyze family and construct a pedigree (See Appendix 1.10)

Journal Writing S1-0-2c

Students identify the meanings of new words, and keep a personal glossary for quick reference at the back of their journals.

Students complete Compare and Contrast or Three-Point Approach frames to demonstrate their understanding of vocabulary. (See *SYSTH*, pages 10.9, 10.15, and 10.22)

Collaborative Teamwork S1-0-1a, 1b, 3a

Students work in teams to solve single trait genetics problems. (Emphasize the ability of genetics to predict outcomes. For example, if brown eye colour in humans is dominant over blue, can two blue-eyed parents have a brown-eyed child?)
(See Appendices 1.7, 1.8, and 1.9)

Case Study: Students complete missing data from a genealogical table (either a fictional or real-life scenario).

Suggestions for Assessment

Laboratory Report S1-0-5c, 6a, 6b,7a

Students

- analyze class data of a variety of single inheritance traits and prepare a report of their findings. Spreadsheet and word processing software can be used.
- prepare portraits of their "babies." Assess portraits on the basis of phenotype accuracy when compared to the genotypes obtained from coin tosses.

Journals

Assess journal entries using a Journal Evaluation form. (See *SYSTH*, page 13.21)

Suggested Learning Resources

Appendices

1.7 Student Learning Activity
Single Trait Inheritance Problems

1.8 Student Learning Activity
Genetics — Punnett Squares

1.9 Student Learning Activity
Vocabulary Review on Genes

1.10 Student Learning Activity
It Runs in the Family

SYSTH

10.9, 10.15, 10.22
Building a Scientific Vocabulary

13.21 Writing to Learn Science

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-1-13 Describe the relationships among DNA, chromosomes, genes, and the expression of traits.

Include: genetic similarity among all humans.

GLO: A2, D1, E1, E2

Skills and Attitudes Outcomes

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6;
TFS: 2.3.1, 4.3.4

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

SUGGESTIONS FOR INSTRUCTION
(1 HOUR)

➢ Entry-Level Knowledge

Students are familiar with chromosomes and traits from previous learning outcomes in this cluster, and will be accustomed to the term genes.

➢ Notes for Instruction

Activate prior knowledge by asking students what comes to mind when they hear the terms DNA and gene. Have students suggest definitions of these terms and how they are related to chromosomes and the expression of traits. Use examples such as dimples in the discussion. A KWL frame could be used. (See *SYSTH*, pages 9.8–9.9 and 9.24)

Introduce some of the ways scientists can compare DNA between different people and/or different species (e.g., DNA fingerprinting).

➢ Student Learning Activities

Visual Displays S1-0-2c, 5c

Students draw and label diagrams or build models showing the relationship among DNA, chromosomes, genes, and the inheritance of traits.

Journal Writing S1-0-2c, 7e

Students reflect on the following metacognitive questions:

- How does the new knowledge compare to what I used to think?
- How can I make sure that I can remember this?

Students complete a Concept Map or Three-Point Approach to demonstrate their understanding of vocabulary and concepts. (See *SYSTH*, pages 9.6 and 10.9)

Students describe the importance of methods that enable scientists to compare genetic material. Students reflect and respond to questions such as:

- Why is it important or advantageous to be able to compare genetic material?
- In what ways can this information help us?

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students

- describe the relationship among DNA, chromosomes, and genes.
- label a diagram of the relationship among DNA, chromosomes, and genes.
- complete a Word Cycle using the terms DNA, genotype, dominant, chromosome, phenotype, gene, recessive, trait, and inheritance. Assess the connections made between the terms.
- construct a Concept Map to show the relationship among DNA, chromosomes, genes, and the expression of traits. Words from the previous learning outcomes, such as genotype, inheritance, and so on, can be included.

Visual Displays S1-0-2c, 5c

Assess student diagrams/models according to the relationship shown among DNA, chromosomes, and genes.

Journals

Assess journal entries using a Journal Evaluation form. (See *SYSTH*, page 13.21)

Suggested Learning Resources

Science 9

6.1	The Genetic Material, p. 176
TSM-3	Cooperative Learning
TSM-7	Graphic Organizers

Sciencepower 9

4.2 The Importance of DNA, p. 114
Investigation 4-A:
Extracting DNA from Onions, p. 115

SYSTH

9.6, 9.8, 9.24	Tapping into Prior Knowledge
10.9, 10.15	Developing Scientific Concepts Using Graphic Displays
13.21	Writing to Learn Science

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-1-14 Explain the inheritance of sex-linked traits in humans and use a pedigree to track the inheritance of a single trait.

Examples: colour-blindness, hemophilia…

GLO: D1, E1, E2

Skills and Attitudes Outcomes

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6;
TFS: 2.3.1, 4.3.4

S1-0-3c. Plan an investigation to answer a specific scientific question.
Include: materials, variables, controls, methods, safety considerations.
GLO: C1, C2

S1-0-4a. Carry out procedures that comprise a fair test. Include: controlling variables, repeating experiments to increase accuracy and reliability of results.
GLO: C1, C2; TFS: 1.3.1

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5a. Select and use appropriate methods and tools for collecting data or information.
GLO: C2; TFS: 1.3.1

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

S1-0-6a. Interpret patterns and trends in data, and infer and explain relationships.
(ELA: S1: 3.3.1) GLO: C2, C5;
TFS: 1.3.1, 3.3.1

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

SUGGESTIONS FOR INSTRUCTION
(1-1/2 HOURS)

➢ Entry-Level Knowledge

Students are familiar with gametes and chromosomes from previous learning outcomes in the cluster.

➢ Notes for Instruction

To introduce sex-linked traits, survey the class to determine how many students know someone who is colour-blind. Then ask how many of these colour-blind people are male and how many are female. Ask why that may be. Make the distinction between autosomes and sex-linked chromosomes. Use overheads or diagrams to show how sex-linked genes are identified with letters (e.g., X^BX^b or X^bY). Ask students to predict gamete genotypes of traits carried on the sex chromosomes. Students then predict how recessive sex-linked traits are expressed using examples such as red-green colour-blindness. Examine the implications of males carrying one gene and females carrying two genes of a sex-linked trait. (See Appendix 1.11)

➢ Student Learning Activities

Journal Writing S1-0-2c, 6a, 7e

Students speculate on how the gene for hemophilia was acquired by Queen Victoria of England. (Note: The lives of European royalty are well documented, and it has been noted that there is no history of hemophilia in the British royal family prior to Queen Victoria.) Students use a Concept Frame or Overview to develop an understanding of sex-linked inheritance. (See *SYSTH*, pages 11.20–11.22)

Collaborative Teamwork S1-0-4e

Students work in teams to solve problems related to the inheritance of sex-linked traits. Students predict the passage of the hemophilia gene in Queen Victoria's children and grandchildren with the use of a pedigree.

Students explain the transmission of the passage of a unique hereditary trait or disease from preceding to present generations of a familiar family.

Laboratory Activity S1-0-3c, 4a, 5a, 5c

Students gather and analyze class data using colour-blindness test charts (available in many biology texts). (Approximately one male in 10 and one female in 100 have red-green colour-blindness.)

Student Research S1-0-4e

Students research the inheritance of sex-linked traits among historical figures.

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Test/Quiz

Students

- describe the inheritance of sex-linked traits.
- solve sex-linked inheritance problems.
- use a pedigree to track the inheritance of a single trait.
- complete a Compare and Contrast or Concept Relationship frame demonstrating their understanding of autosomal and sex-linked inheritance. (See *SYSTH*, pages 10.24, 11.20, 11.35)
- suggest appropriate symbols for various dominant and recessive genes.

Visual Displays S1-0-2c, 5c

Students prepare charts showing possible genotypes of a sex-linked trait and the phenotypes produced for both men and women.

Laboratory Report S1-0-3c, 4a, 5a, 5c

Students analyze the class colour-blindness data and prepare a report of their findings. Spreadsheet and word processing software can be used.

Journals

Assess journal entries using a Journal Evaluation form. (See *SYSTH*, page 13.21)

Teacher Background

Sex-linked traits are recessive, carried on the X-chromosome. As a consequence, the fact that males carry one gene and females carry two genes causes certain traits to be expressed more often in males than in females. Examples of sex-linked traits are: red-green colour blindness, Duchenne muscular dystrophy, and hemophilia.

Suggested Learning Resources

Science 9

TSM-3 Cooperative Learning

Sciencepower 9

BLM 2-3 How Organisms Get Their Traits

BLM 2-4 All in the Family

Appendices

1.11 Student Learning Activity Making Sense of Sex-Linked Traits

SYSTH

10.15 Building a Scientific Vocabulary

11.20 Developing Scientific Concepts Using Graphic Displays

13.21 Writing to Learn Science

Teacher Resources

Biology textbooks can provide additional information

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-1-15 Investigate and describe environmental factors and personal choices that may lead to a genetic mutation or changes in an organism's development.

Examples: fetal exposure to alcohol, overexposure to sunlight, toxins, hormone mimics, food additives, radiation…

GLO: B1, B3, D1, D2

Skills and Attitudes Outcomes

S1-0-1d. Identify stakeholders and initiate research related to an STSE issue.
(ELA: S1: 3.1.4, 4.4.1) GLO: C4

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print and electronic sources, specialists, and other resource people.
(ELA: S1: 3.1.4, 3.2.3;
Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6;
TFS: 1.3.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6;
TFS: 2.3.1, 4.3.4

S1-0-3d. Summarize relevant data and consolidate existing arguments and positions related to an STSE issue.
(ELA: S1: 1.2.1, 3.3.1, 3.3.2) GLO: C4;
TFS: 2.3.1, 4.3.4

S1-0-5d. Evaluate, using pre-determined criteria, different STSE options leading to a possible decision.
Include: scientific merit; technological feasibility; social, cultural, economic, and political factors; safety; cost; sustainability.
(ELA: S1: 3.3.3) GLO: B5, C1, C3, C4;
TFS: 1.3.2, 3.2.3

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

S1-0-8g. Discuss social and environmental effects of past scientific and technological endeavours.
Include major shifts in scientific world views, unintended consequences.
GLO: B1

S1-0-9f. Demonstrate personal involvement and be proactive with respect to STSE issues.
GLO: B5, C4

SUGGESTIONS FOR INSTRUCTION
(1-1/2 HOURS)

➢ Entry-Level Knowledge

Students have not previously studied causes of genetic mutations or changes in development; however, they may have some prior knowledge gathered from life experience or the media.

➢ Notes for Instruction

Discuss the importance of lifestyle choices students make to their health and development. Ask them if they know what kinds of materials can cause mutations and what precautions can be taken to minimize their own personal risk of an increased rate of mutation. (See Appendix 1.12)

➢ Student Learning Activities

Journal Writing S1-0-2c, 7e

Students complete a KWL chart to activate their prior knowledge. (See *SYSTH*, pages 9.8–9.9)

Students reflect in writing on how their lifestyle choices may have an impact on their own health and the health of others (e.g., poem, story, diary entry, song, etc.).

Students complete a fact- or issue-based article analysis of a current newspaper or magazine article related to the topic.

Guest Speaker: Contact the Canadian Cancer Society or a Public Health Nurse to give a presentation on the topic. Students prepare questions in advance of the visit. Questions may include:

- What environmental factors are known to cause cancer?
- What lifestyle choices are known to cause cancer?
- What are the leading types of cancer suffered by Canadian men/women?

Class Discussion S1-0-1d, 3d, 5d, 9f

Students debate the ethical dilemma surrounding fetal alcohol syndrome. Potential divergent values include the infringement on mothers' rights and the welfare of the fetus.

(continued)

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Student Research

Students

- identify substances that may cause genetic mutations.
- identify substances that may cause changes in development.
- identify potentially harmful environmental factors and individual choices over which they have some control.
- describe preventative measures they may take to reduce the risk of genetic mutations or changes in development.
- complete a fact- or issue-based article analysis of a current newspaper or magazine article related to the learning outcome. (See *SYSTH*, pages 11.30, 11.40)
- write a newspaper article outlining current research and findings related to the topic.

(continued)

Suggested Learning Resources

Science 9

6.2 DNA, Mutations, and Cancer, p. 180

6.3 Activity: Lifestyle and Cancer, pp. 182–83

6.4 Investigation: Inhibiting Cell Division, pp. 184–85

8.9 Explore an Issue: Fetal Alcohol Syndrome, pp. 252–53

TSM-3 Cooperative Learning

TSM-9 Debating

Sciencepower 9

1.3 The Cell Cycle in Your Body, p. 24

3.3 Differentiation and Birth, p. 95
Investigation 3-D: Public Education Campaign pp. 102–04

BLM 1-20 Estimated New Cases and Deaths for Selected Cancer Sites by Sex, Canada 1999

BLM 1-21 Factors that Affect Development of Cancer

BLMG-39 Internet Research Tips

BLMG-40 Internet Research Worksheet

SYSTH

9.8 Tapping into Prior Knowledge

11.30, 11.40 Developing Scientific Concepts Using Graphic Displays

(continued)

PRESCRIBED LEARNING OUTCOMES

Students will...

(continued)

S1-1-15 Investigate and describe environmental factors and personal choices that may lead to a genetic mutation or changes in an organism's development.

Examples: fetal exposure to alcohol, overexposure to sunlight, toxins, hormone mimics, food additives, radiation…

GLO: B1, B3, D1, D2

SUGGESTIONS FOR INSTRUCTION

(1-1/2 HOURS)

➢ **Student Learning Activities (continued)**

Student Research S1-0-2a, 2c, 8g

Students research possible environmental factors that may lead to genetic mutation or changes in development. For example:

- fetal exposure to alcohol
- overexposure to sunlight
- toxins
- carcinogens
- food additives
- hormone mimics
- pollution
- pesticides

A variety of information sources, including the Internet, can be used. Word processing and desktop publishing software can be used to prepare reports.

SUGGESTIONS FOR ASSESSMENT

Research and Reporting S1-0-2a, 2c, 8g

Students or student groups investigate a lifestyle choice or environmental factor that may cause a mutation or developmental change, and prepare

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- cartoon/comic books
- newspaper articles
- dramatic presentations
- multimedia presentations

(See Appendix 5.2)

Teacher Background

A mutation is a change in the genetic material (DNA) of a cell. Mutations may occur in any cell of the body and may be the result of one or several unpredictable factors. If the mutations affect the reproductive cells, they can be passed from one generation to the next. Mutations that affect other cells of the body are not inheritable. Many cancers are caused by such mutations.

Not all mutations are harmful. Many have no effect, or cause slight, harmless changes (e.g., blue eye colour in humans). Occasionally, mutations arise that are beneficial to organisms. Many such beneficial mutations can also be the result of genetic engineering, where a specific mutation is acquired in a lab and repeated many times over. Some bacteria may have developed resistance to antibiotics in this manner.

SUGGESTED LEARNING RESOURCES

Appendices

1.12 Student Learning Activity Mutations

5.2 Rubric for the Assessment of Class Presentations

Other Resources

Consult the Internet, print, and electronic media for current information related to this topic (e.g., Canadian Cancer Society pamphlets and website). See Learning Resources and Links section of the Science website at http://www.gov.mb.ca/curricul/K-S4curr/science/

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-1-16 Investigate Canadian and international contributions to research and technological development in the field of genetics and reproduction.

Example: Human Genome Project

GLO: A3, A4, B1, B2

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print and electronic sources, specialists, and other resource people.
(ELA: S1: 3.1.4, 3.2.3;
Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6;
TFS: 1.3.2, 4.3.4

S1-0-2b. Evaluate the reliability, bias, and usefulness of information.
(ELA: S1: 3.2.3, 3.3.3) GLO: C2, C4, C5, C8;
TFS: 2.2.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6;
TFS: 2.3.1, 4.3.4

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

S1-0-8c. Describe examples of how scientific knowledge has evolved in light of new evidence, and the role of technology in this evolution.
GLO: A2, A5

S1-0-8d. Describe examples of how technologies have evolved in response to changing needs and scientific advances.
GLO: A5

S1-0-8e. Discuss how peoples of various cultures have contributed to the development of science and technology.
GLO: A4, A5

S1-0-9a. Appreciate and respect that science and technology have evolved from different views held by women and men from a variety of societies and cultural backgrounds.
GLO: A4

SUGGESTIONS FOR INSTRUCTION

(2 HOURS)

➢ **Notes for Instruction**

Take advantage of current research and technological developments available in both print and electronic media. (See Suggested Learning Resources)

➢ **Student Learning Activities**

Collaborative Teamwork S1-0-2a, 2b, 8c, 8d

Student groups clip relevant newspaper and magazine articles and search the Internet for accurate information to create a scrapbook. Groups then annotate the articles, stating the connection to the cluster and the background knowledge needed to understand the article.

Students complete a fact- or issue-based article analysis of a current newspaper or magazine article related to the topic. (See *SYSTH*, pages 11.30, 11.40)

Journal Writing S1-0-2c, 7e

Students prepare a glossary of new words for quick reference.

Student Research S1-0-2a, 2c, 8e, 9a

Students research Canadian and international contributions in the field of genetics and reproduction such as

- Human Genome Project
- in vitro fertilization
- cystic fibrosis research
- genetic engineering
- fetal alcohol syndrome
- gene therapy
- fertility drugs
- genetically modified food

Information can be gathered from a variety of sources. Word processing and desktop publishing software can be used to prepare reports.

Class Discussion: The themes of several popular movies and books are centred on the advantages of different human mutations (e.g., X-Men). Students reflect on which human mutations would be possible and/or desirable, and then discuss whether or not the Human Genome Project should be used for these purposes, giving justification for their opinions.

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students

- describe the Human Genome Project, and suggest reasons why it is important for our understanding of human genetics.
- use a Compare and Contrast frame to differentiate between science and technology in terms of their purpose, procedures, and products. (See *SYSTH*, pages 10.15, 10.24)
- complete a fact- or issue-based article analysis of a current newspaper or magazine article related to Canadian and international contributions. (See *SYSTH*, pages 11.30, 11.40)
- write a newspaper article outlining current research and findings related to the learning outcome.

Research Report S1-0-2a, 2b, 2c

Working individually or in small groups, students investigate a particular contribution, and prepare

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- cartoon/comic books
- newspaper articles

(See Appendix 5.2)

Journals

Assess journal entries using a Journal Evaluation rubric. (See *SYSTH*, page 13.21)

(continued)

Suggested Learning Resources

Science 9

6.1	DNA: The Genetic Material, p. 176
6.9	Cloning, p. 198
7.5	Reproduction of Plants for Food, p. 212
8.6	Human Reproductive Technology, p. 244
BLM 6.5	Isolation and Growth of Stem Cells
BLM 6.9a	Cloning Using a Fertilized Nucleus
BLM 6.9b	Cloning by Embryo Splicing
BLM 6.9c	Cloning Using a Somatic Cell
BLM 8.6a	Fertility Drugs
BLM 8.6b	Intrauterine Insemination
BLM 8.6c	In Vitro Fertilization
BLM 8.6d	Embryo Transfer
TSM-3	Cooperative Learning

Sciencepower 9

4.1	Biotechnology, p. 110
4.2	The Importance of DNA, p. 114
4.3	Biotechnology and the Human Body, p. 122
4.4	Biotechnology in Agriculture, p. 127
4.5	Biotechnology in the Environment, p. 132
BLM 4-10	Method for Cloning Mammals
BLM 4-13	Reading the Human Blueprint
BLM 4-15	Making Biotech Corn

(continued)

Prescribed Learning Outcomes
Students will...
(continued) **S1-1-16** Investigate Canadian and international contributions to research and technological development in the field of genetics and reproduction. *Example: Human Genome Project* GLO: A3, A4, B1, B2

Suggestions for Instruction
(2 hours)

Suggestions for Assessment

Teacher Background

The Human Genome Project is an ambitious endeavour to identify and sequence the 3.2 billion base pairs that compose the 23 pairs of human chromosomes. Completion of this project will revolutionize research in the areas of gene therapy and the correction of genetic defects and illnesses.

Suggested Learning Resources

Sciencepower 9 (continued)

BLMG-39 Internet Research Tips

BLMG-40 Internet Research Worksheet

SYSTH

10.15 Building a Scientific Vocabulary

10.24 Building a Scientific Vocabulary

11.20, 11.30 Developing Scientific Concepts Using Graphic Displays

11.40 Developing Scientific Concepts Using Graphic Displays

13.21 Writing to Learn Science

Other Resources

Consult the Internet, print, and electronic media for information on current research and technological developments in the field of genetics and reproduction. See Learning Resources and Links section of Science website at http://www.gov.mb.ca/curricul/K-S4curr/science/

Appendices

5.2 Rubric for the Assessment of Class Presentations

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-1-17 Discuss current and potential applications and implications of biotechnologies including their effects upon personal and public decision making.

Include: genetic engineering, cloning, Human Genome Project, DNA fingerprinting.

GLO: B1, B2, C4, C8

S1-1-18 Use the decision-making process to address a current biotechnology issue.

GLO: C4, C6, C7, C8

Skills and Attitudes Outcomes

S1-0-1c. Identify STSE issues which could be addressed. GLO: C4

S1-0-1d. Identify stakeholders and initiate research related to an STSE issue.
(ELA: S1: 3.1.4, 4.4.1) GLO: C4

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print and electronic sources, specialists, and other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 1.3.2, 4.3.4

S1-0-2b. Evaluate the reliability, bias, and usefulness of information.
(ELA: S1: 3.2.3, 3.3.3) GLO: C2, C4, C5, C8; TFS: 2.2.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.3.1, 4.3.4

S1-0-2d. Review effects of past decisions and various perspectives related to an STSE issue.
Examples: government's, public, environmentalists', and First Nations' positions on hydroelectric development; religious, social, and medical views on genetic screening...
(ELA: S1: 3.2.2) GLO: B1, C4; TFS: 1.3.2, 4.3.4

S1-0-3d. Summarize relevant data and consolidate existing arguments and positions related to and STSE issue.
(ELA: S1: 1.2.1, 3.3.1, 3.3.2) GLO: C4; TFS: 2.3.1, 4.3.4

S1-0-8d. Describe examples of how technologies have evolved in response to changing needs and scientific advances.
GLO: A5

SUGGESTIONS FOR INSTRUCTION

(2-1/2 HOURS)

➢ **Entry-Level Knowledge**

Students may be familiar with biotechnologies from previous outcomes, and from the media. K–8 students will also have experienced the design process, but may not have any experience with the formal decision-making process.

➢ **Notes for Instruction**

Outcomes S1-1-17 and S1-1-18 can be taught/learned together.

Take advantage of current biotechnology issues that are available in both print and electronic media.

Guide students through the steps of the Decision-Making Model. (See *Senior 1 Science Framework*) Model the process, guide students, and provide opportunities for practice. Keep it simple to start. (See Appendix 1.13) Other Senior 1 clusters will provide more opportunities for decision making.

➢ **Student Learning Activities**

Journal Writing S1-0-1c, 1d, 2d, 3d

Students reflect on the pros and cons of creating a DNA fingerprint registry of all Canadians.

Students reflect on and respond to the following questions:

- What kinds of biotechnology were available to your grandparents?
- What kinds of biotechnology are available to you?
- What kinds of biotechnology do you think will be available to your children?

Journal Writing S1-0-2c, 6d, 7b, 7c, 7d

Students complete a fact- or issue-based article analysis of a current newspaper, Internet, or magazine article related to biotechnology. (See *SYSTH*, pages 11.30, 11.40)

Students compose fictitious but scientifically accurate stories about genetic engineering accidents that have produced dangerous organisms and how these "monsters" were eventually stopped. A RAFTS format could be used. (See *SYSTH*, pages 13.23–13.28)

(continued)

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students

- complete a Word Cycle of terms related to biotechnology. (See *SYSTH*, page 10.21)
- write an essay defending their opinion of a biotechnology-related issue.
- complete a fact- or issue-based article analysis of a current newspaper or magazine article related to the biotechnology topic. (See *SYSTH*, pages 11.30, 11.40)
- write a newspaper article outlining current research and findings related to the biotechnology topic.

Research Report S1-0-2a, 2b, 2c, 8d

Students or student groups investigate a particular application/issue and prepare

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- debates
- newspaper articles
- dramatic presentations
- multimedia presentations

(See Appendix 5.2)

Journals

Assess journal entries using a Journal Evaluation form. (See *SYSTH*, page 13.21)

(continued)

Suggested Learning Resources

Science 9

5.13 Explore an Issue: Slowing Down Aging, p. 170

6.6 Explore an Issue: Transplant Farms, p. 188

7.10 Explore an Issue: Genetic Screening, p. 224

BLM 6.1c Who Committed the Crime?

BLM 7.10 Amniocentesis — A Genetic Screening Method

TSM-3 Cooperative Learning

TSM-9 Debating

Sciencepower 9

Investigation 4-C:
The Cloning Controversy, pp. 120–21

Investigation 4-D:
Genetic Screening, p. 123

Investigation 4-E:
Problems with Pesticides, p. 134

Investigation 4-F:
Assessing Breeding Potential, pp. 139–140

Issue Analysis
Genetically Altered Food, p. 146

BLM 3-1 In Vitro Fertilization Project

BLM 4-1 The Steps in Making DNA Fingerprints

BLM 4-2 Identify the Murderer

BLM 4- 8 Designer Genes: Pros and Cons

BLM 4-9 Panel Discussion about Cloning

BLM 4-11 The Proof Is in the Blood

BLM 4-12 Create a Karyotype

(continued)

Prescribed Learning Outcomes

Students will...

(continued)

S1-1-17 Discuss current and potential applications and implications of biotechnologies including their effects upon personal and public decision making.

Include: genetic engineering, cloning, Human Genome Project, DNA fingerprinting.

GLO: B1, B2, C4, C8

S1-1-18 Use the decision-making process to address a current biotechnology issue.

GLO: C4, C6, C7, C8

Skills and Attitudes Outcomes

S1-0-3e. Determine criteria for the evaluation of an STSE decision.
Examples: scientific merit; technological feasibility; social, cultural, economic, and political factors; safety; cost; sustainability...
GLO: B5, C1, C3, C4

S1-0-3f. Formulate and develop options which could lead to an STSE decision.
GLO: C4

S1-0-4d. Use various methods for anticipating the impacts of different options.
Examples: test run, partial implementation, simulation, debate...
GLO: C4, C5, C6, C7

S1-0-5d. Evaluate, using pre-determined criteria, different STSE options leading to a possible decision.
Include: scientific merit; technological feasibility; social, cultural, economic, and political factors; safety; cost; sustainability.
(ELA: S1: 3.3.3) GLO: B5, C1, C3, C4; TFS: 1.3.2, 3.2.3

S1-0-6d. Adjust STSE options as required once their potential effects become evident.
GLO: C3, C4, C5, C8

S1-0-7b. Select the best option and determine a course of action to implement an STSE decision.
GLO: B5, C4

S1-0-7c. Implement an STSE decision and evaluate its effects.
GLO: B5, C4, C5, C8

S1-0-7d. Reflect on the process used to arrive at or to implement an STSE decision, and suggest improvements.
(ELA: S1: 5.2.4) GLO: C4, C5

Suggestions for Instruction

(2-1/2 hours)

➢ **Student Learning Activities (continued)**

Collaborative Teamwork S1-0-1c, 1d, 2d, 3d, 5d, 7b

Students prepare and present mock interviews of people who have been affected by biotechnologies. For example, a television talk show host interviews David Milgaard and O.J. Simpson about DNA fingerprinting.

Students hold a mock Royal Commission on a biotechnology issue. They identify the issue and the stakeholders, break into groups representing the stakeholders, research the issue from the stakeholders' perspectives, and present their briefs at public hearings. Class discussions are held after all of the briefs have been presented, and recommendations for a course of action are developed. The Decision-Making Process could be used in this learning activity.

Class Discussion S1-0-3e, 3f, 4d, 5d

Students debate the pros and cons of biotechnology applications, such as the ethics of organ transplant farming, genetic screening, etc.

Field Trip/Guest Speaker: Students visit a lab where biotechnology methods are used OR invite a biotechnologist to the classroom. Students prepare questions in advance of the tour or visit. Questions may include:

- What biotechnology methods are used?
- Who are you clients (if appropriate)?
- What background/education/experience is required to work in the field of biotechnology?
- What proportion of your work generates revenue? What proportion is purely research? Does it provide a service to the public?

Suggestions for Assessment

Rubrics/Checklists

(See Appendix 5.4: Rubric for the Assessment of a Decision-Making Process Activity)

Suggested Learning Resources

BLM 4-14	How Credible are Movies?
BLM 4-17	Role-Play a Press Conference
BLM 4-18	Organic Foods
BLM 4-19	Create a Biotech Glossary
BLM 4-23	Boom or Bust of Bt?
BLM 4-24	Terminator Technology and Patents
BLM 4-25	Why Is Biodiversity Important?
BLMG-41	Procedure for a Public Hearing
BLMG-42	Debating Procedures
BLMG-28B	Debate Organizer
BLMG-44	Worksheet for Investigating Issues
BLMG-45	Decision-Making Organizer

Appendices

1.13	Student Learning Activity Biotechnology Organizer
5.2	Rubric for the Assessment of Class Presentations
5.4	Rubric for the Assessment of a Decision-Making Process Activity

SYSTH

10.21	Building a Scientific Vocabulary
11.30, 11.40	Developing Scientific Concepts Using Graphic Displays
13.21, 13.23–13.28	Writing to Learn Science

NOTES

Senior 1

Cluster 2: Atoms and Elements

Overview

This cluster builds on the particle theory of matter introduced in previous grades. Students will

- become familiar with the basic constituents of matter by learning about the historical development of the atomic model and the periodic table.
- investigate the properties of elements and compounds.
- acquaint themselves with chemical symbols and families.
- become familiar with natural phenomena and everyday technologies that demonstrate chemical change.

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-2-01 Describe how historical ideas and models have furthered our understanding of the nature of matter.

Include: Greek ideas, alchemy, Lavoisier.

GLO: A1, A2, A4

Skills and Attitudes Outcomes

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia (ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2

S1-0-8e. Discuss how peoples of various cultures have contributed to the development of science and technology.
GLO: A4, A5

S1-0-9a. Appreciate and respect that science and technology have evolved from different views held by women and men from a variety of societies and cultural backgrounds.
GLO: A4

SUGGESTIONS FOR INSTRUCTION
(2 HOURS)

➢ Entry-Level Knowledge

Students have not previously studied atomic structure in K–8 Science. They have studied positive and negative charges as they relate to the concept of electricity (Grade 6); the particle theory of matter, pure substances, mixtures, and solutions (Grade 7); and have reviewed the particle theory of matter (Grade 8).

➢ Notes for Instruction

Help students gain an appreciation for the importance of keen observations. They should also learn to appreciate how scientists have progressively extended their knowledge over time through experimentation. Introduce students to a more sophisticated way of explaining the differences among elements. Discuss how models of matter were developed through experimental evidence and the contributions of ancient Greek philosophers, alchemists, and modern chemists.

➢ Student Learning Activities

Journal Writing

Students use a Compare and Contrast frame to describe how alchemists and early chemists were similar to and different from modern chemists. (See *SYSTH*, page 10.15)

Remember, the work of alchemists was not accepted even in their own time, but many prominent individuals (e.g., Sir Isaac Newton) were practitioners of the craft. Students write a letter assuming the role of one of the persons with whom an alchemist might have had contact.

Students write a short story describing how they think a common element could have been discovered. They reflect on and respond to the following question: Do you think it was necessary to understand the atom in order to make this discovery?

Students begin to build a science timeline to learn the origins of early chemistry, and the development of models of matter based on each scientist's specific contributions.

Class Discussion S1-0-8e, 9a

Students discuss social and political issues of ancient Greece and their impacts on the advancement of scientific thought (e.g., exclusive presence of men in science, importance of thinkers, lack of experimentation).

(continued)

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/ Test

Students

- describe how the concept of matter has changed throughout history.
- match historical descriptions of ideas/models/concepts with the people who proposed them.
- create a timeline outlining the changes in thinking about matter.
- compare and contrast the activities of early philosophers with the activities of alchemists. Compare these two groups to modern scientists.

Teacher Background

Ancient Greek philosophers wondered why matter behaved as it did. They studied it and came up with many ideas, but they did almost no experimentation. During this time, Empedocles proposed that matter was composed of "four elements:" earth, fire, air, and water. Democritus suggested matter was made of tiny particles that could not be broken down further. He called these particles "atomos" which means indivisible. Socrates and Aristotle rejected this idea, and the ideas of Empedocles prevailed in the scientific world for the next 2000 years.

Alchemists were the first people to perform experiments. They believed that some elements could be changed into other elements, and had three main goals:

- To change base metals, like lead and tin, into valuable ones, like gold. In this process, they discovered new elements as well as many new facts about existing materials.
- To find the substance that would give them eternal life.
- To produce a universal solvent that would dissolve all substances.

(continued)

Suggested Learning Resources

Science 9

3.1 Investigation: Making a Logical Model, p. 80

3.2 Developing Models of Matter, p. 82

Skills Handbook:
#2 Scientific Inquiry
#3 Research

Sciencepower 9

5.3 Compounds and Elements, p. 75

Appendix B: Using Resources and the Internet Effectively

Appendices

5.2 Rubric for Assessment of Class Presentations

5.3 Rubric for the Assessment of a Research Project

2.2 Blackline Master Historical Ideas About the Nature of Matter

SYSTH

10.15 Building a Scientific Vocabulary

13.21 Writing to Learn Science

PRESCRIBED LEARNING OUTCOMES

Students will...

(continued)

S1-2-01 Describe how historical ideas and models have furthered our understanding of the nature of matter.

Include: Greek ideas, alchemy, Lavoisier.

GLO: A1, A2, A4

SUGGESTIONS FOR INSTRUCTION
(2 HOURS)

➢ **Student Learning Activities (continued)**

Student Research

Student groups investigate the methods used by early scientists as they tried to make sense of their world.

Teacher Demonstration

Provide evidence through demonstrations to support the existence of smaller particles in nature. Explain how it was logical for the people of ancient Greece to speculate about the smallest particles of matter.

- Hold up a piece of aluminum foil, and ask students what type of material it is made of. Then tear the foil in half, and ask the same question. Repeat the same procedure several times. This will help lead to an understanding that an atom is the smallest particle of matter.
- Blow up a balloon with a scented fluid inside of it. Discuss why the odour will travel throughout the room. This will help reinforce the concept of atoms as tiny particles of matter.

Visual Displays S1-0-5c
Students display their timeline of the evolution of the concept of matter, including chronological dates, scientists' names, and diagrams of matter.

Student Research

Students research the development of scientific thought as it relates to matter and include early ideas about the nature of science.

SUGGESTIONS FOR ASSESSMENT

Research Report/Presentation

Students or student groups research and report on the development of scientific thought as it relates to matter and early ideas about the nature of science. Students could present a

- written report
- oral presentation
- newspaper article
- dramatic presentation
- pictorial representation (poster/pamphlet)

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

Visual Display

Students or student groups prepare visual displays that represent the timeline of the evolution of the concept of matter, and could include posters, diagrams, charts, models, and concept maps.

Laboratory Report/Demonstration

Students record their observations during a teacher demonstration and explain them in terms of their understanding of matter.

Journals

Assess journal entries using a Journal Evaluation form. (See *SYSTH*, page 13.21)

Teacher Background

Modern Chemists (17th–18th centuries) used the scientific method to investigate the physical world when the focus was on determining the properties of pure substances and attempting to explain their composition.

Sir Francis Bacon was one of the first scientists to develop new knowledge as a result of experimentation.

Robert Boyle believed that the Greek philosophers' four-element theory could be improved, and he helped lay the foundation for the concept of elements and compounds.

Antoine de Lavoisier defined the term "element" and identified 23 different elements. He based his investigations on careful measurement and observations. He recognized that mixtures exist, and identified air as a mixture of oxygen and some other gas.

SUGGESTED LEARNING RESOURCES

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-2-02 Investigate the historical progression of the atomic model.

Include: Dalton, Thomson, Rutherford, Bohr, and quantum model.

GLO: A1, A2, A4, D3

Skills and Attitudes Outcomes

S1-0-5a. Select and use appropriate methods and tools for collecting data or information.
GLO: C2; TFS: 1.3.1

S1-0-8c. Describe examples of how scientific knowledge has evolved in light of new evidence, and the role of technology in this evolution.
GLO: A2, A5

S1-0-8d. Describe examples of how technologies have evolved in response to changing needs and scientific advances.
GLO: A5

SUGGESTIONS FOR INSTRUCTION
(3 HOURS)

➢ Notes for Instruction

Students understand from previous learning outcomes how observation and experimentation can support our understanding of nature and the development of models.

Provide students with an understanding of the concept of the “atom” and the development of the model of the atom, including all of its components. As previously demonstrated, define “atom” as the smallest particle of any given type of matter.

Discuss the possible existence of units that are smaller than an atom (i.e., subatomic particles: protons, neutrons, and electrons).

Use the following analogy to help students appreciate the size of the subatomic particles within the atom.

Atom = Skydome, Toronto

Nucleus = baseball

Protons = marbles inside baseball

Electrons = mosquitoes buzzing around baseball

Use the following chart to demonstrate the characteristics of the three fundamental subatomic particles of matter.

Subatomic Particle	Symbol and Charge	Mass	Location
Proton	p+	1 amu	nucleus
Neutron	n	1 amu	nucleus
Electron	e–	1/1837amu	electron shell

Students should gain an understanding of the need for revision from one model to the next. Therefore, discuss Dalton, Thomson, Rutherford, and Bohr models in detail, including the presence of protons, electrons, neutrons, nucleus, and electron shells’ energy levels.

Discuss the quantum model very briefly, as it will be discussed in more detail in future Senior Years science courses. (See Teacher Background)

➢ Student Learning Activities

Prior Knowledge Activity

Students write down anything they know about the atom, including sketches to illustrate what they think an atom might look like. Guiding questions could include:

(continued)

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students

- match five models of the atom with their descriptions and with the scientist who developed them.
- describe reasons for revisions of previous models of the atom.
- using the Bohr model of the atom, discuss the statement: "If it is true that protons repel one another, how can they be positioned together in the nucleus?"
- describe the subatomic particles in terms of size, location, who discovered them, charge, and symbol.
- compare and contrast each of the five atomic models.

Teacher Background

All matter has mass.

AMU = atomic mass unit = 1.66×10^{-27} kg.

Proton and neutron have a mass of 1 amu, while the electron is almost 2000 times less massive.

According to classical physics, the Bohr model could not exist. Electrons do not move in definite orbits around the nucleus; rather, they move randomly in electron clouds called orbitals. Work principally done by Schrödinger and others linked the energy levels of atoms to the electromagnetic spectrum. As electrons moved from one energy level to another, energy in the form of light was either radiated or absorbed. The energy released or absorbed occurred in fixed amounts or quanta of energy, hence the quantum model of the atom.

(continued)

Suggested Learning Resources

Science 9

3.3 Inside the Atom, p. 87

3.4 A "Planetary" Model of the Atom, p. 90

BLM 3.2a, 3.2b Atomic Theories and Models

BLM 3.3 Subatomic Particles Worksheet

BLM 3 Review Models for Atoms: Word Search

Sciencepower 9

7.1 Probing the Atom, p. 228

7.2 Bohr-Rutherford Model, p. 236

BLM 7-5 Subatomic Particles

BLM 7-6 Rutherford's Theory

BLM 7-18 Concept Mapping: Parts of the Atom

BLM 7-19 Composition of Atoms

BLM 7-22 Vocabulary Puzzle

7-C Investigation: Modeling the Atom, p. 251

Appendices

2.3 Blackline Master Models of Atomic Structure

Success for All Learners

6.108 Teaching and Learning Strategies

(continued)

PRESCRIBED LEARNING OUTCOMES

Students will...

(continued)

S1-2-02 Investigate the historical progression of the atomic model.

Include: Dalton, Thomson, Rutherford, Bohr, and quantum model.

GLO: A1, A2, A4, D3

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people. (ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 1.3.2, 4.3.4

S1-0-2b. Evaluate the reliability, bias, and usefulness of information.
(ELA: S1: 3.2.3, 3.3.3) GLO: C2, C4, C5, C8; TFS: 2.2.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.3.1, 4.3.4

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia (ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2

SUGGESTIONS FOR INSTRUCTION
(3 HOURS)

➢ **Student Learning Activities (continued)**

- What shape is an atom?
- What particles does it consist of?
- What size is an atom?
- Where do you find an atom?
- Can you see an atom with the unaided eye, or do you need a microscope?
- Who do you think discovered the atom?
- What other models of the atom, if any, have been developed?

Student Research S1-0-2a, 2b, 2c, 5a

Students learn about the lives of these four scientists, and the experiments they performed to develop their model.

Collaborative Teamwork S1-0-4e

Students use a Jigsaw to learn about the five models of the atom and develop a Concept Relationship frame for each scientist and his model, illustrating the differences and the need for revisions to the model. (See *SYSTH*, page 11.20)

Visual Displays S1-0-5c

Students display the evolving models of the atom, including detail about the components of the atom and the scientist who developed the model.

Journal Writing

Students write an account of their own atomic models as if they were research scientists like those studied previously.

Oral Presentation/Debate: Student groups debate the pros and cons of each of the five models.

Visual Displays S1-0-5c

Students interactively view a video about the structure of the atom using a “LAPS” strategy.

L = listen to what is said in the video.

A = ask three questions that could be on a test.

P = picture or illustrate a concept discussed in the video.

S = summarize 15 key points addressed in the video.

Role-Playing: Students act out the role of the particles in the five atomic models.

Newspaper Article: Students write a fact-based article using newly acquired knowledge to describe one of the five atomic models.

SUGGESTIONS FOR ASSESSMENT

Research Report/Presentation

Students or student groups research and report on the following:

- the scientists involved in the development of the atomic model
- the revisions made to the scientists' model as novel facts were discovered
- the problems that arose with the inability of the scientists' model to be consistent with new evidence

Reports can be presented as

- written reports
- oral presentations
- newspaper articles
- dramatic presentations
- song or poem
- a student-generated test or series of questions and answers

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

Visual Displays

Students prepare visual displays that represent the evolving models of the atom. These displays could include posters, models, concept maps, and diagrams.

Debate

Assess the information students present in support of or against each of the five models of the atom. (See *SYSTH*, pages 4.19–4.22)

Journals

Assess journal entries using a Journal Evaluation form. (See *SYSTH*, page 13.21)

SUGGESTED LEARNING RESOURCES

Appendices

5.2 Rubric for the Assessment of Class Presentations

5.3 Rubric for the Assessment of a Research Project

SYSTH

3.19 Cooperative Learning and Science

4.19 Science — Technology — Society — Environment Connections

11.20 Developing Scientific Concepts Using Graphic Displays

13.21 Writing to Learn Science

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-2-03 Define element and identify symbols of some common elements.

Include: the first 18 elements and K, Ca, Fe, Ni, Cu, Zn, I, Ag, Sn, Au, W, Hg, Pb, U.

GLO: C2, D3

Skills and Attitudes Outcomes

S1-0-5a. Select and use appropriate methods and tools for collecting data or information.
GLO: C2; TFS: 1.3.1

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia (ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

SUGGESTIONS FOR INSTRUCTION
(1/2 HOUR)

➢ Notes for Instruction

Define "element" as a pure substance that cannot be broken down into simpler substances (i.e., elements are made of identical atoms).

An understanding of elements is needed to examine exact numbers of subatomic particles and to draw Bohr models (S1-2-04).

Discuss the diversity of sources of names for the elements. (Berzelius developed a naming system in 1817 as a way to provide symbols that would communicate clearly across language barriers.)

Define "chemical symbol" as an abbreviation of the name of the element and discuss the following rules when naming:

- a single-letter symbol is always capitalized (e.g., Carbon = C)
- the first letter of a two-letter symbol is always capitalized, while the second letter is lower case (e.g., Aluminum = Al)

Note: Briefly discuss the connection between elements with Latin (or other source) names and their symbols, Gold = Au (Latin name aurum), Silver = Ag (argentum), Tungsten = W (from the German Wolfram), Lead = Pb (Plumbum), Scandium = Sc (from region of its discovery, Scandinavia), Berkelium = Bk (from the University of California at Berkeley where the element was created), Einsteinium = Es (in honour of the contributions of the physicist Albert Einstein).

Refer to the periodic table of the elements (See Appendix 2.9) to help students link elements they currently know with others that are not familiar.

➢ Student Learning Activities

Class Discussion

Students brainstorm examples of chemical symbols they have encountered in their daily lives, and suggest which element the symbol represents. Flash cards can be used to familiarize students with the elements and symbols.

Students generate lists of elements with which they are familiar (e.g., calcium in milk for bone development, iron metal filings used to show the magnetic lines of force from magnets, oxygen in the atmosphere and the Earth's crust).

Game: Students play Element Bingo to gain more exposure to the chemical symbols. (See Appendix 2.4)

(continued)

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students

- write the names and symbols for the first 18 elements and the most common elements.
- explain why an international system of chemical naming is important and necessary.
- match the name of an element to its use, and its symbol.

(continued)

Suggested Learning Resources

Science 9

2.7 Chemical Symbols and Formulas, p. 58

Sciencepower 9

6.1 Symbols for the Elements, p. 192

6.2 Elements on Planet Earth, p. 198

6-D Investigation: The Story of Aluminum, pp. 210–12

Appendices

2.4 Student Learning Activity Chemical Symbol Bingo

(continued)

PRESCRIBED LEARNING OUTCOMES

Students will...

(continued)

S1-2-03 Define element and identify symbols of some common elements.

Include: the first 18 elements and K, Ca, Fe, Ni, Cu, Zn, I, Ag, Sn, Au, W, Hg, Pb, U.

GLO: C2, D3

SUGGESTIONS FOR INSTRUCTION

(1/2 HOUR)

➢ **Student Learning Activities (continued)**

Vocabulary: Students create/complete crossword puzzles to connect the name of an element with its use and symbol.

Student Research S1-0-5a

Students research the history of element symbols and names, from early alchemists in the Middle Ages, to Dalton's symbols in the 1800s, to modern symbols used today.

Visual Displays S1-0-5c

Students create displays of a few of the most common elements to illustrate their symbols, uses, abundance, and properties.

Journal Writing

Students reflect and respond to the following questions:

- Why do you think some elements such as gold and silver have been around for centuries, while others were only discovered in the 20th century?
- Why are some symbols similar to the name of the element, while others are not? (Answer: language spoken by scientist, geographic location of discovery, characteristic of element, etc.)

Suggestions for Assessment

Research Report/Presentation

Students or student groups research and report on the history of element symbols and names. Reports can be presented as

- written reports
- oral presentations
- newspaper articles
- dramatic presentations

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

Visual Displays

Students prepare visual displays that feature a few of the most common elements and illustrate their symbols, uses, abundance, and properties. Displays can be in the form of posters, charts, or concept maps.

Journals

Assess journal entries using a Journal Evaluation form. (See *SYSTH*, page 13.21)

Suggested Learning Resources

SYSTH

13.21 Writing to Learn Science

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-2-04 Explain the atomic structure of an element in terms of the number of protons, electrons, and neutrons and explain how these numbers define atomic number and atomic mass.

GLO: D3, E2

Skills and Attitudes Outcomes

S1-0-1b. Select and justify various methods for finding the answers to specific questions. (Math: S1: A-1) GLO: C2

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people. (ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 1.3.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources. (ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.3.1, 4.3.4

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia (ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2

SUGGESTIONS FOR INSTRUCTION
(2 HOURS)

➢ Notes for Instruction

Use a periodic table of the elements to familiarize students with the position of the element's name, symbol, atomic mass (also called mass number), and atomic number.

Define atomic mass (mass number) and atomic number as follows:

- *Atomic mass (mass number):* The average mass of an atom of the element (can also be described as the sum of the number of neutrons and protons in the nucleus of an atom).
- *Atomic number:* The number of protons in the nucleus of an atom.

The standard atomic notation or shorthand representation for an element's symbol, atomic number, and atomic mass is written as follows:

(atomic mass written in upper left, as superscript)

C^{12}_{6} (chemical symbol)

(atomic number written in lower left, as subscript)

Note: Atomic mass is rounded to the nearest whole number.

Caution: Changes to the number of electrons and neutrons will be discussed in Senior 2 Science. Do not discuss ions and isotopes in Senior 1 Science.

➢ Student Learning Activities

Problem Solving S1-0-1b

Using a table, students determine the number of protons, electrons, and neutrons of any element.

Element	Atomic #	Atomic Mass	# of protons	# of electrons	# of neutrons

(continued)

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students

- distinguish between atomic mass and atomic number.
- determine the number of fundamental particles in the atom of an element given the atomic number and atomic mass.
- determine which particles can be used to identify an element.
- determine which particles represent the mass of an atom.
- determine the element from the number of subatomic particles within the atom.

(continued)

Suggested Learning Resources

Science 9

3.3 Inside the Atom, p. 87

Sciencepower 9

7.3 A New Basis for the Periodic Table, p. 245

7-B Investigation: Inferring the Number of Neutrons, p. 250

Appendices

2.5 Student Learning Activity Determining the Number of Atomic Particles

Prescribed Learning Outcomes

Students will...

(continued)

S1-2-04 Explain the atomic structure of an element in terms of the number of protons, electrons, and neutrons and explain how these numbers define atomic number and atomic mass.

GLO: D3, E2

Suggestions for Instruction

(2 hours)

➢ **Student Learning Activities (continued)**

Game (S1-0-1b): Students create questions/answers for a "Jeopardy" game that illustrates their understanding of this outcome. For example,

Question: "This element has six protons in its nucleus."

Answer: "What is Carbon?"

Student Research S1-0-2a, 2c

Students investigate the methods used to determine or calculate the atomic mass of elements by both Mendeleev and the modern periodic table.

Visual Displays S1-0-5c

Students plot graphs of various characteristic physical properties of elements versus atomic mass and atomic number using a spreadsheet and a graphing program.

SUGGESTIONS FOR ASSESSMENT

Research Report/Presentation

Students or student groups research and report on the methods used by Mendeleev and the modern periodic table to determine or calculate the atomic mass of elements. Reports can be presented as

- written reports
- oral presentations
- newspaper articles
- dramatic presentations

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

Visual Displays

Students prepare visual displays that feature a few of the most common elements and illustrate their symbols, uses, abundance, and properties. Displays can be in the form of posters, charts, or concept maps.

Teacher Background

The number of fundamental particles (subatomic) in an atom can be determined by knowing the atomic number and atomic mass, and that there is an important difference in these numbers.

- Number of protons is equal to the atomic number.
- Number of electrons is equal to the atomic number (In a neutral atom, proton # = electron #).
- Number of neutrons is calculated by subtracting the atomic number from the atomic mass.

For example: sodium Na^{23}_{11}

Atomic number = 11

Atomic mass = 22.990

Protons = 11

Electrons = 11

Neutrons 23 – 11 = 12

Elements can be identified by the number of protons they contain, as this value never changes. If this value is known, the element can be identified because proton number = atomic number.

SUGGESTED LEARNING RESOURCES

Appendices

5.2 Rubric for Assessment of Class Presentations

5.3 Rubric for the Assessment of a Research Project

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-2-05 Assemble or draw Bohr atomic models for the first 18 elements and group them according to the number of outer shell electrons.

GLO: A2, C2, D3

Skills and Attitudes Outcomes

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

SUGGESTIONS FOR INSTRUCTION

(1-1/2 HOURS)

➢ **Notes for Instruction**

Students have studied the structure of the atom including subatomic particles and have been introduced to a diagram of the Bohr model in previous learning outcomes.

Students use Bohr diagrams to represent the electronic structure of elements (i.e., protons and neutrons are located in the nucleus, electrons are located in electron shells (energy levels or orbits) around the nucleus).

Caution: Although more than three electron shells exist, do NOT diagram Bohr models beyond the first 18 elements.

Once students can draw Bohr diagrams successfully, ask them to arrange their diagrams according to the number of electrons in the outermost shell, and look for patterns. For example:

- H, Li, and Na all have one electron in their outermost shell and should be grouped together.
- O and S have six electrons in their outermost shell and should be grouped together.

(This exercise will lead into a discussion of the arrangement of elements and reactivity, which is addressed in later learning outcomes.)

➢ **Student Learning Activities**

Visual Displays S1-0-5c, 6a

Students draw Bohr models for the first 18 elements on separate index cards and then arrange the cards into groups based on patterns they see in the outer shell electron positions.

Students compare and contrast their groupings with those of a modern periodic table.

Students construct a three-dimensional model of a given atom using atomic model kits if available. Other objects, such as toothpicks and multi-coloured marshmallows, could be used if kits are not available.

Class Activity: For a class-centred activity, draw Bohr Models of a selection of elements. Students determine the number of protons and neutrons in the nucleus. Draw this on the board, and then draw in rings to represent electron shells. Add electrons to the correct unfilled electron shells, filling shells closest to the nucleus first, then progressing outward.

SUGGESTIONS FOR ASSESSMENT

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students draw Bohr diagrams for any of the first 18 elements, including the number and correct position of protons, electrons, neutrons, nucleus, and electron shells.

Visual Displays

Students or student groups prepare visual displays that represent the first 18 elements of the periodic table as Bohr diagrams. Displays can be in the form of posters or index cards.

Teacher Background

The exact number of electrons positioned in electron shells is important.

The first shell closest to the nucleus can hold a maximum of **two** electrons and must be filled before electrons are placed in any additional shell.

The second shell can hold a maximum of **eight** electrons and must be filled before electrons are placed in any additional shell.

The third shell can also hold a maximum of **eight** electrons and must be filled before electrons can be placed in any additional shell.

The exact position of electrons within the electron shell is not important, however, electrons should be spaced equally throughout the electron shell.

SUGGESTED LEARNING RESOURCES

Science 9

BLM 3.4: Bohr-Rutherford Diagrams Worksheet

Sciencepower 9

BLM 8-1: Outer Electrons

Appendices

2.1 Blackline Master
Vocabulary

2.6 Blackline Master
Bohr Model Diagrams

2.7 Student Learning Activity
Drawing Bohr Model Diagrams

Prescribed Learning Outcomes

Students will...

S1-2-06 Investigate the development of the periodic table as a method of organizing elements.

Include: periods, families (groups).

GLO: A2, A4, B2, E1

Skills and Attitudes Outcomes

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

Suggestions for Instruction

(3 hours)

➢ **Entry-Level Knowledge**

Students have not previously studied the periodic table; however, in Grades 5 and 8, they have discussed the physical properties of matter, such as density and solubility, with respect to solids, liquids, and gases.

➢ **Notes for Instruction**

Students should study Dmitri Mendeleev's periodic table (1869), which included the 64 elements known at the time. Discuss how Mendeleev used his periodic table to predict the properties of missing elements, leaving blank spaces within the table for "undiscovered elements."

Students should also use a modern periodic table to examine how families or groups of elements are organized in terms of periodic law.

Define "*period*" as horizontal rows on the periodic table (with a numbering system of 1–7 from the top to the bottom of the table) representing an electron shell or orbit in the Bohr model and an energy level in the quantum model of the atom.

Define "*groups*" or "*families*" as the vertical columns on the periodic table (with an IUPAC numbering system of 1–18 from left to right across the table or an old labelling system of Roman numerals I – VIII, followed by the letter "A" or "B") containing elements with similar physical and chemical properties, and the same number of electrons in their outermost shell/orbit (called valence electrons).

Note: Roman numeral group number = number of valence electrons.

The groups or families studied in Senior 1 include:

- Alkali Metals (IA)
- Alkaline Earth Metals (IIA).
- Hydrogen (belongs in a family by itself, due to its special properties)
- Chalcogens (VI-A)
- Halogens (VII-A)
- Noble Gases (VIII-A) (have eight valence electrons and are, therefore, chemically stable and unreactive)

Define "*Periodic Law*" as elements arranged according to atomic number resulting in a reoccurring pattern of similar properties in different elements.

(continued)

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students

- locate elements given their period and group.
- compare and contrast Mendeleev's periodic table with the modern periodic table.
- define "family" of elements.
- describe the five families stating one characteristic of each.

Teacher Background

Mendeleev's periodic table organized elements by atomic mass and helped to establish the concept of families of elements with similar physical and chemical properties. He accurately predicted the elements gallium and germanium, demonstrating the validity of his periodic table as a powerful predictive tool.

Henry Moseley's work with X-ray diffraction did much to confirm the order of elements in the periodic table proposed by Mendeleev. Moseley revised Mendeleev's table and arranged elements according to atomic number in order to incorporate the noble gases and elements that did not "fit" their position in terms of properties.

(continued)

Suggested Learning Resources

Science 9

4.1 Organizing the Elements, p. 104

4.2 Activity: Inventing a Periodic Table, pp. 106–7

4.3 Activity: Exploring the Modern Periodic Table, pp. 108–9

4.4 Groups of Elements, pp. 110–13

4.5 Investigation: Groups of Elements and Compounds, pp. 114–16

BLM 4.4a Classification of the Elements Worksheet

BLM 4 Review: Periodic Table Crossword

BLM 4.4b Chemical Groups Jigsaw

Sciencepower 9

6.4 Families of Elements, p. 215

BLM 6-20 Mendeleev's Periodic Table

BLM 6-22 Word Maze

BLM 6-23 Symbols for the Elements

6-F Investigation: Meet the Modern Periodic Table, pp. 219–22

Appendix C: Periodic Table of the Elements

Appendices

2.8 Teacher Support Material Development of the Periodic Table

2.9b Blackline Master Organization of the Periodic Table

2.10 Student Learning Activity "What Element am I?

(continued)

PRESCRIBED LEARNING OUTCOMES

Students will...

(continued)

S1-2-06 Investigate the development of the periodic table as a method of organizing elements.

Include: periods, families (groups).

GLO: A2, A4, B2, E1

SUGGESTIONS FOR INSTRUCTION

(3 HOURS)

➢ **Student Learning Activities**

Collaborative Teamwork S1-0-4e

Students examine and discuss a variety of periodic tables constructed over time to determine the basis for their design and the criteria used to classify elements in each table.

Students use a Jigsaw activity to learn the names and properties of the chemical families.

Game: Students create questions/answers for a game that identifies an element based on its family name, group number, period, and/or properties (or vise versa). For example,

1. Statement: Found in a family by itself.
   Response: "What is Hydrogen?"
2. Statement: Found in period 4 and is the basis of life on Earth.
   Response: "What is Carbon?"

Student Research: Students research and prepare a presentation that explains the evolution of the periodic table since 1869.

Problem Solving S1-0-6a

Given a copy of the modern periodic table on which the properties of certain elements are hidden, students predict the properties of these elements in the same manner as Mendeleev.

Laboratory Activity

Students examine the physical and chemical properties of some elements, then group the elements, and invent their own periodic table.

Journal Writing S1-0-5c

Students suggest how they would classify all the elements known today and ensure their classification system was universal.

Students view a video about the periodic table using a "LAPS" strategy.

L = listen to what is said in the video.

A = ask three questions that could be on a test.

P = picture or illustrate a concept discussed in the video.

S = summarize 15 key points addressed in the video.

Students complete Concept Frames, Compare and Contrast charts, or Word Cycles to demonstrate their knowledge of the concepts and vocabulary related to the periodic table and its evolution. (See *SYSTH*, pages 10.15, 10.21, 11.24)

Suggestions for Assessment

Research Report/Presentation

Students or student groups research and report on the evolution of the periodic table since 1869. Reports can be presented as

- written reports
- oral presentations
- newspaper articles
- dramatic presentations

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

Visual Displays

Students describe the process they used when looking for patterns as they grouped the index cards to create/invent their own periodic table.

Suggested Learning Resources

Appendices

5.2 Rubric for Assessment of Class Presentations

5.3 Rubric for the Assessment of a Research Project

SYSTH

10.15, 10.21 Building a Scientific Vocabulary

11.23–11.24 Developing Scientific Concepts Using Graphic Displays

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-2-07 Investigate the characteristic properties of metals, non-metals, and metalloids and classify elements according to these properties.

Examples: ductility, conductivity of heat and electricity, lustre, reactivity…

GLO: D3, E1

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources. Include: print, electronic, specialists, other resource people. (ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 1.3.2, 4.3.4

S1-0-2b. Evaluate the reliability, bias, and usefulness of information. (ELA: S1: 3.2.3, 3.3.3) GLO: C2, C4, C5, C8; TFS: 2.2.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms. Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources. (ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.3.1, 4.3.4

S1-0-3c. Plan an investigation to answer a specific scientific question. Include: materials, variables, controls, methods, safety considerations. GLO: C1, C2

S1-0-4a. Carry out procedures that comprise a fair test. Include: controlling variables, repeating experiments to increase accuracy and reliability of results. GLO: C1, C2; TFS: 1.3.1

S1-0-4b. Demonstrate work habits that ensure personal safety of others, as well as consideration for the environment. Include: knowledge and use of relevant safety precautions, WHMIS regulations, emergency equipment. GLO: B3, B5, C1, C2

S1-0-4c. Interpret relevant WHMIS regulations. Include: symbols, labels, Material Safety Data Sheets (MSDS). GLO: C1, C2

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise. (ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5c. Record, organize, and display data using an appropriate format. Include: labelled diagrams, graphs, multimedia (ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2

SUGGESTIONS FOR INSTRUCTION
(2 HOURS)

➢ Entry-Level Knowledge

Students have been introduced to the concept of chemical families or groups in previous outcomes.

➢ Notes for Instruction

Relate the location of the metals, nonmetals, and metalloids on the periodic table. Demonstrate some physical properties of metals, nonmetals, and metalloids.

Caution: Demonstration and laboratory activities may involve dangerous chemicals. Ensure everyone is aware of laboratory safety and chemical disposal procedures, household and workplace hazard symbols, and WHMIS regulations. (See *Science Safety*)

Students collect and examine labels of various household products and respond to the following:

- Identify and explain the symbols and the dangers associated with each product.
- What is the significance of the geometric shape of the household symbols? Why do they vary?
- Compare the warning labels on chemicals with those on household products.

➢ Student Learning Activities

Collaborative Teamwork S1-0-4e

Small student groups list 10 items made of metal, including the composition and properties of the metal that make it useful for that particular item.

Laboratory Activity S1-0-3c, 4a, 4b, 4c

Students examine and perform various tests on metals and nonmetals to determine their properties, including conductivity, lustre, malleability, ductility, and state of matter.

Student Research S1-0-2a, 2b, 2c

Students research useful applications of certain metals, nonmetals, and metalloids throughout history, e.g., in early North American Aboriginal societies. Students could also investigate the science and technology of mining and metallurgy.

Visual Displays S1-0-5c

Students create a poster illustrating when an element was discovered, its physical and chemical properties, its uses, and its abundance on Earth.

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students

- differentiate among metals, nonmetals, and metalloids based on their position in the periodic table.
- classify elements as metals, nonmetals, and metalloids based on their properties.
- describe the properties of metals, nonmetals, and metalloids.
- outline safety procedures that should be followed when performing given experiments or disposing of specific hazardous chemicals.
- discuss the importance of WHMIS.
- match the WHMIS symbols with their description and name.

Research Report/Presentation

Students or student groups research and report on the use of certain metals, nonmetals, and metalloids today and throughout history. Reports can be presented as

- written reports
- oral presentations
- newspaper articles
- dramatic presentations

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

Visual Displays

Students or student groups prepare a visual display that illustrates the properties, uses, and the importance of any element on the periodic table. Displays can be in the form of posters, information technology presentations, or models.

Laboratory Report

Students prepare a report describing the observed properties of metals, nonmetals, and metalloids. Use a checklist to assess students' safety practices. (See *Science Safety*)

(continued)

Suggested Learning Resources

Science 9

2.2 Investigation: Classifying Elements, pp. 48–49

2.3 Putting Metals to Work, p. 50

2.12 Metal Extraction and Refining in Canada, p. 70

2.13 Explore an Issue: A Mine in the Community, p. 74

Sciencepower 9

6.2 Elements on Planet Earth, p. 198

6.3 Science and Technology of Metallic Elements, p. 205

BLM 6-1 Identifying Metals

BLM 6-11 Classification of the Elements

BLM 6-17 Researching an Element

BLM 6-13 Using Material Safety Data Sheet (MSDS)

6-B Investigation: Comparing the Reactivity of Metals, pp. 201–02

Appendices

5.2 Rubric for Assessment of Class Presentations

5.3 Rubric for the Assessment of a Research Project

(continued)

PRESCRIBED LEARNING OUTCOMES

Students will...

(continued)

S1-2-07 Investigate the characteristic properties of metals, non-metals and metalloids and classify elements according to these properties.

Examples: ductility, conductivity of heat and electricity, lustre, reactivity…

GLO: D3, E1

SUGGESTIONS FOR INSTRUCTION

(2 HOURS)

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Laboratory Safety

Science Safety, Manitoba Education and Training, 1997
www.edu.gov.mb.ca/docs/support/scisafe/

Be safe! A health and safety reference for Science and Technology Curriculum, Science Teachers' Association of Ontario, 1998
http://www.stao.org/

Appendices

2.11 Blackline Master
Metals — Nonmetals — Metalloids

2.12 Student Learning Activity
WHMIS Symbols

Teacher Background

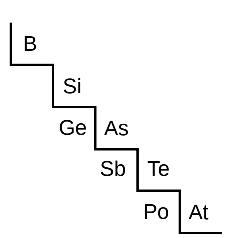
Metals constitute more than 75% of the elements. They are located throughout the periodic table, and are concentrated on the left side and centre.

Physical properties: shiny, generally silver-grey in colour (except gold and copper), malleable, ductile, solid at room temperature (except mercury), conduct heat, and conduct electricity.

Nonmetals constitute about 15% of the elements. They are located on the far-right side of the periodic table.

Physical properties: no lustre, brittle (not malleable or ductile), nonconductors or insulators of heat, nonconductors or insulators of electricity (except graphite), and either solid or gas at room temperature (except bromine).

Metalloids constitute about 6% of the elements, and are located on the "staircase" of the periodic table.



Metalloids have properties of both metals and nonmetals.

Physical properties: all are solid at room temperature, some have lustre, they tend to behave like nonmetals (except in terms of electrical conductivity), and are semiconductors.

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-2-08 Relate the reactivity and stability of different families of elements to their atomic structure.

Include: alkali metals, alkaline earths, chalcogens, halogens, noble gases.

GLO: D3, D4, E1, E2

Skills and Attitudes Outcomes

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

S1-0-6a. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

SUGGESTIONS FOR INSTRUCTION
(1-1/2 HOURS)

➢ **Entry-Level Knowledge**

Students have studied the Bohr model of atomic structure and the organization of the periodic table in previous learning outcomes.

➢ **Notes for Instruction**

Pose the question: "What would happen if sodium and chlorine were put into the same container and heated gently?" Draw Bohr diagrams to help explain the result.

Caution: Do not discuss ionic or covalent bonding, or the concept of ions, as this will be discussed in Senior 2, Senior 3, and Senior 4 Science courses.

➢ **Student Learning Activities**

Journal Writing S1-0-5c, 6a

Students identify which of three elements is the most reactive, and explain why (e.g., oxygen, neon, and fluorine).

Students view a video on chemical families using a "LAPS" strategy. (See *Success for All Learners*, page 6.108)

L = listen to what is said in the video.

A = ask three questions that could be on a test.

P = picture or illustrate a concept discussed in the video.

S = summarize 15 key points addressed in the video.

Laboratory Activity

Students investigate the link between atomic structure and periodicity.

Case Study: Students study the importance of metal reactivity to technology (e.g., the use of reactive elements to create "fireworks").

Visual Displays

Students draw Bohr diagrams for the first 18 elements (or examine diagrams drawn earlier) and classify them into their respective families. Students reflect on and respond to the following questions:

- What similarities do you notice for all the elements of each family?
- How do the outer shell electrons help you determine the reactivity of the element?

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Test/Quiz

Students

- explain variations in chemical reactivity of elements based on their position on the periodic table relative to the noble gases.
- explain why the alkali metals and halogens are the most reactive families.
- explain why the noble gases are generally unreactive.
- explain why the outer shell of electrons is an important factor for determining chemical properties.

Laboratory Report

Students prepare a report explaining the link between atomic structure and reactivity based on their observations.

Journals

Assess journal entries using a Journal Evaluation form. (See *SYSTH*, page 13.21)

Suggested Learning Resources

Science 9

4.5 Investigation: Groups of Elements and Compounds, pp. 114–16

4.8 Investigation: Linking Atomic Structure and Periodicity, pp. 122–23

4.9 Activity: Groups of Elements Profile, p. 124

3.7 Explore an Issue: Fireworks, pp. 98–99

Sciencepower 9

8.1 Explaining Chemical Families, p. 258

Success for All Learners

6.108 Teaching and Learning Strategies

Teacher Background

The chemical reactivity of an element is determined by the number of electrons in its outer shell or orbit (valence electrons). All atoms want to become structurally and, thereby, chemically stable. An atom achieves this stability when it has a filled outer shell (i.e., eight valence electrons). Recall the noble gases have eight valence electrons and are chemically stable and unreactive.

The atoms of all other elements can achieve this stability only through losing electrons (alkali metals, alkaline earth metals), gaining electrons (halogens, chalcogens), or sometimes sharing electrons. For example, sodium has one electron in its outer shell. Chlorine has seven electrons in its outer shell. Since elements want a stable structure (a filled outer shell), a simple transfer of the outer electron from sodium to chlorine occurs. Now both elements have filled outer shells (sodium's next shell in becomes its outer shell).

Hydrogen has a combining capacity of 1 and will either lose, gain, or share one electron to fill its outer shell.

The alkali metals are very reactive because they have one more electron than the noble gases. The alkaline earth metals are less reactive because they have two additional electrons than the noble gases but are still considered reactive. The halogens are very reactive because they have one fewer electron than the noble gases.

The chalcogens are less reactive because they have two fewer electrons than the noble gases but are still considered reactive.

Alkali metals and halogens readily combine to form compounds involving the transfer of electrons.

Alkaline earth metals and chalcogens also readily combine to form compounds involving the transfer of electrons.

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-2-09 Compare elements to compounds.

Include: atoms, molecules.

GLO: D3, E1, E2

Skills and Attitudes Outcomes

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

SUGGESTIONS FOR INSTRUCTION
(1-1/2 HOURS)

➢ Entry-Level Knowledge

Students have studied pure substances, mixtures, and solutions as well as the particle theory of matter in Grade 7.

The particle theory of matter was reviewed in Grade 8.

➢ Notes for Instruction

Review the particle theory of matter. Consider Dalton's atomic theory to help students distinguish between the properties of elements and compounds.

Define the molecule, element, and compound as follows:

A *Molecule* is composed of a cluster of atoms and can be broken down into those atoms during a chemical change.

An *Element* is a pure substance whose molecules are made up of identical atoms.

A *Compound* is a pure substance whose molecules are made of different kinds of atoms. Compounds can be broken down into simpler substances called elements.

➢ Student Learning Activities

Class Discussion

Discuss the fact that only 112 of the 10 million known pure substances are elements. The rest are compounds.

Students reflect on and respond to the following questions:

- Are there elements that are also compounds?
- Are there atoms that are also molecules?

Prior Knowledge Activity

Students brainstorm to develop a list of common (real-life) chemicals or substances (e.g., salt, sugar, baking soda) and speculate about the chemical composition.

Laboratory Activity S1-0-4e

Student groups bring samples of household products in their original packaging, examine the labels, and list the names of chemicals that make up the product. Each group discusses its findings with the whole class. The class records the findings in a table (see sample below).

Name of Substance	Compound/Elements
Toothpaste	sodium fluoride
Baking soda	sodium bicarbonate

(continued)

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students

- discuss the makeup of a compound, element, atom, molecule, and pure substance.
- classify examples of pure substances as elements or compounds.

Visual Displays

- Students build models of compounds and molecules from building blocks or molecular model kits.
- Students or student groups prepare displays containing common household chemicals. Displays can be in the form of posters, information technology presentations, index cards, or models.

Teacher Background

Dalton's atomic theory (1808) is a refinement of the particle theory of matter. Dalton explained the differences among elements in terms of the different kinds of particles called atoms.

A pure substance is defined as a substance that contains only one kind of particle. A mixture is defined as a substance that contains two or more pure substances.

(continued)

Suggested Learning Resources

Science 9

2.1 Models of Matter: The Particle Theory, p. 44

2.8 Atoms, Molecules, and the Atmosphere, p. 60

2.9 Activity: Building Models of Molecules, pp. 62–63

3.5 Investigation: Using Electrons to Identify Elements, pp. 94–95

BLM 2 Classification of Matter Concept Map

BLM 2.1 Particle Theory of Matter

Sciencepower 9

5.4 Atomic Theory, p. 183

6.2 Elements on the Planet Earth, p. 198

BLM 8-19 Kitchen Chemistry

BLM 7-2 Elements and Colours

(continued)

Prescribed Learning Outcomes

Students will...

(continued)

S1-2-09 Compare elements to compounds.

Include: atoms, molecules.

GLO: D3, E1, E2

Suggestions for Instruction

(1-1/2 hours)

➢ **Student Learning Activities (continued)**

Laboratory Activity

Students perform flame tests to obtain evidence of the presence of a metal element in a compound or mixture.

Journal Writing S1-0-6a

Students name as many compounds as they can from their previous knowledge or experience.

Students use a Compare and Contrast frame to illustrate the relationship among atoms, elements, molecules, and compounds. (See *SYSTH*, pages 10.15, 10.24)

Students create a list of at least 20 pure substances that they know of. A review of differences between pure substances and mixtures may be necessary at this time to help students avoid generating lists that contain mixtures. Have students classify the substances as elements or compounds in chart form.

Pure substance	Element	Compound
Salt		
Water		
Gold		
Ozone		
Carbon Dioxide		

Models: Students build models of compounds and molecules from building blocks or molecular model kits to illustrate the relationship among atoms, elements, compounds, and molecules.

Visual Displays S1-0-5c

Students collect and post pictures of common chemicals and chemical names throughout the classroom.

Students create a concept map depicting the relationships among the terms associated with this learning outcome.

Suggestions for Assessment

Laboratory Report

Students prepare a lab report based on the flame tests of different elements.

Journals

Assess journal entries using a Journal Evaluation form. (See *SYSTH*, page 13.21)

Suggested Learning Resources

SYSTH

10.15, 10.24	Building a Scientific Vocabulary
11.38–11.39	Laboratory Report Outline
13.21	Writing to Learn Science

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-2-10 Interpret chemical formulas of elements and compounds in terms of the number of atoms of each element.

Examples: He, H_2, 0_2, H_2O, CO_2, NH_3…

GLO: C2, D3

Skills and Attitudes Outcomes

S1-0-4a. Carry out procedures that comprise a fair test.
Include: controlling variables, repeating experiments to increase accuracy and reliability of results.
GLO: C1, C2; TFS: 1.3.1

S1-0-4b. Demonstrate work habits that ensure personal safety of others, as well as consideration for the environment.
Include: knowledge and use of relevant safety precautions, WHMIS regulations, emergency equipment.
GLO: B3, B5, C1, C2

S1-0-4c. Interpret relevant WHMIS regulations.
Include: symbols, labels, Material Safety Data Sheets (MSDS).
GLO: C1, C2

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

SUGGESTIONS FOR INSTRUCTION
(3 HOURS)

➢ **Entry-Level Knowledge**

Students have studied the relationship among atoms, elements, and compounds in previous learning outcomes.

➢ **Notes for Instruction**

Define a chemical formula as the combination of chemical symbols that indicate what elements make up the compound and the number of atoms of each element present. For example: H_2O.

H = symbol for hydrogen. The number following H indicates the number of hydrogen atoms present.

O = symbol for oxygen. The number following O indicates the number of oxygen atoms present. When no value is shown, it is treated as 1.

Avoid discussing detailed molecular bonding or structure. It is sufficient that students should recognize that a particular pure substance is made up of the same type of molecules, all sharing the same chemical formula.

➢ **Student Learning Activities**

Prior Knowledge Activity

Students draw a diagram to show their mental picture of a specific molecule such as water (H_2O), carbon dioxide (CO_2), or oxygen (O_2).

Problem Solving

Students complete a chart demonstrating chemical formulas. For example:

Name of Compound	Formula of molecule	Elements present	Number/Type of atoms
Water	H_2O	Hydrogen	2 atoms H
		Oxygen	1 atom O

Models: Students use building blocks or molecular model kits to further their understanding of compounds.

Case Study: Students investigate tests used to identify elements and compounds (e.g., flame tests, spot tests, etc.).

Laboratory Activity S1-0-4a, 4b, 4c, 4e

Students perform a laboratory assignment to determine what gases make up the composition of air.

Teacher Demonstration

Students record their observations during a demonstration of the electrolysis of water and identify the gases formed.

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Test/Quiz

Students

- determine the number of atoms and elements within the molecule of a compound.
- interpret a chemical formula in terms of the elements present in the molecule and the number of atoms of each element.

Visual Displays/Models

Students build molecular models to represent various compounds, given the ratio of elements they contain. Assess using an observation checklist.

Laboratory Report

Students prepare a report based on the identification of gases within air. Students record their observations and explain them in terms of their understanding of matter.

Suggested Learning Resources

Science 9

2.4 Investigation: Breaking Compounds and Elements, pp. 52–53

2.5 Case Study: Testing for Elements and Compounds, pp. 54–55

2.6 Identifying Mystery Gases, pp. 56–57

2.9 Building Models from Molecules, pp. 62–63

4.7 Explore an Issue: Ozone: a Global Environmental Hazard, pp. 120–21

BLM 2.7a How to Count Atoms

BLM 2.7b Counting Atoms Worksheet

Sciencepower 9

6.1 Symbols for the Elements, p. 192

BLM 6-3 Anatomy of Chemical Formula

6-A Investigation: Interpreting Chemical Formulas, pp. 195–96

5-D Investigation: Decomposing Water with Electricity, pp. 180–82

Appendices

2.1 Blackline Master Vocabulary

2.13 Student Learning Activity Chemical Formulas

Prescribed Learning Outcomes

Students will...

S1-2-11 Investigate properties of substances and explain the importance of knowing these properties.

Examples: usefulness, durability, safety…

GLO: A5, B2, D3, E1

Skills and Attitudes Outcomes

S1-0-4a. Carry out procedures that comprise a fair test.
Include: controlling variables, repeating experiments to increase accuracy and reliability of results.
GLO: C1, C2; TFS: 1.3.1

S1-0-4b. Demonstrate work habits that ensure personal safety of others, as well as consideration for the environment.
Include: knowledge and use of relevant safety precautions, WHMIS regulations, emergency equipment.
GLO: B3, B5, C1, C2

S1-0-4c. Interpret relevant WHMIS regulations.
Include: symbols, labels, Material Safety Data Sheets (MSDS).
GLO: C1, C2

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

Suggestions for Instruction
(1-1/2 hours)

➢ Entry-Level Knowledge

Students have studied physical and chemical changes and the properties of substances in Grade 5.

Students have studied physical properties like density and solubility with respect to solids, liquids, and gases in Grade 8.

➢ Notes for Instruction

Discuss the importance of knowing and understanding the properties of materials in order to understand their usefulness, cost to society, safety, durability, production, and disposal. For example:

Iron rusts at room temperature when exposed to oxygen and water. Platinum does not react and is very strong. Hydrogen peroxide is very unstable and breaks down when exposed to light, and therefore must be stored in a dark container.

Emphasize that materials are selected for their properties (e.g., solidity, density, melting point, viscosity, malleability, hardness, durability, stability, plasticity, conduction of electricity, etc.).

Environmental considerations also affect material selection. Materials that are cheap to make and last a long time are not always the most desirable from the standpoint of our environment. For example, plastics are very durable but are not readily biodegradable or necessarily "environment-friendly."

➢ Student Learning Activities

Prior Knowledge Activity

Students brainstorm answers to the following questions: What properties of aluminum are important to its use? Aluminum is one of the most abundant elements in the Earth's crust and is relatively cheap today, but in the 19th century, it was more expensive than gold. Why?

Student Research/Journal Writing

Students discuss how the properties of different substances influence their use (e.g., hot air balloons versus gas-filled balloons [reactivity with air, density, flammability]; antifreeze is useful because it has a low freezing point). Students research to find their own examples.

(continued)

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students

- describe the importance of understanding the properties of substances in determining their usefulness.
- discuss the environmental impact of certain types of products.
- identify both positive and negative aspects of using different substances to accomplish a specific function.

Research Report/Presentation

Students or student groups research the resources, energy requirements, and chemical processes involved in the production, use, and disposal of a specific item. Reports can be presented as

- written reports
- oral presentations
- newspaper articles
- dramatic presentations
- visual displays (posters, pamphlets, etc.)

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

(continued)

Suggested Learning Resources

Science 9

1.3 Investigation: Identifying Substances Using Properties, pp. 20–21

1.4 Case Study: In Search of Safer Paint, pp. 22–23

BLM 1 Matter Concept Map

BLM 1.2 Properties of Matter

Sciencepower 9

BLM 5-1 Let's Look at Properties and Change

5-B Investigation: Testing for Gases, pp. 177–78

Appendix D: Properties of Common Substances

Appendices

5.2 Rubric for Assessment of Class Presentations

5.3 Rubric for the Assessment of a Research Project

PRESCRIBED LEARNING OUTCOMES

Students will...

(continued)

S1-2-11 Investigate properties of substances and explain the importance of knowing these properties.

Examples: usefulness, durability, safety…

GLO: A5, B2, D3, E1

SUGGESTIONS FOR INSTRUCTION

(1-1/2 HOURS)

➢ **Student Learning Activities (continued)**

Journal Writing

Students list the various substances that become garbage during a typical day, and write an account of how these materials and their properties have an impact on the environment (e.g., students compare metals that rust with metals that are coated with plastic and do not degrade easily).

Laboratory Activity S1-0-4a, 4b, 4c, 4e

Students investigate different types of matter and the changes that occur when they are combined, heated, mixed with water, etc. (e.g., baking soda and vinegar or sodium bicarbonate and water to inflate a balloon).

Case Study: Students study products that are being made safer for human use and the environment (e.g., unleaded gasoline, water-based inks and paints).

Student Research

Students research and report on the resources, energy requirements, and chemical processes involved in the production, use, and disposal of a specific item (e.g., plastic milk bottles, aluminum cans, newspapers).

Suggestions for Assessment

Laboratory Report/Case Study

Students prepare a lab based on the identification of gases from the electrolysis of water.

Students record their observations and explain them in terms of their understanding of matter.

Journals

Assess journal entries using a Journal Evaluation form. (See *SYSTH*, page 13.21)

Suggested Learning Resources

SYSTH

13.21 Writing to Learn Science

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-2-12 Differentiate between physical and chemical changes.

GLO: D3, E1, E3

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources. Include: print, electronic, specialists, other resource people. (ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 1.3.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms. Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources. (ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.3.1, 4.3.4

S1-0-4a. Carry out procedures that comprise a fair test. Include: controlling variables, repeating experiments to increase accuracy and reliability of results. GLO: C1, C2; TFS: 1.3.1

S1-0-4b. Demonstrate work habits that ensure personal safety of others, as well as consideration for the environment. Include: knowledge and use of relevant safety precautions, WHMIS regulations, emergency equipment. GLO: B3, B5, C1, C2

S1-0-4c. Interpret relevant WHMIS regulations. Include: symbols, labels, Material Safety Data Sheets (MSDS). GLO: C1, C2

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise. (ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

SUGGESTIONS FOR INSTRUCTION
(2 HOURS)

➢ Notes for Instruction

Define physical and chemical changes and properties as follows:

During a *physical change*, the substance remains the same even though it may change state or form (shape).

During a *chemical change*, the original substance is changed into one or more different substances that have different properties. Atoms stay the same but molecules are transformed, so the products are different substances than the reactants. Changes in colour or temperature, and/or the production of a gas are some of the indicators of a chemical change.

Physical properties include colour, texture, odour, lustre, clarity, taste, state of matter, hardness, malleability, ductility, mp, bp, crystal form, solubility, viscosity, density.

Chemical properties include combustibility, and reaction with acid.

➢ Student Learning Activities

Class Discussion

Students discuss and determine if the following examples describe a physical or chemical change.

- margarine spoils in the fridge
- chocolate goes soft in the hot sun
- clear liquid is mixed with a base and turns purple
- leaves change from green to red
- metal on a bike frame turns from silver to reddish-brown
- water disappears from a glass over time
- sawdust forms from wood being cut with a saw
- brown liquid forms when coffee grounds are put into hot water
- ice breaks into smaller pieces
- CO_2 is dissolved in carbonated drinks

(continued)

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Test/Quiz

Students
- provide concise descriptions of physical and chemical changes.
- identify whether changes are physical or chemical and explain why.

Research Report/Presentation

Students or student groups research and report on careers that require knowledge of the physical and chemical properties of substances. Reports can be presented as
- written reports
- oral presentations
- newspaper articles
- dramatic presentations
- visual displays (posters, pamphlets, etc.)

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

(continued)

Suggested Learning Resources

Science 9

1.2 Properties of Matter, p. 16

1.7 Physical and Chemical Changes, p. 28

Career Profile: Biochemistry and Ethics, p. 86

BLM 1.11b Matter and Change Crossword

Sciencepower 9

5.1 Exploring the Nature of Matter, p. 156

5-A Investigation: Chemical or Physical Change, pp. 160–63

Appendices

2.1 Blackline Master Vocabulary

2.14 Student Learning Activity Physical and Chemical Changes

5.2 Rubric for Assessment of Class Presentations

5.3 Rubric for the Assessment of a Research Project

(continued)

PRESCRIBED LEARNING OUTCOMES

Students will...

(continued)

S1-2-12 Differentiate between physical and chemical changes.

GLO: D3, E1, E3

SUGGESTIONS FOR INSTRUCTION

(2 HOURS)

➢ **Student Learning Activities (continued)**

Journal Writing

- Students compare the "danger factor" between chemical and physical changes.
- Students compare and contrast physical and chemical changes and properties.
- Students investigate physical and chemical properties of products in their homes and assess their potential uses and associated risks.

Teacher Demonstration/Laboratory Activity
S1-0-4a, 4b, 4c, 4e

Students observe a variety of simple demonstrations to distinguish between chemical and physical changes and identify some characteristics of each. For example:

- Add salt to water and evaporate water to recover salt.
- Add Mg to HCl and demonstrate that Mg cannot be recovered by evaporation.
- Add dry ice to water so that the dry ice vigorously boils. Demonstrate how the carbon dioxide gas cannot be recovered by evaporation.

Students perform experiments to investigate the characteristic properties of matter (e.g., test for the presence of different gases, observe the state of different substances, test for conductivity, magnetism, boiling point, flammability, etc.).

Student Research

Students research and report on potential careers that rely on an understanding of physical and chemical properties of substances.

Suggestions for Assessment

Laboratory Report

Students explain and report their observations of physical and chemical changes. (See *SYSTH*, page 11.26)

Journals

Assess journal entries using a Journal Evaluation form. (See *SYSTH*, page 13.21)

Suggested Learning Resources

SYSTH

11.26 Developing Scientific Concepts Using Graphic Displays

13.21 Writing to Learn Science

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-2-13 Experiment to determine indicators of chemical change.

Examples: colour change, production of heat and/or light, production of a gas or precipitate or new substance…

GLO: C2, D3, E3

Skills and Attitudes Outcomes

S1-0-4a. Carry out procedures that comprise a fair test. Include: controlling variables, repeating experiments to increase accuracy and reliability of results.
GLO: C1, C2; TFS: 1.3.1

S1-0-4b. Demonstrate work habits that ensure personal safety of others, as well as consideration for the environment.
Include: knowledge and use of relevant safety precautions, WHMIS regulations, emergency equipment. GLO: B3, B5, C1, C2

S1-0-4c. Interpret relevant WHMIS regulations. Include: symbols, labels, Material Safety Data Sheets (MSDS).
GLO: C1, C2

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

SUGGESTIONS FOR INSTRUCTION

(2 HOURS)

➢ Entry-Level Knowledge

Students have studied the concept of chemical change in previous outcomes.

➢ Notes for Instruction

Students must consider several clues in order to determine the type of change that has taken place. One test is not enough to signify that a chemical change has occurred. Two or more tests will provide better evidence that a chemical change has occurred.

Compare reactants and products from a chemical equation to help students understand if chemical changes have occurred (e.g., $C + O_2 \rightarrow CO_2$; carbon mixes with oxygen to produce a new substance — carbon dioxide). Alternatively, in the example: $H_2O_{(l)} \rightarrow H_2O_{(g)}$; liquid water changes into water vapour. Evaporation has occurred. This is a physical change.

➢ Student Learning Activities

Class Discussion

Students brainstorm and discuss common chemical reactions. Students speculate why the following events occur:

- The rooftops of the Parliament Buildings in Ottawa have turned from reddish-brown to green. The Statue of Liberty in New York harbour has also turned from reddish-brown to green.
- The wax of a candle melts but also disappears.
- Garbage starts to smell after a period of time.
- Metal surfaces, when exposed to water, rust.

Laboratory Activity/Teacher Demonstration
S1-0-4a, 4b, 4c, 4e

Students observe teacher demonstrations that provide examples of various indicators of chemical changes. For example:

- burning candle (gas, heat, light)
- mixing vinegar with baking soda (gas)
- burning steel wool (light and heat)
- adding hydrogen peroxide to manganese dioxide (gas)
- mixing potassium iodide with lead (II) nitrate (colour change, precipitate forms)
- mixing sugar with sulfuric acid (new substance, heat)
- burning magnesium ribbon (light, new substance)
- mixing any base solution with phenolphthalein indicator (colour change)

(continued)

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students

- list observations that indicate a chemical change has taken place.
- discuss how to determine if a colour change is a physical or chemical change.

Laboratory Report/Demonstration

Students explain and report their observations of demonstrations involving indicators of chemical changes. (See *SYSTH*, page 11.26)

Teacher Background

Several indicators or clues of chemical changes can be observed qualitatively and quantitatively. For example:

- bubbles of gas
- heat loss or gain
- light emission
- colour changes
- solid material called precipitate forms in a liquid
- production of a new substance
- changes in properties of original substances (reactants)
- changes that are difficult to reverse

Note: All clues or indicators suggest a new substance has been produced but any one of the indicators could also be accompanied by a physical change.

(continued)

Suggested Learning Resources

Science 9

1.6 Investigation: Chemical Magic, pp. 26–27

1.8 Investigation: Observing Changes, pp. 32–33

Sciencepower 9

BLM 1.7a Clues that a Chemical Change has Happened

Appendices

5.5 Lab Report Assessment

SYSTH

11.26 Developing Scientific Concepts Using Graphic Displays

Chapter 14 Technical Writing in Science

PRESCRIBED LEARNING OUTCOMES

Students will...

(continued)

S1-2-13 Experiment to determine indicators of chemical change.

Examples: colour change, production of heat and/or light, production of a gas or precipitate or new substance…

GLO: C2, D3, E3

SUGGESTIONS FOR INSTRUCTION

(2 HOURS)

➢ **Student Learning Activities (continued)**

Journal Writing

Have students write a journal entry discussing examples of common daily reactions that involve chemical changes.

Laboratory Activity S1-0-4a, 4b, 4c, 4e

Students perform investigations in which they are asked to identify substances and observe changes of chemical reactions.

SUGGESTIONS FOR ASSESSMENT

Journals

Assess journal entries using a Journal Evaluation form. (See *SYSTH*, page 13.21)

SUGGESTED LEARNING RESOURCES

SYSTH

13.21 Writing to Learn Science

Prescribed Learning Outcomes

Students will...

S1-2-14 Investigate technologies and natural phenomena that demonstrate chemical change in everyday situations.

Examples: photography, rusting, photosynthesis, combustion, baking…

GLO: A3, A5, B1, B2

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people. (ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 1.3.2, 4.3.4

S1-0-2b. Evaluate the reliability, bias, and usefulness of information.
(ELA: S1: 3.2.3, 3.3.3) GLO: C2, C4, C5, C8; TFS: 2.2.2, 4.3.4

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia (ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2

S1-0-8a. Distinguish between science and technology.
Include: purpose, procedures, products.
GLO: A3

S1-0-8c. Describe examples of how scientific knowledge has evolved in light of new evidence, and the role of technology in this evolution.
GLO: A2, A5

S1-0-8d. Describe examples of how technologies have evolved in response to changing needs and scientific advances.
GLO: A5

S1-0-8f. Relate personal activities and possible career choices to specific science disciplines.
GLO: B4

S1-0-9b. Express interest in a broad scope of science- and technology-related fields and issues.
GLO: B4

Suggestions for Instruction
(1-1/2 hours)

➢ Notes for Instruction

Discuss technologies and natural phenomena that involve chemical reactions to help students appreciate the extent of chemical changes occurring in both natural and artificial environments.

Discuss chemical changes that are the result of technology (e.g., corrosion, electroplating, combustion, pollution resulting from production of fertilizers, silver tarnishing, preservatives, baking, forensic science, influence of drugs on the human body, synthetic drugs, and photography, etc.).

Discuss natural phenomena that demonstrate chemical change (e.g., photosynthesis, respiration, fermentation, decomposition, digestion, hormonal responses in the human body, etc.).

➢ Student Learning Activities

Students brainstorm and discuss both natural occurrences and artificial occurrences of chemical changes.

Laboratory Activity/Teacher Demonstration

Students investigate the importance of chemical changes in various technologies (e.g., electroplating, chemical fertilizers, film processing, baking, etc.). Students perform an experiment that examines and stops the oxidation of fresh fruit.

Field Study: Students take a walking tour in or around the school and list the applications of science that they notice (e.g., the materials used to build the school; how the school is heated, cooled, ventilated, and lit; uses of electricity, vehicles, fuels, plants, pollution, their own bodies.

Guest Speaker (S1-0-2b): Invite a guest speaker into the classroom from a farm supply company, a manufacturing plant, a bakery, a film processing lab, a hair salon, or a mechanic shop to discuss the role of chemical changes in his or her business. Students prepare questions in advance of the visit. Questions could include:

- What background/education/experience is required for your job?
- What is the role that chemical changes play in your line of work?
- What safety procedures are in place in your work environment?
- Describe a typical work day.

(continued)

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students answer the following questions:

- How are chemistry and chemical change related to food?
- Describe the importance of chemical compounds and chemical changes to various industries (e.g., farming, gardening, baking, forensic science, hair styling, pharmacy, water treatment, automotive, etc.).

(continued)

Suggested Learning Resources

Science 9

1.9 Corrosion, p. 34

1.10 Investigation: Preventing Corrosion, pp. 36–37

1.11 Combustion, p. 38

2.11 Plant Nutrients and Fertilizers, p. 66

3.7 Explore an Issue: Fireworks: Electron Jumps in Action, pp. 98–99

BLM 1.11a Changes in Matter Map

Sciencepower 9

8.4 Chemicals in Your Life, p. 277

(continued)

PRESCRIBED LEARNING OUTCOMES

Students will...

(continued)

S1-2-14 Investigate technologies and natural phenomena that demonstrate chemical change in everyday situations.

Examples: photography, rusting, photosynthesis, combustion, baking…

GLO: A3, A5, B1, B2

SUGGESTIONS FOR INSTRUCTION

(1-1/2 HOURS)

➢ **Student Learning Activities (continued)**

Student Research/Report S1-0-2a

Students research and report on any modern technology that relies on chemical reactions.

Throughout history, women have had the main responsibility for preparing and preserving food for their families. Speculate on their knowledge of the properties of different substances, and how they used this information.

Collaborative Teamwork S1-0-4e

Student groups draft proposals that promote a new material to a manufacturing company — a material that changes either physically or chemically. The proposal should answer the question: How does this property make it useful?

Visual Displays S1-0-4e, 5c

Students or student groups prepare a visual display of technologies that rely on chemical changes.

Journal Writing

Students reflect and write about what a day in their lives would be like without chemical changes. They respond to the question: In what ways would their regular routines and activities be altered?

Suggestions for Assessment

Research Report/Presentation:

Students or student groups research and report on any technology that relies on chemical reactions, or create a proposal that promotes some sort of new material to a manufacturing company. Reports can be presented as:

- written reports
- oral presentations
- newspaper articles
- dramatic presentations

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

Visual Display

Students or student groups prepare a visual display of technologies that rely on chemical changes. The display may include posters, diagrams, concept maps, or models.

Laboratory Report/Demonstration

Students explain their observations of demonstrations involving technologies that rely on chemical changes. (See *SYSTH*, page 11.26)

Journals

Assess journal entries using a Journal Evaluation form. (See *SYSTH*, page 13.21)

Suggested Learning Resources

Appendices

5.2 Rubric for Assessment of Class Presentations

5.3 Rubric for the Assessment of a Research Project

SYSTH

11.26 Developing Scientific Concepts Using Graphic Displays

13.21 Writing to Learn Science

NOTES

Senior 1

Cluster 3: The Nature of Electricity

Overview

The conceptual development of the particle model of electricity underlies an understanding of electrostatics and current electricity.

Students construct simple devices like an electrophorus to investigate electrostatic phenomena. A transition from static to current electricity enables the learner to:

- develop a model of electricity.
- construct simple devices, like an electroscope, to investigate electrostatic phenomena.
- investigate circuits and make connections to daily applications, including the cost of electrical energy and the safety and efficiency of electrical appliances.
- investigate hydroelectric power and address sustainability issues associated with the generation and transmission of electricity in Manitoba.

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-01 Demonstrate evidence for the existence of two types of charge.

GLO: A1, C2, C5

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2

SUGGESTIONS FOR INSTRUCTION

(1 HOUR)

➢ Entry-Level Knowledge

In Grade 5, students were introduced to the phenomena of static and current electricity.

➢ Notes for Instruction

The goal of this cluster is to help students develop a conceptual model that answers the question: “What is electricity?” Conceptual models play an important role in science. A good model is simple and provides explanations and predictions for our observations. Students should understand that models in science are tentative. Moreover, a historical perspective permits students to consider early models, discrepant events which challenge the model, and the revision or rejection of the model.

➢ Student Learning Activities

Teacher Demonstration

Capture students’ attention with some simple but effective demonstrations (e.g., bend a stream of water or raise a 2" x 4" board with a charged rod). (See Appendix 3.1)

Class Discussion

Ask students to provide evidence for the existence of only two types of charge. (See Appendix 3.2) Related teacher support materials are also offered in the Appendix. After students provide evidence for the existence of two types of charge (positive and negative), establish a simple model that demonstrates that charge is a property that exerts electrical forces. Like charges repel and unlike charges attract.

Suggestions for Assessment

Prior Knowledge Activity

Students write a short story to describe their prior experiences with electricity using a RAFTS strategy. (See *SYSTH*, pages 13.23–13.28)

Visual Displays S1-0-2a, 5c

Students create a poster of their previous experiences with electricity. Other displays could include Concept Overviews or Concept Frames. (See *SYSTH*, pages 11.24, 11.25)

Written Quiz/Test

Students diagram and explain the evidence for the existence of only two types of charge.

Suggested Learning Resources

Science 9

Chapter 9, p. 268

Sciencepower 9

Chapter 9, p. 294

Appendices

3.1 Teacher Support Material
Pre-Model Activities

3.2 Student Learning Activity
An Introduction to Electrostatics — Home Experiment

5.2 Rubric for the Assessment of Class Presentations

SYSTH

11.24, 11.25 Developing Scientific Concepts Using Graphic Displays

13.23–13.28 Writing to Learn Science

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-02 Discuss early models of electricity to support the premise that models in science change.

Include: one-fluid model, two-fluid model, particle model.

GLO: A1, A2, A5, C8

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-2b. Evaluate the reliability, bias, and usefulness of information.
(ELA: S1: 3.2.3, 3.3.3) GLO: C2, C4, C5, C8; TFS: 2.2.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2

SUGGESTIONS FOR INSTRUCTION
(1/2 HOUR)

➢ Entry-Level Knowledge

In the previous outcome, students examined evidence that only two charges are possible.

➢ Notes for Instruction

Today, we accept the particle model of electricity because Thomson's discovery of the electron, Millikan's oil drop experiment, and Rutherford's gold foil experiment provide consistency between this model and the atomic model of matter. Ask students to use these early models to explain electrostatic phenomena. Encourage students to examine these early models, and design their own tests to challenge them. For example, a student may suggest trying Plutarch's model in a vacuum to see if air has any effect on electric force.

➢ Student Learning Activities

Collaborative Teamwork S1-0-4e, 5c

Student groups brainstorm an explanation for the charging of the transparent tapes in Appendix 3.2 using one of the models. Assign the following sample questions randomly by drawing them out of a hat.

- Using the one-fluid model, explain how the transparent tapes acquire their charge.
- Using Plutarch's model, explain why the top tape attracts the bottom tape.
- Using the particle model, explain why both tapes are attracted to your finger.

Student Research S1-0-2a, 2b, 2c

Students research the major contributions to the conceptual development of electric charge including those of Plutarch, Gilbert, Gray, Franklin, Dufay, and Rutherford.

SUGGESTIONS FOR ASSESSMENT

Journal Writing

Students compare and contrast the early models of electricity (i.e., one-fluid, two-fluid models, particle model) using Compare and Contrast frames. (See *SYSTH*, pages 10.15, 10.24)

Visual Displays

Outline the role of models in science using a concept map. (See *SYSTH*, page 9.6)

Research Report/Presentation

Students research the major contributors to the conceptual development of electric charge. Reports can be presented as

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- multimedia presentations
- storytelling or dramatic presentations

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

Teacher-, peer-, or self-assessment can be used.

Teacher Background

Plutarch, a Greek philosopher, explained electrical attraction by suggesting that the electric (in his case, rubbed amber) heated the surrounding air. Then, the air swirled around tiny nearby objects (like bits of straw) and pushed them back to the electric. Gilbert, in his text *De Magnete*, proposed that a substance, called effluvium, emanated from the electric and attached itself to the nearby object. Franklin's one-fluid model asserted that every object contained a "normal" amount of electric fluid. If an object gained fluid it became positively charged; if it lost fluid it became negatively charged. Dufay's two-fluid model and the particle model of electricity are similar. An object becomes charged if you lose or gain one fluid (or particle).

SUGGESTED LEARNING RESOURCES

SYSTH

9.6	Tapping into Prior Knowledge
10.4	Building a Scientific Vocabulary
10.15	Building a Scientific Vocabulary
10.24	Building a Scientific Vocabulary

Appendices

5.2	Rubric for the Assessment of Class Presentations
5.3	Rubric for the Assessment of a Research Project

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-03 Explain how a discrepant event can be used to evaluate the particle model of electricity.

Include: the attraction of neutral objects to charged objects.

GLO: A1, A2, A3, C8

S1-3-04 Relate the particle model of electricity to atomic structure.

GLO: A1, A2, D3

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-2b. Evaluate the reliability, bias, and usefulness of information.
(ELA: S1: 3.2.3, 3.3.3) GLO: C2, C4, C5, C8; TFS: 2.2.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

SUGGESTIONS FOR INSTRUCTION

(1 HOUR)

➢ Notes for Instruction

Help students relate the positive and negative charges to the protons and electrons in the atomic model. Discuss the fixed nature of the nucleus of the atom including its positively charged protons, and the movement of its negatively charged electrons.

➢ Student Learning Activities

Student Research/Reports S1-0-2a, 2b, 2c

Students or student groups research and report on the contributions of Rutherford, Thomson, and Millikan to the particle model of electricity.

Class Discussion/Teacher Demonstration

Introduce the attraction of neutral objects as a discrepant event. Show that a neutral object is attracted to both positive and negative charges. Then ask students: "How do we know that the object is neutral and not a third kind of charge?" To guide students towards an answer, ask them: "What happens when neutral charges are brought near each other?" When students realize that neutral objects don't demonstrate electrical effects, they can modify their idea of charge to explain the attraction of neutral objects to both positive and negative charges by the polarization of charge. (See Appendix 3.3)

It is important to explain the attraction of neutral objects before students begin related investigations. Emphasize the difference between "touching" and "nearby." Discuss the idea of charge polarization (as in a neutral insulator where the charges align but do not move very far) versus charge separation (as in a neutral conductor where the charges are displaced by some distance). (See Figures 1 and 2 below)

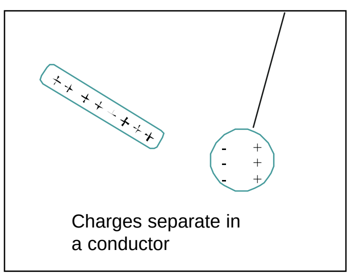


Figure 1: Charge Separation

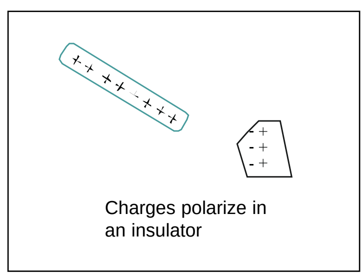


Figure 2: Charge Polarization

Suggestions for Assessment

Written Quiz/Test

Students summarize the particle model of electricity as follows:

- Two types of charge particles, positive (protons) and negative (electrons), exist.
- Charge cannot be created or destroyed — charge is conserved.
- Positive charges are fixed and negative charges are free to move.
- A neutral object has equal numbers of positive and negative charge.
- A negative object has an excess of negative charge. A positive object has a deficit of negative charge.
- Charge is shared by contact. Materials which allow charge to move easily are called conductors, and materials which do not allow charge to move easily are called insulators.
- Like charges repel; unlike charges attract.

Visual Displays

Students diagram and explain the attraction of neutral objects to either positively or negatively charged objects using the particle model of electric charge.

Research Report/Presentation

Students or student groups research and report on the contributions that led to the development of the particle model of electricity. Reports can be presented as

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- multimedia presentations
- storytelling or dramatic presentations

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

Suggested Learning Resources

Science 9

Rutherford: Chapter 3, p. 85

Thomson: Chapter 3, p. 84

BLM 9.2 A Model for the Electrical Nature of Matter

Sciencepower 9

Rutherford: Chapter 7, p. 239

Thomson: Chapter 9, p. 307

Appendices

3.3 Teacher Support Material Attraction of a Neutral Object

Prescribed Learning Outcomes

Students will...

S1-3-05 Investigate and explain electrostatic phenomena using the particle model of electricity.

Include: conservation of charge, conduction, grounding, attraction of a neutral insulator, induction.

GLO: A2, D3, D4, E4

Skills and Attitudes Outcomes

S1-0-1b. Select and justify various methods for finding the answers to specific questions. (Math: S1: A-1) GLO: C2

S1-0-3a. State a testable hypothesis or prediction based on background data or on observed events.
GLO: C2

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

Suggestions for Instruction
(3 hours)

➢ **Student Learning Activities**

Teacher Demonstration

Demonstrate conservation of charge by rubbing a glass rod with silk. (Negative charges are removed from the rod by friction, resulting in a net positive charge on the rod.) Hold another positively charged object near the rod. The rod will repel a positively charged object. The silk, on the other hand, has gained electrons and will attract a positively charged object, as it is now charged negatively. Help students infer that charge is not created or destroyed, but moved around.

Laboratory Activity S1-0-1b, 3a, 4e, 5c

Students investigate electrostatic phenomena using the lab described in Appendix 3.4. It is not necessary to use traditional materials, as most of the commercial plastic rods and pith balls are reliable and inexpensive. Different types of materials, such as vinyl or acetate, may replace glass and ebony rods. Try different types of cloth — whatever works best in your environment.

Students use a simple foil electroscope to test for charge. (See Appendix 3.5) Charge the electroscope positively. (Any object that repels the foil must also be charged positively. Any object which attracts the foil could be negative or neutral.) Students determine the only definitive test for a negative charge (i.e., charge the electroscope negatively and look for a repelling effect).

Visual Displays S1-0-5c

Students diagram electrostatic phenomena observed during their investigations, showing the movement of negative charges, the resulting net charge, and the effects of the net charges on the objects involved.

Suggestions for Assessment

Performance Assessment

Given an unknown charge, students demonstrate their ability to determine the charge using a pith ball and two rods or strips (for positive and negative charges).

Laboratory Report

Students investigate electrostatic phenomena. (See Appendix 3.4)

Student assessments should include diagrams that show the object, the movement of the negative charges, the net charge, and the resulting effects. For example, charging by conduction requires three diagrams.

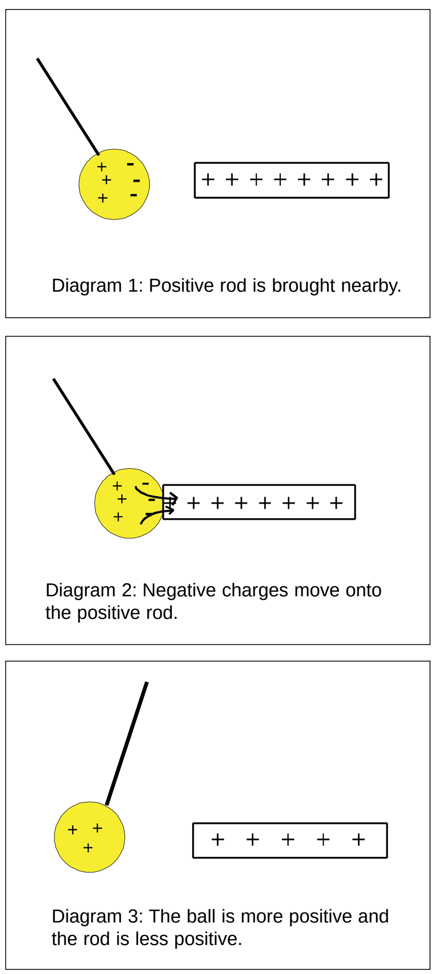


Diagram 1: Positive rod is brought nearby.

Diagram 2: Negative charges move onto the positive rod.

Diagram 3: The ball is more positive and the rod is less positive.

Figure 3: Charging by Conduction

Suggested Learning Resources

Sciencepower 9

BLM 9-11, 12, 19

Appendices

3.4 Student Learning Activity
Electrostatics Lab

3.5 Blackline Master
Electrostatic Devices — Background Information

Teacher Background

Students may wonder why a glass rod rubbed with silk is positive, an ebony rod rubbed with silk is positive, and an ebony rod rubbed with fur is negative. The terms positive and negative are arbitrary and were coined by Ben Franklin.

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-06 Investigate common electrostatic technologies and phenomena and describe measures which reduce dangers associated with electrostatics.

Examples: photocopying, static straps to reduce charge buildup, lightning, electrostatic spray-painting, electrostatic precipitator...

GLO: A5, B1, C1, D4

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-2b. Evaluate the reliability, bias, and usefulness of information.
(ELA: S1: 3.2.3, 3.3.3) GLO: C2, C4, C5, C8; TFS: 2.2.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-8d. Describe examples of how technologies have evolved in response to changing needs and scientific advances.
GLO: A5

SUGGESTIONS FOR INSTRUCTION
(1 HOUR)

➢ **Student Learning Activities**

Class Discussion

Students brainstorm and list the applications, problems, and solutions of everyday situations involving electrostatic charge. This discussion can form the content for the first column of a KWL frame (i.e., What do we know?). (See *SYSTH*, pages 9.8–9.10) Continue the discussion to allow students to express what they want or need to investigate further.

Student Research/Reports S1-0-2a, 2b, 2c, 8d

Using the list created in the previous activity, students or student groups research an item, and report their findings to the class. (See the examples in the learning outcomes column.)

Journal Writing

Students complete their KWL frames, describing what they know, wanted to know, and have learned.

SUGGESTIONS FOR ASSESSMENT

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Research Report/Presentation

Students or student groups research and report on everyday applications and problems/solutions involving electrostatic charge. Reports can be presented as

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- multimedia presentations
- storytelling or dramatic presentation

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations. (See *SYSTH*, page 3.13)

Teacher Background

Many useful everyday applications of electrostatic charge, including photocopy machines and electrostatic spray-painting, are based on the principle that opposites attract. The advent of computer technology and electronic storage devices has also raised awareness of the hazards of electrostatic charge (e.g., computer chips are extremely sensitive to static charge). It is common knowledge that before working on computer components, you should ground yourself by touching a metal or an electrostatic mat.

SUGGESTED LEARNING RESOURCES

Science 9

pp. 278–93

BLM 9.9 Build Your Own Electroscope

Sciencepower 9

pp. 310–18

Appendices

5.2 Rubric for the Assessment of Class Presentations

5.3 Rubric for the Assessment of a Research Project

SYSTH

3.13 Cooperative Learning and Science

9.8–9.10 Tapping into Prior Knowledge

9.24 Tapping into Prior Knowledge

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-07 Construct one or more electrostatic apparatus and explain how they function using the particle model of electricity.

Include: pieplate electrophorus.

GLO: A2, C3, D3, D4

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2;
TFS 2.2.1) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-2b. Evaluate the reliability, bias, and usefulness of information.
(ELA: S1: 3.2.3, 3.3.3) GLO: C2, C4, C5, C8;
TFS: 2.2.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6;
TFS: 2.2.2, 4.3.4

S1-0-4a. Carry out procedures that comprise a fair test. Include: controlling variables, repeating experiments to increase accuracy and reliability of results.
GLO: C1, C2 TFS: 1.3.1

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5a. Select and use appropriate methods and tools for collecting data or information.
GLO: C2; TFS: 1.3.1

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

S1-0-7a. Draw a conclusion that explains the results of an investigation.
Include: cause and effect relationships, alternative explanations, supporting or rejecting the hypothesis or prediction.
(ELA: S1: 3.3.4) GLO: C2, C5, C8

S1-0-8d. Describe examples of how technologies have evolved in response to changing needs and scientific advances.
GLO: A5

S1-0-8e. Discuss how peoples of various cultures have contributed to the development of science and technology.
GLO: A4, A5

SUGGESTIONS FOR INSTRUCTION
(1-1/2 HOURS)

➢ **Notes for Instruction**

An important component of Senior 1 Science is the active involvement of students in the construction of their own electrostatic equipment.

➢ **Student Learning Activities**

Laboratory Activity S1-0-4a, 4e, 5a, 5c, 7a

Students construct electroscopes, an electrophorus, and Leyden jars. (See Appendix 3.5) See the simple electrophorus shown below.

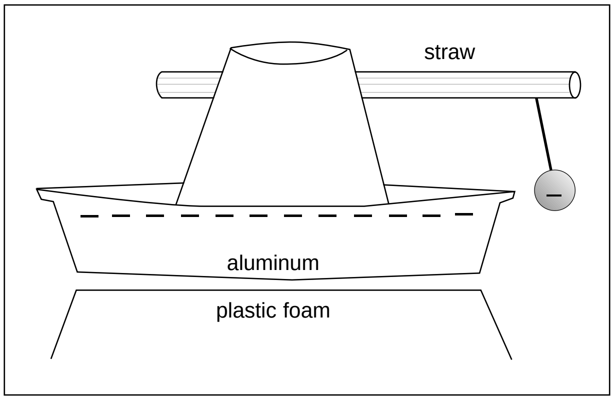


Figure 4: The Pieplate Electrophorus

Students use these devices to test for charge. See the Appendix for more learning activities with the electrophorus and other devices.

Teacher Demonstration

Demonstrate that the charges do not move from the plastic foam to the aluminum plate by putting wax paper between the plastic foam and aluminum.

Student Research S1-0-2a, 2b, 2c, 8d, 8e

Students research some of the early electrostatic devices built by scientists (e.g., Von Guericke's sulfur globe, Volta's electrophorus, Kelvin's water drop static generator) in order to make the connection among a particle model of electricity, new technologies, and their influence on the design of new experiments.

Suggestions for Assessment

Journal Writing S1-0-2c

Students complete a Compare and Contrast frame that distinguishes the charging of a conductor by conduction and induction. (See *SYSTH*, pages 10.15, 10.24)

Students prepare a Concept Overview outlining the characteristics of insulators and conductors. (See *SYSTH*, pages 11.25, 11.37)

Students explain some real-life phenomena that demonstrate the principle of induction (e.g., lightning formation, balloon sticking to a wall, the attraction of a stream of water to positive or negative charges, or the rotation of the 2" x 4" demonstration. (See Appendix 3.1)

Written Quiz/Test

Students
- diagram and explain the charging of an **electroscope** by conduction and induction.
- diagram and explain the charging of an **electrophorus** by induction.

Laboratory Report

Students explain how an electroscope, an electrophorus, and a Leyden jar function using the particle model of electricity.

Research Report/Presentation

Students or student groups research and report on early electrostatic devices. Reports can be presented as
- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- multimedia presentations
- storytelling or dramatic presentations

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

Suggested Learning Resources

Appendices

3.1 Teacher Support Material
Pre-Model Activities

3.5 Blackline Master
Electrostatic Devices

3.7 Teacher Support Material
Pieplate Electrophorus

5.2 Rubric for the Assessment of Class Presentations

SYSTH

10.15, 10.24 Building a Scientific Vocabulary

11.25, 11.37 Developing Scientific Concepts Using Graphic Displays

Other Resources

Morse, Robert, *Teaching Electrostatics*, American Association of Physics Teachers, College Park, MD: 1999
www.aapt.org

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-08 Demonstrate and explain the like nature of electrostatics and current electricity.

Include: discharge an electrophorus through a neon bulb.

GLO: C3, D4, E4

Skills and Attitudes Outcomes

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6;
TFS: 2.2.2, 4.3.4

SUGGESTIONS FOR INSTRUCTION

(1/2 HOUR)

➢ **Notes for Instruction**

Make a connection between electrostatics and current electricity (and ultimately the electrical outlets in your students' homes) by discharging an electrophorus through a neon bulb. Using the particle model for electric charge, explain how the negative charges flow from the ground (your finger) through the bulb, where they bump into neon atoms and give up some energy as heat and light. (See the diagram below and Appendix 3.7)

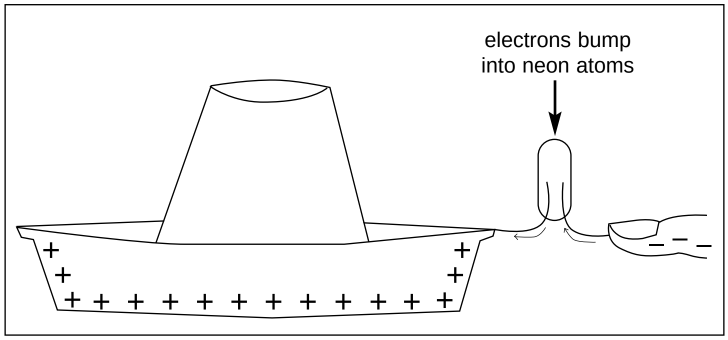


Figure 5: Discharging through a Neon Bulb

Note: Use NH-2 neon bulbs (available at local electronic supply stores).

➢ **Student Learning Activities**

Journal Writing

Students explain, using a Concept Overview frame, the like nature of electrostatics and electricity after viewing the demonstration above. (See *SYSTH*, pages 11.25, 11.37)

Suggestions for Assessment

Journal Writing S1-0-2c

Students describe the various kinds of electricity and some of their effects. The descriptions should include connections with chemistry and biology (e.g., biology — animal electricity contracts muscles).

Teacher Background

Historically, it was not apparent that electricity generated from various sources was of the same nature. Michael Faraday performed comprehensive investigations in the 1830s to show the “Identity of Electricities Derived from Various Sources.” He demonstrated that electricity from batteries, magnetos, animals, and thermo sources produced shocks, deflected magnetic needles, and exerted forces of attraction and repulsion.

Suggested Learning Resources

Appendices

3.6 Teacher Support Material
Transition from Static to Current Electricity

3.7 Teacher Support Material
Pieplate Electrophorus

SYSTH

11.25, 11.37 Developing Scientific Concepts Using Graphic Displays

Other Resources

Arons, Arnold, *A Guide to Introductory Physics Teaching*. John Wiley and Sons, Toronto, ON: 1990, p. 164ff.

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-09 Define electric current as charge per unit time and solve related problems.

Include: $I = \frac{Q}{t}$.

GLO: C2, C3, D4

S1-3-10 Define voltage (electric potential difference) as the energy per unit charge between two points along a conductor and solve related problems.

Include: $V = \frac{E}{Q}$.

GLO: C2, C3, D4

Skills and Attitudes Outcomes

S1-0-1b. Select and justify various methods for finding the answers to specific questions. (Math: S1: A-1) GLO: C2

S1-0-2a. Select and integrate information obtained from a variety of sources. Include: print, electronic, specialists, other resource people. (ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-2b. Evaluate the reliability, bias, and usefulness of information. (ELA: S1: 3.2.3, 3.3.3) GLO: C2, C4, C5, C8; TFS: 2.2.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms. Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources. (ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-3b. Identify probable mathematical relationships between variables. *Examples: relationship between current and resistance...* GLO: C2

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise. (ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding. (ELA: S1: 4.2.1) GLO: C2, C3, C4

SUGGESTIONS FOR INSTRUCTION
(2 HOURS)

➢ **Notes for Instruction S1-0-3b**

Extend the particle model to a discussion of current electricity and define electric current as the number of charges (electrons) which pass a given point per unit time. (The coulomb is the unit for charge and 6.25×10^{18} electrons make up a coulomb. Thus, the unit for current is a coulomb/second, also known as an ampere [A]). Ask students to look on the side of a flashlight bulb for stamps, e.g., 2.2 V or 0.25 A, and then ask, “How many electrons pass through the bulb in one second?” Guide students through the following calculation:

$I = q/t$ and $q = I \times t$

Therefore, $q = 0.25$ A x 1 Second or 0.25 C

but 1 C = 6.25×10^{18}

Therefore, $0.25 \times 6.25 \times 10^{18} = 1.56 \times 10^{18}$ e

(That’s a lot of electrons!)

➢ **Student Learning Activities**

Collaborative Teamwork S1-0-4e

Student groups brainstorm to identify other forms of unit quantities (e.g., unit costs for grocery items) and make up questions to challenge other groups. Your total cost equals the unit cost times the number of items you buy. Similarly, electric energy is the unit energy (electric potential) times the number of charges you have.

Teacher Background

Electric potential (V) is a unit of energy. The units are joules/coulomb, commonly called volts. The volt is the energy of each charge. Therefore, if you have more charges you have more total energy (Energy = charge x potential [$E = qV$]). This concept is important when calculating energy in the home.

You don’t pay for the amount of charge or the potential; instead you pay for the energy that is consumed.

Electric potential difference (ΔV), also called voltage, is the measure of the potential difference between two points. Electric potential is a difficult concept and should be related to the more familiar gravitational potential. If you lift an object above the Earth, the energy is stored as gravitational potential between two masses (the object and the Earth). If you release the mass, the energy is transformed into kinetic energy as the object accelerates towards the Earth. In electricity, you must also apply a force to separate charge. This energy is stored as electric potential and when the charges are released, the energy is transformed to kinetic energy as they accelerate. Therefore, to create an electric potential, we must accumulate and separate charge.

SUGGESTIONS FOR ASSESSMENT

Written Quiz/Test

Students

- solve problems using I = q/t.
- solve problems using V = E/q. Include questions that emphasize the unit nature of electric potential (i.e., E = qV).

Journal Writing S1-0-2c, 7e

Students

- use a water analogy to describe electric potential and current flow.
- compare and contrast electric and gravitational potential energy.
- use a Word Cycle to connect the electrical terms positive charge, negative charge, separation, electric potential difference, conductor, insulator, current, unit energy, total energy, electrophorus, time, joules, and coulomb. (See *SYSTH*, page 10.21)

Student Research S1-0-1b, 2a, 2b, 2c

Students

- investigate the physiological effects of electric current on the human body.
- compare the voltage ratings for different sources of electrical energy (e.g., wall outlet, battery, photocell, and animal electricity).

Teacher Background

Educational research clearly shows that students lack a conceptual background when studying current electricity. Therefore, this cluster has been written to help students develop a conceptual model of electricity using a particle. In an electric circuit, electrons are present in ALL PARTS of the circuit all the time. In order to move electrons in a wire, we need a potential difference between the ends of the wire. A potential difference is created by an accumulation of charge at the ends of the wire. As one electron is pushed into one end of the wire, ALL electrons in the wire move simultaneously and one electron moves off the other end. The electrons actually move through the wire relatively slowly, as they bump into the fixed particles in the wire. However, the signal (the electron moving off the other end) travels instantaneously (speed of light).

SUGGESTED LEARNING RESOURCES

Science 9

Chapter 10, p. 316 (S1-3-10)

Sciencepower 9

Chapter 10, p. 325 (S1-3-09)

Chapter 10, p. 331 (S1-3-10)

SYSTH

10.21 Word Cycle

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-11 Identify the five sources of electrical energy and some associated technologies.

Include: chemical, photo, thermo, electromagnetic, piezo.

GLO: B1, D4, E4

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

SUGGESTIONS FOR INSTRUCTION

(2 HOURS)

➢ Notes for Instruction

The five sources of electrical energy are chemical, photo (light), electromagnetic, thermo (heat), and piezo (crystals). Chemical sources accumulate charge through chemical processes; photoelectric materials emit electrons when they are struck by light; a wire moving in a magnetic field generates current; some dissimilar metals generate current when heated; and certain crystals generate current when they are stressed.

➢ Student Learning Activities

Teacher Demonstration

Demonstrate several sources of electrical energy such as

- chemical energy using a battery (e.g., a potato clock or a lemon battery).
- photo energy using a photocell (available in hobby stores or scientific catalogues). For a bright light, use your overhead.
- electromagnetic energy by pushing a magnet into a coil of wire or using a hand-held generator from commercial suppliers.
- thermoelectric energy by heating thermocouples.
- piezo electric energy using piezoelectric crystals (found in microphones) to change mechanical energy to electrical energy.

Note: Chemical (batteries), photoelectricity (photocells), and electromagnetic (generators) sources are readily available.

Student Research

Students research and identify a common application of electricity at home, work, or school.

SUGGESTIONS FOR ASSESSMENT

Research Report/Presentation S1-0-2a, 2c

Students research

- fuel cells, including their advantages over traditional sources of chemical energy, and their applications.
- ultrasonic waves. (In medicine, ultrasonic waves are produced by electrically stimulating a piezoelectric crystal. Alternating electric current applied to a piezoelectric crystal causes rapid deformations of the crystal. These vibrations cause compressions in the air surrounding the crystal, or ultrasonic waves.)
- guitar tuners and microphones (piezoelectricity), thermocouples (heat-sending switch), and photocells.

Reports can be presented as

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- multimedia presentations
- storytelling or dramatic presentations

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

Journal Writing S1-0-2a, 2c

Students compare the energy used when manufacturing batteries with the energy delivered by batteries.

Students examine the toxic chemicals involved in manufacturing batteries and discuss the environmental problems associated with their disposal.

Teacher Background

To create electric potential energy, we must accumulate and separate charge. As the negative charges move, the energy is transformed to kinetic energy. If we do not replace the negative charge, the potential reduces very quickly and no more current will flow. For a continuous flow of charge, we must maintain this accumulation of charge.

SUGGESTED LEARNING RESOURCES

Science 9

Chapter 11, pp. 342, 346

Sciencepower 9

Chapter 12, p. 380

Appendices

5.2 Rubric for the Assessment of Class Presentations

5.3 Rubric for the Assessment of a Research Project

Prescribed Learning Outcomes

Students will...

S1-3-12 Describe resistance in terms of the particle model of electricity.

GLO: A2, D3, E2

Skills and Attitudes Outcomes

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6;
TFS: 2.2.2, 4.3.4

Suggestions for Instruction
(1/2 hour)

➢ **Notes for Instruction**

According to our particle model of electricity, positive charges are fixed and the negative charges (electrons) move. As the electrons move through a conductor, they bump into the fixed particles (the atoms) in the conductor. When they bump into the atoms, the electrons slow down and give up their energy as heat and light. This opposition to the flow of electrons is called resistance.

The accepted unit of resistance is the Ohm (Ω). One Ohm is the resistance of a wire with a potential difference of one volt and a current of one ampere.

Encourage students to describe their understanding of resistance in their own words using analogies or creative writing.

➢ **Student Learning Activities**

Journal Writing

Using a RAFTS format, students describe the journey of the electrons in a wire. For example: You are an electron writing a letter of complaint to the atoms of a conductor who are always in the way. (See *SYSTH*, pages 13.23–13.28)

Alternatively, students use a water pump analogy to describe the energy changes in an electric circuit.

SUGGESTIONS FOR ASSESSMENT

Written Quiz/Test

Students describe the energy transfer in an electrical circuit in terms of the particle model.

Teacher Background

Traditionally, the unit of electrical resistance was the length of a standard wire. Conceptually, length is an excellent description of the resistance of a wire. A longer wire means there are more atoms for the electrons to bump into.

SUGGESTED LEARNING RESOURCES

Science 9

Chapter 10, p. 316

Sciencepower 9

Chapter 10, p. 337

SYSTH

13.23–13.28 Writing to Learn Science

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-13 Construct electric circuits using schematic diagrams.

Include: series, parallel.

GLO: C3, D4, E4

Skills and Attitudes Outcomes

S1-0-1b. Select and justify various methods for finding the answers to specific questions.
(Math: S1: A-1) GLO: C2

S1-0-3c. Plan an investigation to answer a specific scientific question.
Include: materials, variables, controls, methods, safety considerations.
GLO: C1, C2

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-6a. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

S1-0-7a. Interpret patterns and trends in data, and infer and explain relationships.
(ELA: S1: 3.3.1) GLO: C2, C5;
TFS: 1.3.1, 3.3.1

SUGGESTIONS FOR INSTRUCTION

(1 HOUR)

➢ **Notes for Instruction**

See Appendix 3.8: Batteries and Bulbs.

Class Discussion

Demonstrate the two-endedness of a light bulb by wrapping an ordinary household light in a towel and breaking the glass enclosure. (Exercise caution when breaking the bulb. The glass is sharp!) Students should identify the path of the electrons. (See Figure 7)

Teacher Demonstration

Introduce a second wire and the concept of a circuit loop. (See Figures 8 and 9) After drawing a picture of the circuit, introduce the convenience of schematics (symbols), including the symbols for cells, a switch, a bulb, and a resistance.

➢ **Student Learning Activities**

Laboratory Activity S1-0-4e

Students build a simple circuit with a battery, one wire, and a mini lamp. Students perform lab exercises in simple circuits. (See Appendices 3.9–3.10)

SUGGESTIONS FOR ASSESSMENT

Journal Writing

Students compare and contrast the characteristics of series and parallel circuits.

Performance Assessment

Given a schematic diagram, students build an electric circuit, and draw a schematic diagram from a given electric circuit.

Laboratory Report

Students complete an investigation in series and parallel circuits.

Design Project S1-0-1b, 3c, 6a

Students design a circuit with two bulbs and a buzzer so that one bulb is always lit and the other only lights when the buzzer is turned on.

Teacher Background

A lamp is simply a wire (the filament) enclosed in a glass bulb. One end of the filament is connected to the shield and the other end touches the bottom contact.

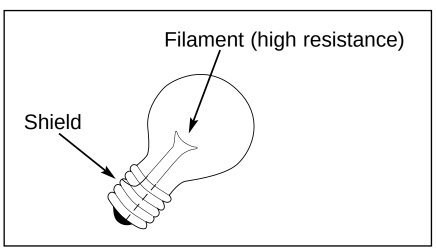


Figure 7: Bulb

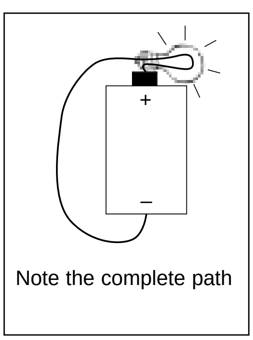


Figure 8:
Battery and bulb

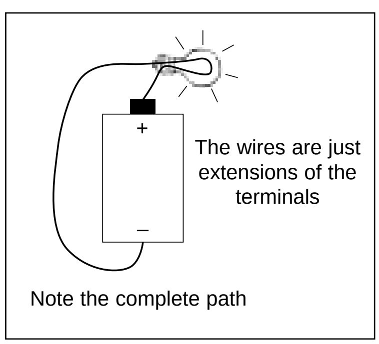


Figure 9:
Simple circuit with battery and bulb

SUGGESTED LEARNING RESOURCES

Science 9

Chapter 10, p. 300

Skills, p. 544

Sciencepower 9

Chapter 10, p. 334

Chapter 11, p. 354

Appendices

3.8 Teacher Support Material
Batteries and Bulbs

3.9 Student Learning Activity
Simple Circuits Lab

3.10 Blackline Master
DC Circuits and Schematic Diagrams

Other Resources

Evans, James. "Teaching Electricity with Batteries and Bulbs." *The Physics Teacher* (January 1978): 15.

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-14 Use appropriate instruments and units to measure voltage (electric potential difference), current, and resistance.

GLO: C2, C3, D4

Skills and Attitudes Outcomes

S1-0-3a. State a testable hypothesis or prediction based on background data or on observes events. GLO: C2

S1-0-3c. Plan an investigation to answer a specific scientific question.
Include: materials, variables, controls, methods, safety considerations.
GLO: C1, C2

S1-0-4a. Carry out procedures that comprise a fair test. Include: controlling variables, repeating experiments to increase accuracy and reliability of results.
GLO: C1, C2; TFS: 1.3.1

S1-0-4b. Demonstrate work habits that ensure personal safety of others, as well as consideration for the environment.
Include: knowledge and use of relevant safety precautions, WHMIS regulations, emergency equipment.
GLO: B3, B5, C1, C2

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5b. Estimate and measure accurately using Système International (SI) and other standard units.
Include: SI conversions.
GLO: C2

SUGGESTIONS FOR INSTRUCTION

(1 HOUR)

➢ **Notes for Instruction**

Use a multimeter or a voltmeter and an ammeter to measure voltage and current in circuits. Digital multimeters (numerical display) can be expensive; however, inexpensive analog meters can be found commercially. These have the additional advantage of providing students an opportunity to read a scale. The meter should be capable of measuring the voltage and current ranges that are required for simple circuits (e.g., flashlight batteries and bulb circuits require a range of about 5.0 V and 0.5 amperes).

➢ **Student Learning Activities**

Teacher Demonstration

Demonstrate that in order for an ammeter to measure current, it must be placed in series such that the current flows through the meter. (The meter is built with a very low resistance and does not affect the total resistance of the circuit.) Warn students what will happen if they place a meter in a circuit incorrectly (i.e., an ammeter placed in parallel behaves like a low resistance wire — it shorts the circuit). Using equipment and supporting schematics (See Figure 10) show that voltmeters are placed in a circuit in parallel and have a very high resistance. If a voltmeter is placed in series, the large resistance decreases the current (effectively to zero) and the circuit will not work. (See Appendix 3.11)

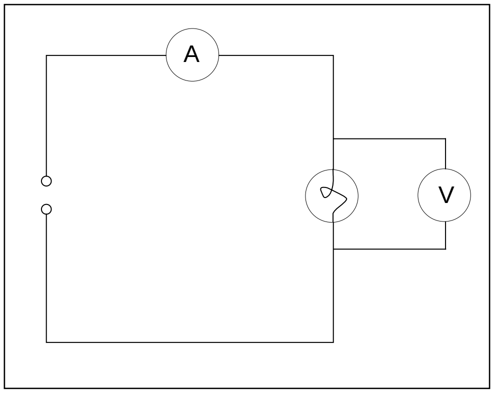


Figure 10: Correct Placement of Meters

Laboratory Activity S1-0-4a, 4b, 4e, 5b

Students perform a lab exercise, measuring voltage, current, and resistance. (See Appendix 3.11)

Suggestions for Assessment

Performance Assessment S1-0-3c

Students measure the current in a simple series or parallel arrangement.

Written Quiz/Test

Students

- draw schematic diagrams to show the placement of a voltmeter and an ammeter in a simple circuit.
- explain what happens to a circuit when the meter is placed incorrectly.

See examples below:

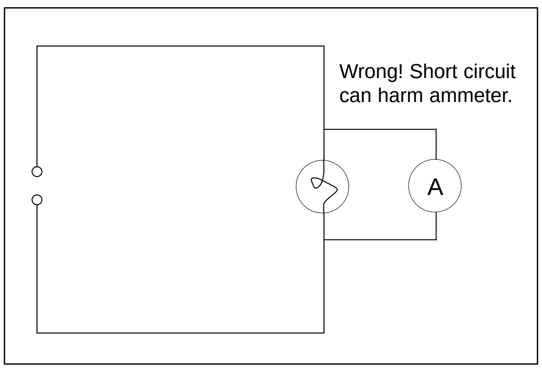


Figure 11: Ammeter is a small resistance

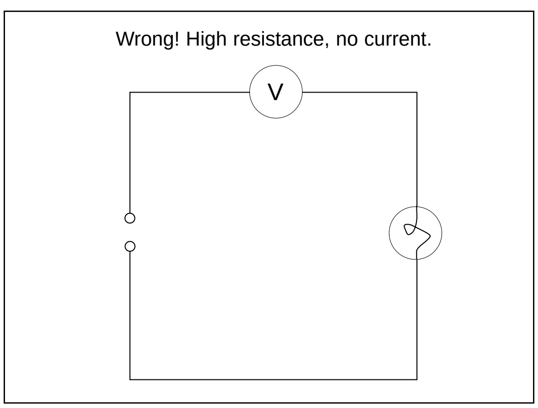


Figure 12: Voltmeter is a huge resistance

Suggested Learning Resources

Science 9

p. 546

Sciencepower 9

pp. 326, 332

Appendices

3.9 Student Learning Activity
Simple Circuits Lab

3.11 Student Learning Activity
Circuits Lab 2 — Measuring Current, Voltage, and Resistance

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-15 Compare and contrast voltage (electric potential difference) and current in series and parallel circuits.

Include: cells, resistance.

GLO: C3, D4

Skills and Attitudes Outcomes

S1-0-5b. Estimate and measure accurately using Système International (SI) and other standard units.
Include: SI conversions.
GLO: C2

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

S1-0-6a. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

S1-0-6b. Identify and suggest explanations for discrepancies in data.
Examples: sources of error...
(ELA: S1: 3.3.3) GLO: C2

S1-0-6c. Evaluate the original plan for an investigation and suggest improvements.
Examples: identify strengths and weaknesses of data collection methods used...
GLO: C2, C5

S1-0-7a. Interpret patterns and trends in data, and infer and explain relationships.
(ELA: S1: 3.3.1) GLO: C2, C5;
TFS: 1.3.1, 3.3.1

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

SUGGESTIONS FOR INSTRUCTION
(1 HOUR)

➢ **Notes for Instruction S1-0-5b, 5c, 6a, 6b, 6c, 7a, 7e**

After a brief demonstration of how to construct circuits in series and parallel, ask students to investigate the effects on current and voltage of these two types of circuits.

➢ **Student Learning Activities**

Class Discussion

Students manipulate equipment and construct circuits in series and in parallel according to circuit diagrams/schematics to compare and contrast current and voltage.

Single sources of electrical energy (cells) can be placed in series and in parallel. If cells are placed in series, the voltage increases proportional to the number of cells. In other words, the individual voltages add up to give the total voltage. For example, one flashlight battery (one cell) has a voltage of 1.5 volts. Three flashlight batteries in series have a voltage of $1.5 + 1.5 + 1.5 = 4.5$ V. You can easily measure this using a voltmeter.

If the cells are placed in parallel, the voltages remain the same and each cell contributes a proportional amount of current. Cells in parallel also last longer.

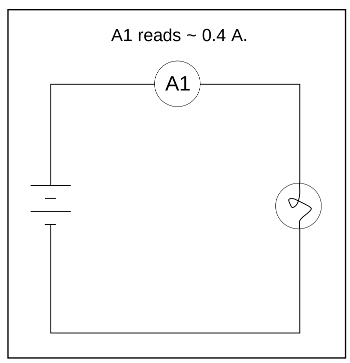


Figure 13: Current in a Simple Circuit

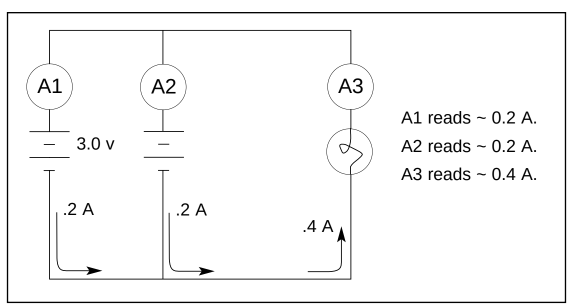


Figure 14: Current for Cells in Parallel

(continued)

Suggestions for Assessment

Journal Writing

Students compare and contrast

- the characteristics of voltage and current in series and parallel arrangements.
- resistance in series and resistance in parallel.

Written Quiz/Test

Students trace the path of the current in series and parallel circuits, and compare the brightness of bulbs in each case.

Teacher Background

It is a common belief that batteries are constant suppliers of current. Although each flashlight battery can deliver 0.2 A of current, the total current of three batteries in parallel is not necessarily 0.6 A. The amount of current in a circuit will also depend on the resistance of the circuit.

Suggested Learning Resources

Appendices

3.10 Blackline Master
DC Circuits and Schematic Diagrams

3.11 Student Learning Activity
Circuits Lab 2 — Measuring Current, Voltage, and Resistance

Other Resources

McDermott, L. and P. Schaffer. "Research as a Guide for Curriculum Development. Part I: An Example from Introductory Electricity." *American Journal of Physics* 60 (11) (1992): 994–1003.

PRESCRIBED LEARNING OUTCOMES

Students will...

(continued)

S1-3-15 Compare and contrast voltage (electric potential difference) and current in series and parallel circuits.

Include: cells, resistance.

GLO: C3, D4

SUGGESTIONS FOR INSTRUCTION

(1 HOUR)

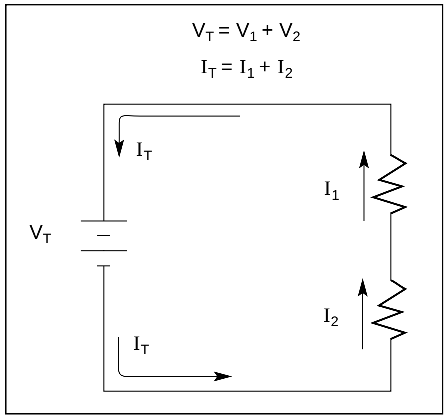


Figure 15: Resistance in Series

Resistance in parallel decreases the overall resistance of the circuit, since the electrons have an extra path to follow (it is like opening another door). Therefore, the current in the circuit increases. For example, a simple circuit with one bulb will have a current; two identical bulbs in parallel means the total resistance is halved and, therefore, the total current is doubled (less resistance, more current). However, this current must be shared by the two bulbs and the brightness of the bulbs remains the same. Resistances in parallel share current and have the same voltage. For resistances in parallel,

$V_T = V_1 = V_2$ and $I_T = I_1 + I_2$

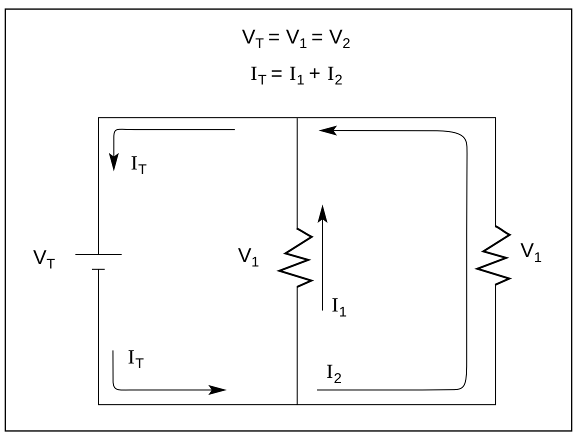


Figure 16: Current for Cells in Parallel

Resistance in series adds up to give the total resistance. Therefore, the current decreases and the brightness of bulbs in series will decrease compared to a single bulb. Resistances in series share the voltage and have the same current. For resistances in series we have, $V_T = V_1 + V_2$ and $I_T = I_1 = I_2$.

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-16 Investigate and describe qualitatively the relationship among current, voltage (electric potential difference), and resistance in a simple electric circuit.

GLO: C2, D4, E4

S1-3-17 Relate the energy dissipated in a circuit to the resistance, current, and brightness of bulbs.

GLO: D4

Skills and Attitudes Outcomes

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5b. Estimate and measure accurately using Système International (SI) and other standard units.
Include: SI conversions.
GLO: C2

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5
TFS: 1.3.1, 3.2.2

S1-0-6a. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

S1-0-7a. Interpret patterns and trends in data, and infer and explain relationships.
(ELA: S1: 3.3.1) GLO: C2, C5;
TFS: 1.3.1, 3.3.1

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

SUGGESTIONS FOR INSTRUCTION
(2 HOURS)

➢ **Notes for Instruction**

Help students relate the brightness of bulbs in a simple circuit to the current and resistance in the circuit. More current means more electrons bumping into things and giving up more energy, thereby causing the bulbs to burn brightly. More resistance means less current and, therefore, the bulbs burn less brightly. Demonstrate this by placing two identical bulbs in series. As a result, the brightness of the bulbs in a circuit is a qualitative measure of current. Use meters to verify quantitatively that current (I) is inversely proportional to resistance (R).

More voltage means more current when resistance is constant. Demonstrate this by comparing a simple circuit with one battery and bulb to a simple circuit with two batteries in series (more voltage) and the same bulb. The brightness of the bulb increases, indicating that the current has increased. Use meters to quantitatively measure the voltage and current. These results suggest that $I \propto 1/R$ and $V \propto I$. Combining them yields $I = V/R$ (Ohm's law). This approach should prepare students to investigate Ohm's law quantitatively.

➢ **Student Learning Activities S1-0-4e, 5b, 5c, 6a, 7a, 7e**

Laboratory Activity

Students investigate and describe qualitatively the relationship among current, voltage, and resistance in a simple electric circuit. (See Appendix 3.11)

SUGGESTIONS FOR ASSESSMENT

Written Quiz/Test

Students

- rank the brightness of the bulbs in a circuit from least bright to brightest. For example:

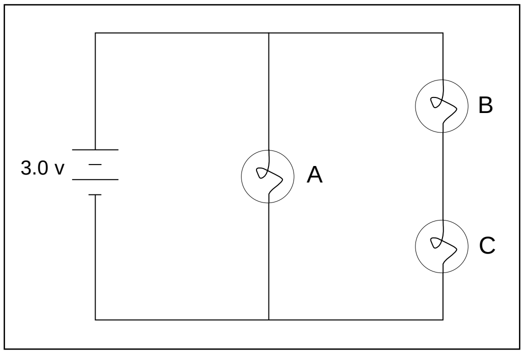


Figure 17: Bulb Brightness Ranking Exercise

(*Answer: The brightness of the bulbs is A > B = C*)

- explain changes in brightness of a bulb in a circuit when different characteristics of the circuit change. For example:

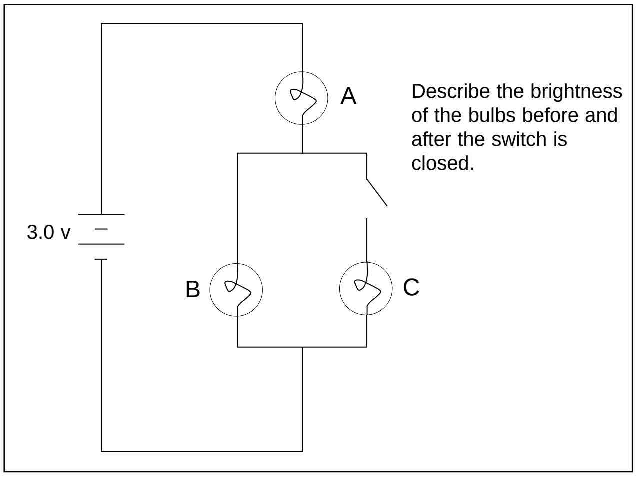


Figure 18: Circuit Changes and Effects on Brightness

SUGGESTED LEARNING RESOURCES

Appendices

3.8 Teacher Support Material
Batteries and Bulbs

3.11 Student Learning Activity
Circuits Lab 2 — Measuring Current, Voltage, and Resistance

Prescribed Learning Outcomes

Students will...

S1-3-18 Explain the parallel circuits, the components, and the safety aspects of household wiring.

Include: switches, fuses, circuit breakers, outlets.

GLO: A5, B1, B2, C1

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

Suggestions for Instruction

(1 hour)

➢ **Notes for Instruction**

Help students recognize the components and parallel circuitry of household wiring.

Teacher Background

A household circuit is a circuit with many resistances in parallel. The source of electrical energy is the electricity supplied by the power company to the electrical panel in the house. The resistances are your lights and the electrical appliances, like the stove and refrigerator. Since electrical energy is converted to heat in a circuit, the wires in a circuit can burn and pose a safety hazard. Each time we add a resistance in parallel, the total resistance decreases and the total current increases. The resistances share this current and generally function properly. However, there is a portion of the circuit that must carry ALL the current. If too much resistance is added and the current exceeds the capacity of this wire, then the wire burns.

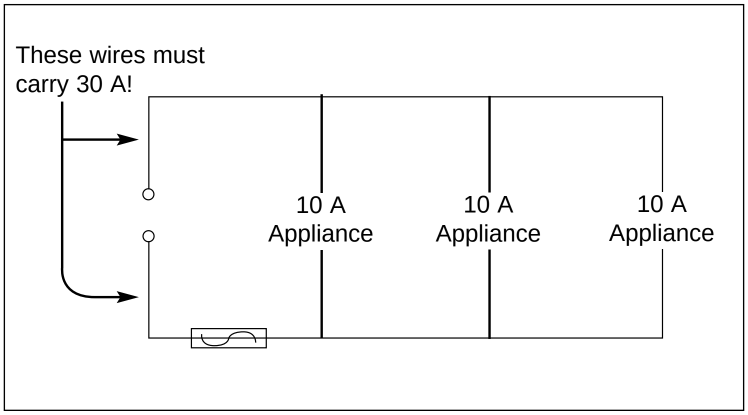


Figure 19: Fuse Placement in a Household Circuit

To protect the wires from burning, a fuse is added to this part of the circuit. A fuse is a small wire enclosed in a case. The wire in the fuse is chosen so that it will burn at a set current (like 1A). If the current exceeds the fuse's rating, the fuse "blows" and the circuit ceases to work.

Circuit breakers in homes protect the circuit and are located in the electric panel. Fuses must be replaced, but circuit breakers can be reset. If too many appliances are plugged into a household circuit, the breaker cuts off the power. The breaker cannot be reset until one or more of the appliances is unplugged.

➢ **Student Learning Activities**

Visual Displays

Students draw a household wiring diagram including all components (such as appliances, fuses, or breakers, etc.) and explaining parallel circuits.

Suggestions for Assessment

Research Report/Presentation S1-0-2a, 2c

Students research the safety features of ground fault circuit interrupter (GCFI) outlets.

Students compare and contrast fuses and circuit breakers.

Written Quiz/Test

Students draw a schematic diagram of a household electrical system.

Suggested Learning Resources

Science 9

BLM 12.2 Electrical Meter and Distribution Panel

Appendices

5.2 Rubric for the Assessment of Class Presentations

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-19 Explain safety considerations of some common household appliances.

Examples: kettle, heater, toaster...

GLO: A5, B1, C1, D4

S1-3-20 Define electrical power as energy per unit time, and solve related problems.

Include: $P = \frac{E}{t}$.

GLO: C2, C3, D4

Skills and Attitudes Outcomes

S1-0-3e. Determine criteria for the evaluation of an STSE decision.
Examples: scientific merit; technological feasibility; social, cultural, economic, and political factors; safety; cost; sustainability...
GLO: B5, C1, C3, C4

S1-0-3f. Formulate and develop options which could lead to an STSE decision.
GLO: C4

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5
TFS: 1.3.1, 3.2.2

S1-0-5d. Evaluate, using pre-determined criteria, different STSE options leading to a possible decision.
Include: scientific merit; technological feasibility; social, cultural, economic, and political factors; safety; cost; sustainability.
(ELA: S1: 3.3.3) GLO: B5, C1, C3, C4;
TFS: 1.3.2, 3.2.3

S1-0-6a. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

SUGGESTIONS FOR INSTRUCTION
(2 HOURS)

➢ **Entry-Level Knowledge**

In previous learning outcomes, students determined that the total energy depends on the amount of charge ($E = qV$).

➢ **Notes for Instruction**

Help students see, through mathematical manipulation, that power is the rate at which energy is delivered to a circuit (i.e., $P = E/t$). (See Figure 20) The energy delivered to a circuit must be used in the circuit of the wires. Otherwise, the resistance in the circuit will not be able to dissipate the energy and the wires will burn.

$E = qV$	divide both sides by time
$\frac{E}{t} = \frac{q}{t} \cdot V$	since $P = E/t$ and $I = q/t$
$P = IV$	The power depends on the current and the voltage.

Figure 20: From Energy to Power

➢ **Student Learning Activities S1-0-5c**

Problem Solving

Students solve electrical power problems. (See Appendix 3.12)

SUGGESTIONS FOR ASSESSMENT

Visual Displays

Students design a poster display to describe how common household appliances work.

Journal Writing

Students compare and contrast

- the total power delivered in a series circuit to the power dissipated in each resistance.
- the total power delivered in a parallel circuit to the power dissipated in each resistance.
- the power dissipated in electric heaters connected in series and in parallel.

Teacher Background

Most small appliances, like kettles, heaters, and hair dryers, are just special forms of resistances which give off heat. They are built to work in a specific voltage and current range. They also wear out over time. Old, cracked, or frayed wires can cause an appliance to short circuit. In a short circuit, a wire may bypass the resistance of the circuit. The small resistance of the "short" causes an increase in the current. If the path cannot handle the increase in current, it will burn. If the path is your body, you will feel an electric shock. In household circuits, this shock can be lethal.

SUGGESTED LEARNING RESOURCES

Appendices

3.12 Student Learning Activity
Power Calculations

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-21 Develop a formula for domestic power consumption costs, and solve related problems.

Include:

$$\text{Cost} = \frac{\text{Power x time x unit price}}{\text{kWh}}.$$

GLO: B2, C2, C3, D4

S1-3-22 Analyze the electrical energy consumption of a household appliance.

Include: calculate consumption using Energuide labels, read hydro meter, interpret monthly hydro bill.

GLO: B5, C4, C5, C8

Skills and Attitudes Outcomes

S1-0-5a. Select and use appropriate methods and tools for collecting data or information.
GLO: C2; TFS: 1.3.1

S1-0-5b. Estimate and measure accurately using Système International (SI) and other standard units.
Include: SI conversions.
GLO: C2

S1-0-6a. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

S1-0-7a. Interpret patterns and trends in data, and infer and explain relationships.
(ELA: S1: 3.3.1) GLO: C2, C5;
TFS: 1.3.1, 3.3.1

SUGGESTIONS FOR INSTRUCTION
(3 HOURS)

➢ **Notes for Instruction**

Help students develop the calculation used by power companies to charge for energy consumption. Discuss household energy consumption and encourage students to become aware of how they can make wise decisions based on information from Energuide labels, hydro bills, etc.

➢ **Student Learning Activities**

Laboratory Activities S1-05a, 5b, 6a, 7a

Energy Awareness and the Energy Audit: Students classify the appliances in the home as low, medium, or high consumers of electricity.

Students perform an energy audit to determine the household energy requirements and habits of their families. Students tally household energy consumption by reading the electric meter at the same time every day. They keep a log of the family's use of appliances, and track other factors, like the weather, which may influence consumption. Students then analyze the audit to address the ways of conserving energy in the home, school, or workplace. (See Appendix 3.12)

Teacher Background

Homeowners pay a power company for energy. The cost of energy is calculated as follows: Cost = Power x time x unit cost/kWh. Since the power company measures energy in kilowatt hours (kWh), the units of power must be kilowatts and the units of time must be hours.

The Energy Efficiency Act and Regulations outline the standards for energy-using products, like major appliances, that we use in our homes. Each major appliance must be sold with an Energuide label that displays the estimated annual energy consumption of the household appliance in kilowatt hours and identifies the most and least energy-efficient models in the same category. This allows the consumer to compare efficiencies of different manufacturers before making a purchase.

Suggestions for Assessment

Journal Writing

Students compare the unit energy costs throughout Canada and the world. They also answer the question: "How does geography and the mode of production (hydro, coal, nuclear) relate to the unit cost?"

Research Report/Presentation

Students compare the cost of operating a portable appliance (like a CD player) with batteries or with hydroelectric power.

Home Assignment

Using a hydro bill, students calculate the cost of using an appliance for 24 hours.

Research Report/Presentation

Students research and report on the different types of bulbs (i.e., incandescent, fluorescent, halogen, compact fluorescent) and compare them for initial cost of purchase versus cost of operating. Reports can be presented as

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- multimedia presentations
- storytelling or dramatic presentations

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

Written Quiz/Test

Students read and record meter readings from diagrams and calculate the cost of energy from the information on a hydro bill.

Home Assignment

Students perform an energy audit.

Suggested Learning Resources

Science 9

BLM 12.5a Sample Electricity Bill

BLM 12.6a Energy Usage Table

BLM 12.6b How to Read Your Meter

Sciencepower 9

BLM 11-14 Reading Meters

BLM 11-15 Practice Meters

BLM 11-16 The Price of Energy

BLM 11-18 Conserving Electricity

Appendices

3.12 Student Learning Activity Power Calculations

5.2 Rubric for the Assessment of Class Presentations

5.3 Rubric for the Assessment of a Research Project

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-23 Recognize and explain the importance of incorporating principles of electrical energy conservation into the decision-making process.

GLO: B2, B5, C4, C8

S1-3-24 Use the decision-making process to address an issue associated with the generation and transmission of electricity in Manitoba.

Include: hydroelectric power, sustainability.

GLO: B2, B5, C4, C8

Skills and Attitudes Outcomes

S1-0-1c. Identify STSE issues which could be addressed. GLO: C4

S1-0-1d. Identify stakeholders and initiate research related to an STSE issue.

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print and electronic sources, specialists, and other resource people.

S1-0-2b. Evaluate the reliability, bias, and usefulness of information.

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.

S1-0-2d. Review effects of past decisions and various perspectives related to an STSE issue.
Examples: government's, public, environmentalists', and First Nations' positions on hydroelectric development; religious, social, and medical views on genetic screening...

S1-0-3e. Determine criteria for the evaluation of an STSE decision.
Examples: scientific merit; technological feasibility; social, cultural, economic, and political factors; safety; cost; sustainability...

S1-0-3f. Formulate and develop options which could lead to an STSE decision.

S1-0-4d. Use various methods for anticipating the impacts of different options.
Examples: test run, partial implementation, simulation, debate...

S1-0-4f. Assume the responsibilities of various roles within a group and evaluate which roles are most appropriate for given tasks.

S1-0-5d. Evaluate, using pre-determined criteria, different STSE options leading to a possible decision.
Include: scientific merit; technological feasibility; social, cultural, economic, and political factors; safety; cost; sustainability.

SUGGESTIONS FOR INSTRUCTION
(3 HOURS)

➢ **Notes for Instruction**

Help students recognize and explain the importance of electrical energy conservation and its influence on our decisions.

➢ **Student Learning Activities S1-0-1c, 1d, 2a, 2b, 2c, 2d, 3c, 3f, 4d, 4f, 5d**

Role Playing Activity (Town Hall Meeting): Student groups role play a town hall meeting to decide if an electric generating station should be built in their community. Groups could include

- the mayor and councillors who preside over the meeting and vote on the motion
- concerned residents
- environmentalists
- engineers
- business representatives

Each stakeholder group presents its case, and the floor is open for questions and debate. The meeting concludes when the mayor and councillors reach a decision.

Student Research/Reports S1-0-2a, 2b, 2c, 2d

Students

- review the public affairs information available from Manitoba Hydro and report on the location of the electric generating stations and transmission wires in Manitoba.
- investigate and report on the public's knowledge and concerns with electric and magnetic fields.
- interview (or email) a resident of northern Manitoba to discuss sustainability issues from his or her perspective.
- research and report on the sustainability issues for nuclear and fossil fuel production of electricity.

Suggestions for Assessment

Research Reports

Students or student groups research and report on early electrostatic devices. Reports can be presented as

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- multimedia presentations
- storytelling or dramatic presentations

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

Teacher Background

Electrical energy is an essential component of our everyday lives. Worldwide consumption of electrical energy is increasing, but the resources we use to generate this energy are not always sustainable. The term sustainability is used to mean that the social, economic, and environmental concerns must be considered for present and future use of electrical energy. Hydro generating stations (usually in the North) produce 99% of the electrical energy in Manitoba. Social, economic, and environmental issues include land claims, flooding, and alternative sources of energy.

Suggested Learning Resources

Science 9

BLM 11.5 Sources of Electricity

BLM 12.5b Making Energy Conservation Choices

Appendices

5.2 Rubric for the Assessment of Class Presentations

5.3 Rubric for the Assessment of a Research Project

5.4 Rubric for the Assessment of a Decision-Making Process Activity

NOTES

Senior 1

Cluster 4: Exploring the Universe

Overview

This cluster leads students through an exploration of the universe, beginning with observational astronomy and ending with a critical look at issues surrounding space science and technology. Students

- observe and locate visible celestial objects. This knowledge provides them with an appreciation for the relevance of astronomy to various peoples.
- develop an understanding of the origin, evolution, and organization of the components of the universe.
- research and study Canada's involvement in international space exploration and evaluate the impact of space science and technologies in terms of their benefits and risks to the human race.

Prescribed Learning Outcomes

Students will...

S1-4-01 Use a coordinate system to locate visible celestial objects, and construct an astrolabe to determine the position of these objects.

Include: altitude, azimuth.

GLO: C2, C3, D6

Skills and Attitudes Outcomes

S1-0-1b. Select and justify various methods for finding the answers to specific questions.
(Math: S1: A-1) GLO: C2

S1-0-3b. Identify probable mathematical relationships between variables.
GLO: C2

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-4f. Assume the responsibilities of various roles within a group and evaluate which roles are most appropriate for given tasks.
(ELA: S1: 5.2.2) GLO: C2, C4, C7

S1-0-5a. Select and use appropriate methods and tools for collecting data or information.
GLO: C2; TFS: 1.3.1

S1-0-5b. Estimate and measure accurately using Système International (SI) and other standard units.
Include: SI conversions.
GLO: C2

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

S1-0-6a. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

S1-0-6b. Identify and suggest explanations for discrepancies in data.
Examples: sources of error...
(ELA: S1: 3.3.3) GLO: C2

S1-0-7a. Draw a conclusion that explains the results of an investigation.
Include: cause and effect relationships, alternative explanations, supporting or rejecting the hypothesis or prediction.
(ELA: S1: 3.3.4) GLO: C2, C5, C8

Suggestions for Instruction

(2 hours)

➢ Entry-Level Knowledge

In Grade 6, students identified technological tools and devices that were designed specifically or indirectly for celestial observations and the exploration of space.

➢ Notes for Instruction

Check for prior knowledge using activities from the *Senior Years Science Teachers' Handbook* (*SYSTH*), pages 9.6, 9.24, 9.25.

Instill in students a curiosity about space by allowing them to *directly* observe the sky. Encourage students to look at the sky both during the school day and at night to learn to recognize several space objects and their patterns of movement. Obviously, the Sun and Moon are easily recognized and would be the best objects to start with, but students should also learn how to find key stars such as Polaris and some of the major planets. Students will design an instrument to make altitude and azimuth measurements in an angular coordinate system that can be used by a local observer to locate astronomical objects in the sky. Students will develop an understanding of how this coordinate system works by using an instrument designed and constructed for the purpose of accurately determining the positions of easily recognizable celestial objects.

➢ Student Learning Activities

Laboratory Activity S1-0-1b, 3b, 4e, 4b, 5a, 5c, 6a, 6b, 7a

Astrolabe Construction and Outdoor Observation: Students or pairs of students construct astrolabes to estimate the angles of elevation of objects above the horizon. Additionally, they will use a compass to determine the azimuth correctly. For example, students can determine the altitude and azimuth of the Moon when it is visible during class time, noting the time of day that the observations were made.

(See Appendix 4.1 for a complete outline of materials, procedures, and construction hints.)

Students gain practice and precision with the astrolabe during daytime hours by locating objects in their immediate vicinity, such as treetops, buildings, etc. Students then attempt to determine the altitudes and azimuths of objects in the sky. It is recommended that students sight the Moon first because of its size and daytime visibility. (See Appendix 4.2)

(continued)

Suggestions for Assessment

Rubrics/Checklists

The following rubrics are provided for Appendices 4.1 and 4.2; however, these are intended to serve only as a guide. Rubrics are most effective when designed and created collectively by discussion and consensus PRIOR to the class activity.

Astrolabe:

- Some descriptors are purposely very general to encourage students and teachers to insert their own.
- Emphasize accuracy, design, construction, etc., depending on the skills of the students (e.g., measurement or sighting accuracy).

Rubric for Astrolabe Construction

Performance Level	Criteria
5	Astrolabe can be used to determine the elevation of a viewed object with a high degree of precision and accuracy. It has been well constructed.
4	Astrolabe can be used to determine the elevation of a viewed object but not accurately. It has been well constructed.
3	Astrolabe can be used to determine the elevation of a viewed object but not accurately. It has not been well constructed.
2	Astrolabe does not measure altitude but has been carefully constructed.
1	Astrolabe does not measure altitude and is poorly constructed with little effort and care taken.

Caution: Solar Observations
Students need a reminder that direct observation of the Sun is dangerous, even with a filter apparatus. Solar images should always be projected onto a screen if using optical aids. Even under obscured conditions, solar infrared (IR) can cause retinal damage to the eye when observing directly.

(continued)

Suggested Learning Resources

Science 9

Activity 13.5: Measuring Angles in the Sky, pp. 408–09

BLM 13.5a: “Properties of the Planets in the Solar System”

BLM 13.5b: Make Your Own Astrolabe

Sciencepower 9

Activity 13.2: The Celestial Movie, pp. 432–33

BLM 13-1: Quiz: “What Can You See with the Unaided Eye?”, p. 434

BLM 13-4: Height of Polaris in the Sky

BLM 13-5 Extension Activity: “Making a Star Map”

Appendices

4.1 Student Learning Activity Astrolabe Construction

4.2 Student Learning Activity Locating Celestial Objects Using a System of Coordinates

SYSTH

9.6, 9.24, 9.25 Tapping into Prior Knowledge

Prescribed Learning Outcomes

Students will...

(continued)

S1-4-01 Use a coordinate system to locate visible celestial objects, and construct an astrolabe to determine the position of these objects.

Include: altitude, azimuth.

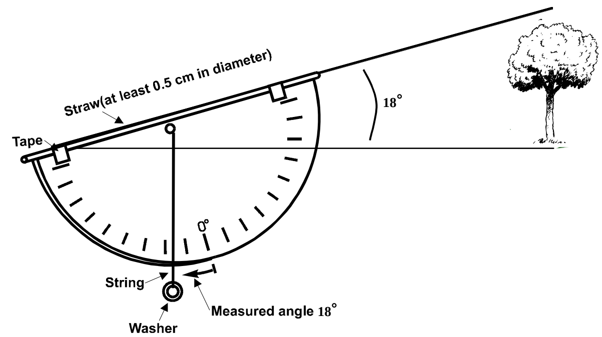
GLO: C2, C3, D6

Suggestions for Instruction

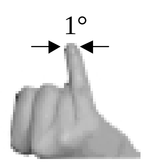
(2 hours)

➢ **Student Learning Activities (continued)**

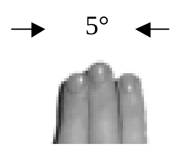
A diagram displaying the use of the student astrolabe to determine angle of elevation appears below. Model the use of an astrolabe with a celestial object like the Moon.



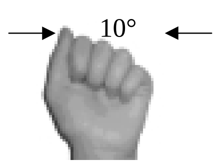
As a first approximation for measuring angles on the sky, encourage students to use a “hand-angle technique.” The diagrams presented below demonstrate how simple hand positions can be used to estimate angle measures on the sky.



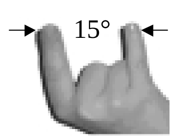
When your hand is stretched out, your small finger will measure approximately 1° of space.



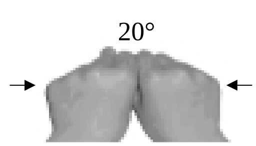
Three fingers as shown at left will measure approximately 5° when your hand is outstretched.



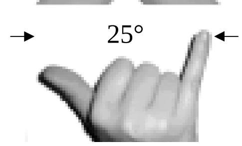
A fist as shown at left will measure approximately 10° when your hand is outstretched.



The index finger to the small finger at left will measure approximately 15° when your hand is outstretched.



Two fists will measure approximately 20° when your hand is outstretched.



The thumb to the small finger will measure approximately 25° when your hand is outstretched.

Suggestions for Assessment

Rubric for Outdoor Observation

Performance Level	Criteria
5	Student determines, with a high degree of precision and accuracy, the altitude and azimuth of at least four celestial objects visible in the night sky.
4	Student determines, with some accuracy, the altitude and azimuth of at least three celestial objects visible in the night sky.
3	Student determines, with some accuracy, the altitude and azimuth of at least two celestial objects visible in the night sky.
2	Student determines, with little accuracy, the altitude and azimuth of at least one celestial object visible in the night sky.
1	Student is not able to locate and measure any celestial objects visible in the night sky.

Suggested Learning Resources

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-4-02 Observe the motion of visible celestial objects and organize collected data.

Examples: graph sunrise and sunset data, track the position of the Moon and planets over time, maintain a log of changes in the night sky…

GLO: C2, C5, C6, D6

Skills and Attitudes Outcomes

S1-0-1b. Select and justify various methods for finding the answers to specific questions. (Math: S1: A-1) GLO: C2

S1-0-3b. Identify probable mathematical relationships between variables. *Examples: relationship between current and resistance...* GLO: C2

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise. (ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-4f. Assume the responsibilities of various roles within a group and evaluate which roles are most appropriate for given tasks. (ELA: S1: 5.2.2) GLO: C2, C4, C7

S1-0-5a. Select and use appropriate methods and tools for collecting data or information. GLO: C2; TFS: 1.3.1

S1-0-5b. Estimate and measure accurately using Système International (SI) and other standard units. Include: SI conversions. GLO: C2

S1-0-5c. Record, organize, and display data using an appropriate format. Include: labelled diagrams, graphs, multimedia (ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2

S1-0-6a. Reflect on prior knowledge and experiences to develop new understanding. (ELA: S1: 4.2.1) GLO: C2, C3, C4

S1-0-6b. Identify and suggest explanations for discrepancies in data. *Examples: sources of error...* (ELA: S1: 3.3.3) GLO: C2

S1-0-7a. Draw a conclusion that explains the results of an investigation. Include: cause and effect relationships, alternative explanations, supporting or rejecting the hypothesis or prediction. (ELA: S1: 3.3.4) GLO: C2, C5, C8

SUGGESTIONS FOR INSTRUCTION

(4 HOURS)

➢ Entry-Level Knowledge

In Grade 6, students made rough observations of planets and constellations to identify movement across the night sky. However, they did not measure the position of the objects over time.

➢ Notes for Instruction

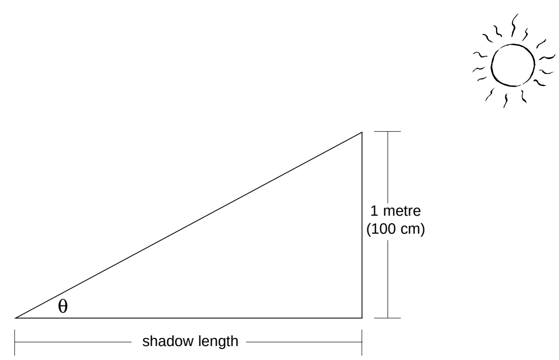
Check for prior knowledge using activities from *SYSTH*, pages 9.6, 9.24, 9.25.

This learning outcome is best accomplished with activities that relate to the recording and analysis of observations of the suggested celestial objects. Emphasize the careful observations and recording of data over time, and the plotting of data in a *graphical mode*. Hopefully, students will then take their observations and link them to the more abstract graphical representations to form a coherent explanation of the motions of celestial objects.

➢ Student Learning Activities

Laboratory Activity

Observation of the Sun's Position: Students will use indirect techniques for observing the Sun in order to collect and record data about its position in the sky. For instance, in order to determine its height above the horizon (altitude), a metre stick can be used to cast a shadow. Its length is then measured, and a simple trigonometric relation can compute the angle.



$$\text{Tangent of altitude angle} = \frac{\text{1 metre}}{\text{shadow length (m)}}, \text{ or}$$

$$\tan \theta = \frac{1}{\text{shadow length (m)}}$$

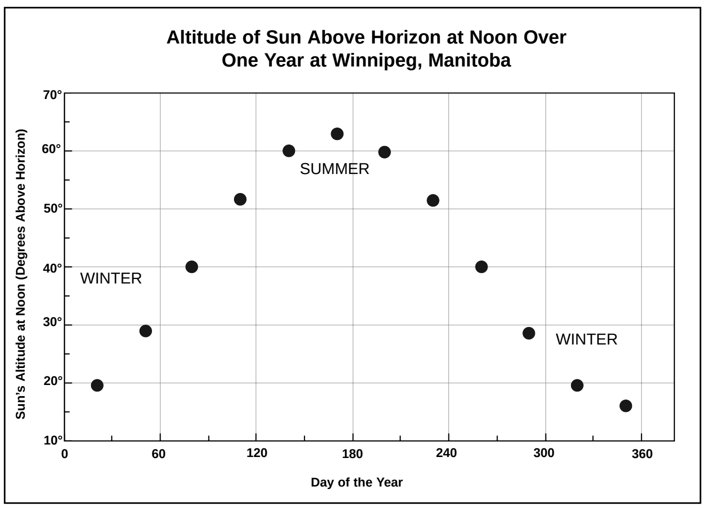
(continued)

SUGGESTIONS FOR ASSESSMENT

Rubrics/Checklists

Assess students' logbooks, data tables, and graphs using the Checklist of Graphing Skills. (See *SYSTH*, page 2.16)

Teacher Background



Sample Solar Observation Graph

The data required to produce this plot could come from the students' own astrolabe measurements (with all due safety precautions for the eyes) over the course of the year's lunch hours. The astrolabe could be held close to the ground, then oriented such that the shadow of the straw cannot be seen (alignment with the Sun). Then, the altitude of the Sun could be read carefully, and recorded in a logbook. For the interested teacher and students, it is instructive to determine the amplitude of this "wave" that you see here — it works out to exactly 23.5 degrees, which is the current axial tilt of our home planet.

SUGGESTED LEARNING RESOURCES

Science 9

Activity 13.8: Observing the Night Sky, pp. 414–15,

Activity 13.7a: Blackline Master Seasonal Star Map

Investigation 13.2:
Sunrise and Sunset (page 403), and Blackline Master 13.2: Sunrise and Sunset Times from 45 Degrees Latitude (Toronto)

Activity13.4: Recognizing Constellations, pp. 406–07

Activity 13.7: A Seasonal Star Map, pp. 412–13

Sciencepower 9

BLM 13-5: Making a Star Map

BLM 13-6: Observing Motions of the Planets

BLM 15-1: Pattern of Stars in the Sky

BLM 15-13: Finding the Andromeda Galaxy with Binoculars

SYSTH

2.16 Checklist of Graphing Skills

9.6, 9.24, 9.25 Tapping into Prior Knowledge

Other Resources

"Canadian Skies" poster available free of charge from
margaret.kennedy@nrc.ca

(continued)

PRESCRIBED LEARNING OUTCOMES

Students will...

(continued)

S1-4-02 Observe the motion of visible celestial objects and organize collected data.

Examples: graph sunrise and sunset data, track the position of the Moon and planets over time, maintain a log of changes in the night sky…

GLO: C2, C5, C6, D6

SUGGESTIONS FOR INSTRUCTION

(4 HOURS)

➢ **Student Learning Activities (continued)**

Students may also estimate using the “hand-angle” technique if proper safety precautions for the eyes are in place. Collected data can then be plotted onto a graph as outlined in Appendix 4.3.

Observation of the Moon: Students directly observe the Moon at the same time over several days or evenings. Students estimate its altitude and azimuth, record their observations (e.g., students could chart the altitude and azimuth of the Moon at the same time [say, 8 p.m. each day] over a 14-day period from New Moon to Full Moon), and then plot graphs of

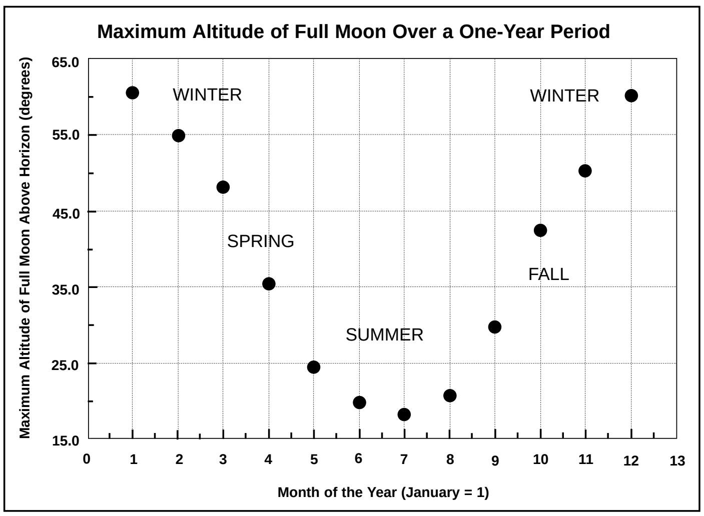
- Altitude vs. Day of Observation (see sample graph at right)
- Azimuth vs. Day of Observation
- Altitude vs. Azimuth (over the course of weeks or months)

Students then analyze their results, and predict the location of the Moon at a particular time, or whether it will be visible at all. Similar activities could be done with the planets Venus, Mars, Jupiter, and Saturn over a period of weeks or months. The number of celestial objects viewed and the degree of recording, plotting, and analysis would be determined by available time, interest, and the skill level of the class.

Students’ Extension Activity: Use a spreadsheet and a plotting program to illustrate and analyze their data.

Suggestions for Assessment

Teacher Background



Sample Lunar Observation Graph

If one were to record data on the maximum height of the Moon in the sky on a series of evenings over the course of a year, a rather interesting result would emerge. The Moon is higher in the sky during the winter in the Northern Hemisphere, and is significantly lower in the sky during the summer months. This is because of the superposition of two opposing geometries: the inclination of the Earth's axis with respect to its orbit around the Sun, and the inclination of the Moon's orbital path around the Earth with respect to the Equator. Historically, and for ancient cultures, it was fortuitous to have the Moon dominating the night sky at a time when the hours of daylight were shortened.

Ask students, "Could this unique situation have an influence on the ocean tides?" This may explain why the Swampy Cree of northern Manitoba refer to the moon as "tipiskaw pissim" or "night Sun," rather than giving it a separate planetary significance.

Suggested Learning Resources

Appendices

4.3 Student Learning Activity Observing and Charting the Motions of Celestial Objects

4.4 Student Learning Activity Motion of the Sun as Seen from Earth

Multimedia

Starry Night Backyard. planetarium software

Prescribed Learning Outcomes

Students will...

S1-4-03 Investigate how various cultures used knowledge of the position and motion of visible celestial objects for navigation.

Example: Aboriginal ceremonies linked to seasonal star positions...

GLO: A4, B1, B2, D6

Skills and Attitudes Outcomes

S1-0-1b. Select and justify various methods for finding the answers to specific questions.
(Math: S1: A-1) GLO: C2

S1-0-3b. Identify probable mathematical relationships between variables.
Examples: relationship between current and resistance...
GLO: C2

S1-0-5a. Select and use appropriate methods and tools for collecting data or information.
GLO: C2; TFS: 1.3.1

S1-0-5b. Estimate and measure accurately using Système International (SI) and other standard units.
Include: SI conversions.
GLO: C2

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

S1-0-6a. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

S1-0-6b. Identify and suggest explanations for discrepancies in data.
Examples: sources of error...
(ELA: S1: 3.3.3) GLO: C2

S1-0-7a. Draw a conclusion that explains the results of an investigation.
Include: cause and effect relationships, alternative explanations, supporting or rejecting the hypothesis or prediction.
(ELA: S1: 3.3.4) GLO: C2, C5, C8

Suggestions for Instruction
(2 hours)

➢ Entry-Level Knowledge

In Grade 6, students described how people from various cultures, past and present, applied astronomy to their daily lives.

➢ Notes for Instruction

Check for prior knowledge using activities from *SYSTH*, pages 9.6, 9.24, 9.25.

It is important for students to recognize that “navigation” is not exclusive to travel at sea. Aboriginal communities of the interior plains utilized the seasonal positions of stars and constellations in a ceremonial way. They had a sophisticated knowledge of the link between seasonal events, such as the solstices and equinoxes, and the star positions that heralded them.

Due to precession (a gyroscopic effect of the Moon’s gravitational attraction to the Earth’s tidal bulge), the Earth’s axis traces out a circle — a cycle that requires about 26,000 years. One result of this is that the North Pole star (“the star that always stands in one place,” according to the Lakota people) changes to whatever stars align with the Earth’s axis at that time. Right now, Polaris is about 0.75° away from true north; in 3,000 B.C., it was Thuban (a star in Draco), and in 14,000 A.D., it will be Vega in the constellation Lyra. For many centuries, no distinct North Pole star could be used to determine the four directions. The timing of certain sun dances has been steadily delayed as precession alters the navigation points in the sky, and knowledgeable elders know of these changes.

➢ Student Learning Activities

Student Research/Reports

Students or pairs of students investigate a culture that used visible celestial objects for navigation (e.g., Greek, Roman, Polynesian, Nordic, Inuit, Aboriginal people of North America, Chinese, etc).

The investigation should include more than one source of information, and more than one type of source (books, Internet, CD-ROMs, encyclopedias, etc.). The written report that the students produce should include a list of their sources, or bibliography (ELA: S1:3.3.2). If time allows, the students could also do a class presentation.

SUGGESTIONS FOR ASSESSMENT

Research Report/Presentation

Students or student groups research a particular culture that made use of astronomical objects for navigation. Reports can be presented as

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- multimedia presentations
- storytelling or dramatic presentation

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

Teacher, peer, or self assessment can be used.

SUGGESTED LEARNING RESOURCES

Science 9

Star Constellations, pp. 400–01

Case Study 13.6: Different Views of the Sky, pp. 410–11

BLM 13.6 Floor Plan of Stonehenge

Sciencepower 9

Teacher's Resource Binder: Assessment and Evaluation Handbook

Assessment Checklist 10: General Presentation Checklist

Assessment Checklist 20: Oral Presentation

Assessment Checklist 26: Writing in Science

What Our Ancestors Saw, pp. 430–31

BLM 13-8: Movement of the Circumpolar Stars

Appendices

5.2 Rubric for the Assessment of Class Presentations

5.3 Rubric for the Assessment of a Research Project

SYSTH

9.6, 9.24, 9.25 Tapping into Prior Knowledge

PRESCRIBED LEARNING OUTCOMES
Students will...
(continued) **S1-4-03** Investigate how various cultures used knowledge of the position and motion of visible celestial objects for navigation. *Example: Aboriginal ceremonies linked to seasonal star positions...* GLO: A4, B1, B2, D6

SUGGESTIONS FOR INSTRUCTION

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Teacher Background

Early Navigation

The need to travel from one place to another became important as ancient cultures gathered into larger groups and settled in towns. The need for food was satisfied when hunters left their settlements, hunted their food, and easily returned to their homes because they remained in familiar territory. As the need for trade with other cultures became important, travel then took people much longer distances away from their home. Overland trade was still relatively easy since the travellers used well-established routes that were easily followed.

Societies that located on the edge of water naturally used the sea as their method of transportation. Initially, boats would travel within sight of shore so that they could fish and carry on commerce with nearby groups. Familiar landmarks, such as rocks or shoals, could have been used to mark locations and routes back and forth from home base. The sea left no trail as land travel did; as a result, the landmarks would be memorized and passed on from one generation to the next. Using sighted landmarks could be dangerous for sailors if the sightings were lost or obscured by fog or sudden storms. Even with these restrictions placed upon them, sailors were able to establish trade routes to distant ports.

Some nations that were able to travel long distances include the Phoenicians and Egyptians. In addition to trade, the nations that were able to navigate successfully over water were able to conquer other countries, increasing their power and wealth.

Seafarers began to use celestial objects to help navigate their ships. They noticed different shapes of star groupings, called constellations, which they could memorize and use as indicators from which they could determine the direction they were heading. Gradually, stars and the Sun became the “landmarks” used for navigation.

Constellations, which are groups of stars, were recognized early in the history of civilization. The Phoenicians, for example, identified and named most of the constellations we know today, and they did it 4,000 years ago! The constellations were given different names by different nations, but they were usually named after gods or familiar animals. The constellations can be used as signposts, as they direct one’s view to particular parts of the sky and help identify individual stars.

The change from having to remain within land view to being able to travel across oceans had a profound impact on travel, trade, and the exchange of ideas. Suddenly, people could travel huge distances with little effort. Trade was taking place between Egypt and the island of Crete, a distance of 500 kilometres, on a regular basis around 2500 BCE. By 600 BCE, Phoenicians were importing tin from Cornwall, England. The Vikings had established routes to England, Greenland, and even North America by the 10th century. Polynesian seamen, considered the best in the world, were able to emigrate all the way from the Marquesas islands to Hawaii, a distance of 3700 kilometres, by 400 AD.

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-4-04 Compare and contrast historical perspectives on the relationship between Earth and space.

Include: geocentric model, heliocentric model.

GLO: A2, A4, B2, E2

Skills and Attitudes Outcomes

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-4f. Assume the responsibilities of various roles within a group and evaluate which roles are most appropriate for given tasks.
(ELA: S1: 5.2.2) GLO: C2, C4, C7

S1-0-7a. Draw a conclusion that explains the results of an investigation.
Include: cause and effect relationships, alternative explanations, supporting or rejecting the hypothesis or prediction.
(ELA: S1: 3.3.4) GLO: C2, C5, C8

S1-0-8c. Describe examples of how scientific knowledge has evolved in light of new evidence, and the role of technology in this evolution.
GLO: A2, A5

S1-0-8e. Discuss how peoples of various cultures have contributed to the development of science and technology.
GLO: A4, A5

SUGGESTIONS FOR INSTRUCTION

(3 HOURS)

➢ Entry-Level Knowledge

In Grade 6, students were introduced to descriptive models of how the Earth's position was explained by earlier pre-scientific and scientific cultures. Students gained a perspective of how these early models were questioned and, as a consequence, evolved over time to become the Sun-centred model of today. The terms geocentric (Earth-centred) and heliocentric (Sun-centred) will now replace the less sophisticated terms used in the Grade 6 Space cluster.

In addition, students should now have their knowledge base extended to investigations of non-western views of the Earth in the cosmos. Particular attention should be paid to North American Aboriginal, Asian, and Mesopotamian cosmologies.

➢ Notes for Instruction

Check for prior knowledge using activities from *SYSTH*, pages 9.6, 9.24, 9.25.

➢ Student Learning Activities

Student Research/Reports S1-0-4e, 4f, 7a, 8c, 8e

The Great Dialogue: Students divide themselves into two opposing world views — the "Ptolemaics" or "Aristotelians," and the "Copernicans." Each group gathers evidence to support their respective views (e.g., each group accounts for the rising and setting of the Sun, the motions of the Moon and planets over successive months, the seasons, retrograde motion of Mars, and other celestial phenomena). The two groups then debate the strengths and shortcomings of each model. (See *SYSTH*, pages 4.19, 4.20, and 4.21)

The Trial of Galileo Revisited: Students involve themselves in their own "dialogue concerning two world systems," as Galileo so aptly put it four centuries ago, by recreating the trial of Galileo under the Holy Office of the Inquisition. Students play the roles of the central characters, and consider the sociological, religious, and cosmological struggles between vested interests of the times to better understand the key concepts related to the Earth and its position relative to other objects in the solar system.

Suggestions for Assessment

Rubrics/Checklists

Rubrics and checklists can be used for self, peer, or teacher assessment. See the Suggested Learning Resources column for specific examples.

Written Quiz/Test

Students

- complete a Compare and Contrast or Concept Relationship frame comparing the Ptolemaic and Copernican models of the cosmos in terms of their advantages and disadvantages for explaining the motions of planets. (See *SYSTH*, page 10.21)
- describe situations in which one of the two competing models is more advantageous than the other in explaining certain phenomena related to planetary motions.
- prepare a Concept Map illustrating the relationship between the geocentric and heliocentric models of the solar system.

Teacher Background

The transition from a geocentric to the acceptance of a heliocentric model of the solar system is generally accepted as an example of a scientific revolution in astronomical thought, which led to a major shift in scientific world views. It is also an example of how scientific knowledge has evolved in light of new evidence, and the role of technology (telescope) in this evolution. Students should have the opportunity to experience as many facets of this revolution as possible, from the individuals involved, to their vested interests, politics, religious beliefs, and observations.

The geocentric model is often referred to as a "Ptolemaic model" in honour of the Greek philosopher, astronomer, and geographer Claudius Ptolemaeus (ca. 85–165 AD). Other geocentric schemes are attributed to Aristotle (384–322 BCE) and Tycho Brahe (d. 1601). All of these models attached themselves to a belief in "crystalline spheres" within which heavenly bodies were embedded. The elegance, functionality, and problem-solving power of the geocentric model allowed it to direct the science of astronomy for over 1500 years. Though eventually abandoned, it is important to recognize that virtually all observations from Earth are more readily acceptable to students operating within a pre-Renaissance view of the cosmos.

The heliocentric model is referred to as the Copernican model since it was first popularized by Nicholaus Copernicus (1473–1543), a Polish astronomer who is considered to be the founder of modern astronomy. It is noteworthy that the heliocentric model dates from early Greek astronomy with Aristarchus of Samos.

Suggested Learning Resources

Brief Biographies of Selected Historical Figures:

Aristotle: *Sciencepower 9*, p. 435; *Science 9*, pp. 82, 144

Ptolemy: *Sciencepower 9*, p. 436

Galileo: *Sciencepower 9*, p. 437; *Science 9*, pp. 430, 438–39

Copernicus: *Sciencepower 9*, p. 436; *Science 9*, p. 438

Sciencepower 9

13.3 Modeling Celestial Motion, pp. 435–42

Activity: Explaining Retrograde Motion in the Earth-Centred Model, p. 437

Activity: Viewing Jupiter's Moons, p. 438

Pause and Reflect, p. 439

Investigation 13-B: Explaining Retrograde Motion in the Sun-Centred Model, pp. 440–41

BLM 13-9 Motion of the Sun in the Earth-Centred Model

BLM 13-10 Seasonal Height of the Sun in the Earth-Centred Model

BLM 13-11 Angle of the Sun in the Sun-Centred Model

BLM 13-13 Path of the Earth Around the Sun

BLM 13-14 The Moon's Motion

SYSTH

4.19–4.21 Debate Guidelines

9.6, 9.24–25 Tapping into Prior Knowledge

10.24 Building a Scientific Vocabulary

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-4-05 Explain the apparent motion of the Sun, stars, planets, and the Moon as seen from Earth.

Include: daily rising and setting, seasonal constellations, retrograde motion.

GLO: D4, D6, E2

Skills and Attitudes Outcomes

S1-0-1a. Propose questions that could be tested experimentally.
(ELA: S1: 3.1.2) GLO: C2

S1-0-1b. Select and justify various methods for finding the answers to specific questions.
(Math: S1: A-1) GLO: C2

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 1.3.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.3.1, 4.3.4

S1-0-3c. Plan an investigation to answer a specific scientific question.
Include: materials, variables, controls, methods, safety considerations.
GLO: C1, C2

S1-0-5a. Select and use appropriate methods and tools for collecting data or information.
GLO: C2; TFS: 1.3.1

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2

S1-0-6a. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

S1-0-6b. Identify and suggest explanations for discrepancies in data.
Examples: sources of error...
(ELA: S1: 3.3.3) GLO: C2

S1-0-7a. Draw a conclusion that explains the results of an investigation.
Include: cause and effect relationships, alternative explanations, supporting or rejecting the hypothesis or prediction.
(ELA: S1: 3.3.4) GLO: C2, C5, C8

S1-0-8c. Describe examples of how scientific knowledge has evolved in light of new evidence, and the role of technology in this evolution.
GLO: A2, A5

SUGGESTIONS FOR INSTRUCTION
(4 HOURS)

➢ Entry-Level Knowledge

In Grade 6, students used models and/or simulations to explain the interrelationships among the Earth, Moon, and Sun with respect to phenomena that included solar and lunar eclipses, tides, the seasons, day and night cycles, and lunar phases.

➢ Notes for Instruction

Students examine more subtle motions — particularly *retrograde motions* that are observed in the planets more distant from the Sun than Earth. Additionally, students should also develop a stronger conceptual understanding of what underlies these “apparent” motions, and be prepared to observe these motions over time outdoors and with planetarium software.

Activate students’ prior knowledge/experience by asking the following questions: Have you ever noticed that a Full Moon in winter is higher in the sky than one in mid-summer? Can this be easily observed or explained?

➢ Student Learning Activities

Visual Displays S1-0-1b, 6a

Students create a “flip-motion” book that illustrates *retrograde motion*, and contains approximately 25 pages of stiff paper, securely stapled at one end with small planet diagrams on each page that appear to move like an animated filmstrip when the pages are flipped.

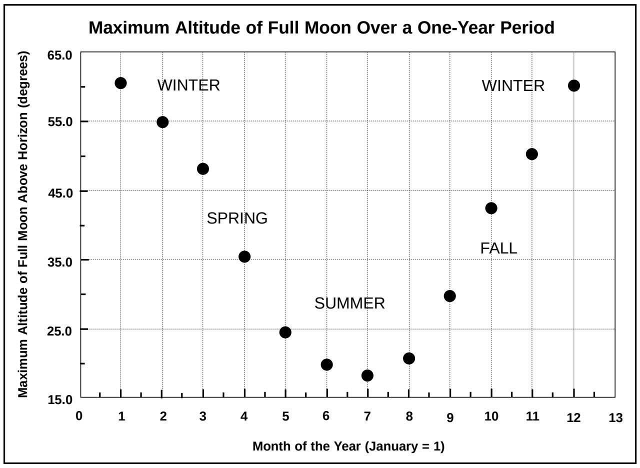
Student Research/Reports S1-0-2a, 5a, 5c, 6a, 6b, 7a

Observations of the motions of planets like Mars and Jupiter over a period of time ranging from days to weeks can illustrate retrograde motion if their positions with respect to the Earth are favourable for this. Students consult astronomy periodicals for precise locations of Mars and Jupiter. By collecting and plotting position data on a simplified seasonal star chart, students observe retrograde motion against the background of “fixed stars.” Students can also graph data manually (or with software) to see the motion more clearly. Planetarium-type software can be used to visually reinforce this phenomenon.

(continued)

Suggestions for Assessment

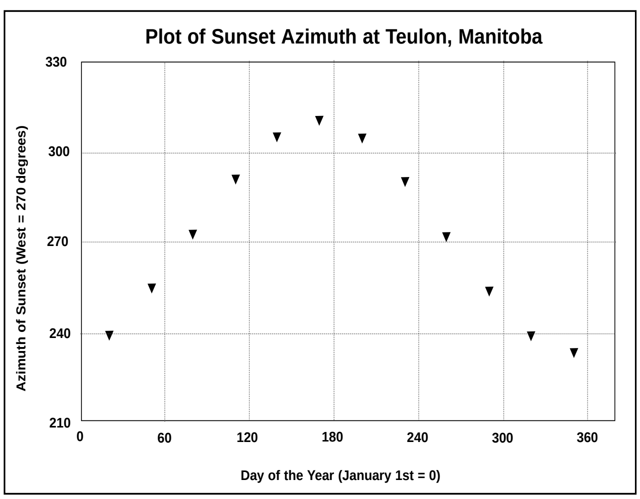
By observing and plotting the location of the Moon over a series of days, weeks, or perhaps months, students explain the Moon's motion. Teachers can refer to the graphs prepared by students earlier (See S1-4-02) or use the sample graphs in Appendix 4.7. (See below for teacher reference graph)



Students also account for the changes in motion of the Sun and answer the following questions:

- On which day(s) does the Sun rise exactly in the east and set exactly in the west? (Vernal and Autumnal Equinoxes)
- Do we attach any significance to these dates? (beginning of spring and fall).

The position of sunset over the year is not always due west. In fact, the Sun sets in the west only twice per year, and these dates can be seen where the azimuth is 270°.



(continued)

Suggested Learning Resources

Science 9

Activity 13.3 The Effects of Planetary Motion, pp. 404–05

Activity 13.4 Recognizing Constellations, pp. 406-07

Activity 13.7 A Seasonal Star Map, pp. 412–13

Sciencepower 9

BLM 13-3 Path of the Sun and Its Height above the Horizon at Noon

BLM 13-5 Making a Star Map

BLM 13-6 Observing Motions of the Planets

BLM 13-7 Positions of Mars

BLM 13-12 Hours of Daylight in Northern Canada in the Sun-Centred Model

BLM 13-13 Path of Earth Around the Sun

BLM 13-14 The Moon's Motion

BLM 13-15 Motions of Mars and Jupiter

Appendices

4.5 Student Learning Activity Monitoring the Retrograde Motion of the Planet Mars

4.7 Teacher Support Material Sample Plots of Astronomical Data for Teacher Reference, and Databases for Objects

(continued)

PRESCRIBED LEARNING OUTCOMES

Students will...

(continued)

S1-4-05 Explain the apparent motion of the Sun, stars, planets, and the Moon as seen from Earth.

Include: daily rising and setting, seasonal constellations, retrograde motion.

GLO: D4, D6, E2

SUGGESTIONS FOR INSTRUCTION
(4 HOURS)

➢ **Student Learning Activities (continued)**

Visual Displays S1-0-1a, 1b, 2c, 3c, 8c

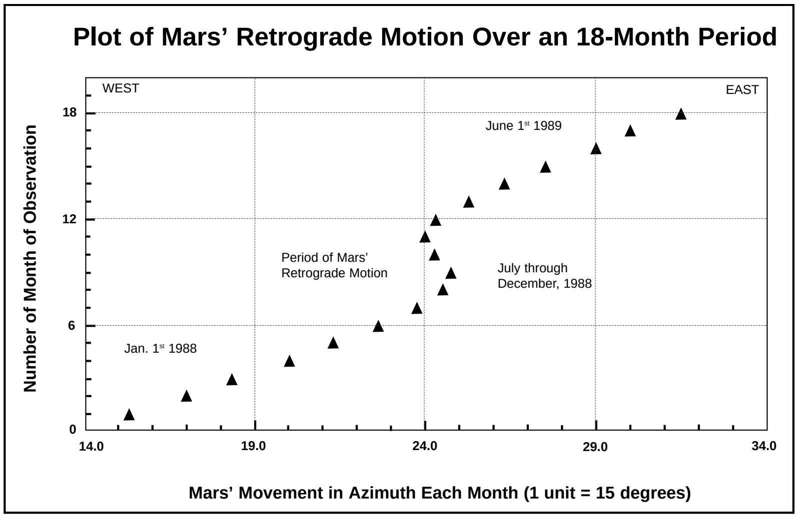
Students use an analysis of retrograde motion as the basis for developing actual working models of how both the geocentric and heliocentric systems accounted for this phenomenon (e.g., dynamic geometry software could be used in modelling these motions).

Journal Writing

Consider the following analogy for retrograde motion: Runners are in a race around an oval track. Each runner represents a planet, with some running on the inside tracks and others on the outside tracks. If all of the runners (planets) were to have the same starting positions, explain why the inner track runners would observe retrograde motion by watching their competitors in the outside lanes. Is this a good analogy for the planets in the solar system?

SUGGESTIONS FOR ASSESSMENT

Often, it is the planet Mars' retrograde motions that are observed, tracked, and plotted. After students have completed Appendix 4.5 on the retrograde motions of Mars, they can compare their plots to the one represented here.



SUGGESTED LEARNING RESOURCES

Multimedia

Starry Night: Deluxe Edition or *Skyglobe 4.0 for Windows*, available as shareware at www.maa.mhn.de.

Canadian Skies poster available free of charge from margaret.kennedy@nrc.ca

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-4-06 Differentiate between units of measure used for astronomical distances, and perform simple calculations using these units.

Include: astronomical unit, light-year.

GLO: C2, D6

Skills and Attitudes Outcomes

S1-0-5a. Select and use appropriate methods and tools for collecting data or information.
GLO: C2; TFS: 1.3.1

S1-0-5b. Estimate and measure accurately using Système International (SI) and other standard units.
Include: SI conversions.
GLO: C2

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

S1-0-6b. Identify and suggest explanations for discrepancies in data.
Examples: sources of error...
(ELA: S1: 3.3.3) GLO: C2

SUGGESTIONS FOR INSTRUCTION
(2 HOURS)

➢ **Notes for Instruction**

Observing and studying the cosmos presents a new set of problems when it comes to students appreciating the *scales* involved with measurement. The distances of even nearby celestial objects are vast — particularly at the scales of interstellar and intergalactic (between galaxies) distances. Help students appreciate the magnitude of the measurements involved, and the need for new units of measure.

Develop students' understanding that because of the vastness of space, special units are required to measure the distances between celestial objects such as stars. Historically, the distances in our solar system were the first to be estimated, followed by distances outside of our solar system. Once students have been introduced to both units (astronomical units and light-years) the Compare and Contrast frame from *SYSTH* (page 10.24) could be used.

Astronomers have developed convenient units of measure to accommodate and reduce interstellar and intergalactic distances to manageable numbers. In the solar system, for instance, the standard unit of measure is the astronomical unit (A.U.), which is the mean distance between the Sun and the Earth (approximately 1.5×10^8 km). Hence, the distances to the planets can be determined using convenient numbers that are less than 50. For example, the distance from the Sun to Jupiter is about 5.0 A.U.

Distances between the stars (interstellar) are measured using the light-year (l.y.), which is equivalent to the distance travelled by a photon of light in a vacuum (space) in the course of one solar year (365.25 days). At a velocity of 300,000 km/second, a light-year is on the order of 10 trillion kilometres (1.0×10^{13} km). To use an example, the distance from our Sun to its nearest star system (Alpha Centauri) is 4.28 light-years. This is a much more convenient measure than, say, 63,000 astronomical units or its equivalent in kilometres.

Suggestions for Assessment

Written Test/Quiz

Students answer questions such as:

- Is the term "light-year" used for interplanetary or interstellar distances?
- What would an "interstudent" distance be, and what would be the most appropriate unit of measure?
- A star is estimated by astronomers to be 570 A.U. from the Sun. Would the equivalent distance in light-years be greater or lesser than 570? Explain.
- A model of planet formation for the Solar System predicts that a planet should be at a distance of 3.0 A.U. from the Sun. What objects are found at this distance from the Sun?

Journals

Students compose at least five questions about measuring distances and space travel and send them to teachers, classmates, or a local astronomer, asking them to assess the quality of their questions and our present ability to answer the questions.

Suggested Learning Resources

Science 9

Activity 14.3 Using Triangles to Measure Distances, pp. 442–43

Activity 14.4 Distances in Space, pp. 444–45

Activity 14.5 Scaling the Universe, pp. 446–47

Sciencepower 9

BLM 15.1 Measuring Distance in the Cosmos, pp. 488–94

Investigation 15-A:
Using Triangulation to Measure an Unknown Distance, pp. 492–93

BLM 15-2 Finding Earth's Size

BLM 15-3 Measuring Distance to the Moon

BLM 15-4 Triangulation

BLM 15-5 Astronomical Distance Units

BLM 15-8 Distances in our Galaxy

BLM 15-12 Astronomical Numbers: Scientific Notation

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-4-07 Compare and contrast scientific and cultural perspectives on the origin and evolution of the universe.

GLO: A1, A2, A4, D6

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 1.3.2, 4.3.4

S1-0-2b. Evaluate the reliability, bias, and usefulness of information.
(ELA: S1: 3.2.3, 3.3.3)
GLO: C2, C4, C5, C8; TFS: 2.2.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.3.1, 4.3.4

S1-0-8c. Describe examples of how scientific knowledge has evolved in light of new evidence, and the role of technology in this evolution.
GLO: A2, A5

S1-0-8e. Discuss how peoples of various cultures have contributed to the development of science and technology.
GLO: A4, A5

S1-0-9a. Appreciate and respect that science and technology have evolved from different views held by women and men from a variety of societies and cultural backgrounds.
GLO: A4

SUGGESTIONS FOR INSTRUCTION
(1-1/2 HOURS)

➢ **Notes for Instruction**

Science is based on physical evidence and our best understanding or explanation of that evidence. Help students to appreciate how the explanation of physical evidence varies among different cultures.

➢ **Student Learning Activities**

Student Research/Reports S1-0-2a, 2b, 2c

Students or student groups research the beliefs about the origin and evolution of the universe for one of the cultures suggested.

Note: An awareness of cultural perspectives is required. It is not necessary to compare scientific theories to various cultural beliefs.

Research could take the form of receiving and summarizing the main ideas from previously selected research articles and then displaying the report as a poster, flip chart, or multimedia presentation. (See *SYSTH*, page 12.3)

Teacher Background

Two generally accepted scientific theories of the origin of our universe exist: George Lemaître's "big bang theory" and Sir Fred Hoyle's "steady-state theory." Both theories and evidence for them are discussed in the texts. However, the big bang theory seems to have gathered more followers than the steady-state theory. Although these are the two most accepted scientific views on the origin of the universe, many other beliefs exist in different cultures around the world (i.e., Greek, Roman, Polynesian, Nordic, North American Aboriginal, Chinese, etc.).

Suggestions for Assessment

Written Test/Quiz

Students

- explain the big bang theory, and suggest reasons why it is important for our understanding of the scientific explanation of the origin of the universe.
- use a Compare and Contrast frame to differentiate among pre-science, science, and emerging technologies in terms of their purpose, procedures, and impact on various cultures' understanding of the origin of the cosmos. (See *SYSTH*, page 10.24)
- complete a fact- or issue-based article analysis of a current newspaper or magazine article related to the topic of culturally based views of the universe. (See *SYSTH*, pages 11.30, 11.40–11.41)
- write a newspaper article outlining current research and findings related to the origin of the universe.

Research Report/Presentation S1-0-2a, 2b, 2c

Students or student groups investigate a contribution of a particular culture related to the origin and evolution of the universe. Reports can be presented as

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- cartoon/comic books
- newspaper articles
- Concept Overview or Compare and Contrast frames

Information can be gathered from a variety of sources. Word processing and desktop publishing software can be used for report writing.

Suggested Learning Resources

Science 9

Activity 15.3: A Model of the Expanding Universe, page 475

Activity 15.4: Evidence of an Expanding Universe, pp. 476–77

Activity 15.5: The Origin of the Universe, pp. 478–79

Sciencepower 9

A number of checklists that will be useful in the assessment of presentation activities:

Checklist 10: General Presentation Checklist

Checklist 20: Oral Presentation

Checklist 21: Poster

Checklist 26: Writing in Science

Activity 15.4: The Formation of the Universe, pp. 506–12

Investigation 15C:
Modeling the Expanding Universe (page 505) and BLM 15-1.

SYSTH

3.3 Cooperative Learning and Science

10.15, 10.24 Building a Scientific Vocabulary

11.30, 11.40 Developing Scientific Concepts Using Graphic Displays

12.3 Reading Scientific Information

Prescribed Learning Outcomes

Students will...

S1-4-08 Differentiate between the major components of the universe.

Include: planets, moons, comets and asteroids, nebulae, stars, galaxies, black holes.

GLO: D6, E1, E2

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 1.3.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.3.1, 4.3.4

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

S1-0-8c. Describe examples of how scientific knowledge has evolved in light of new evidence, and the role of technology in this evolution.
GLO: A2, A5

S1-0-8d. Describe examples of how technologies have evolved in response to changing needs and scientific advances.
GLO: A5

Suggestions for Instruction
(3 hours)

➢ Entry-Level Knowledge

In Grade 6, students focussed on our solar system and discussed the relative positions of planets, and the general physical differences between them based on their position from the Sun. Students also studied the Moon phases and eclipses.

➢ Notes for Instruction

Discussion of all the celestial objects would be time consuming. Help students to differentiate between the various objects, noting their composition, general characteristics, their relative size, and their distance from the Earth. They should have a basic understanding of what each celestial item on the list is, be able to describe its relationship to the solar system, and have a first approximation as to the size of the object and its composition.

Discuss briefly that our Sun is a star, but it may be appropriate to give students the scientific explanation of how a star forms. Most students find this very interesting and want to know how our Sun fits into a star's life cycle. It is not necessary to discuss the Hertzsprung-Russell Diagram, but some background discussions about star formation from gaseous nebulae and the typical "life cycle" of a star such as our Sun may be appropriate. Students should be made aware that there are many classes (families) of stars, but all are based on three intrinsic properties — their surface temperature, mass, and luminosity.

➢ Student Learning Activities

Student Research/Reports S1-0-2a, 2c, 5c, 7e, 8c, 8d

Students or student groups summarize the information about the various celestial objects in a chart.

Students could also show the relationships among the celestial objects using a Web Mind Map (See *SYSTH*, page 11.8), a written summary, an artistic representation, a multimedia presentation, or a flip chart summary.

Visual Displays

Students sketch the shape of our Milky Way galaxy. Beside the galaxy, they sketch our solar system and its planets (proper scale is optional), using an arrow to pinpoint the location of the solar system in the Milky Way galaxy. Students complete the sketch with other correctly placed celestial objects, such as moons, comets, asteroids, nebulae, and stars.

Vocabulary: Because of the depth and richness of the terminologies in this outcome, an organizer may be necessary. Try using Appendix 4.8: The Great Astronomical Word Explosion.

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Science 9

BLM 4-269

Sciencepower 9

13.4: Surveying the Solar System, pp. 443–56

Investigation 13-C:
Consulting the Planetary Expert: You, pp. 446–52

BLM 13-16 Planet Database

BLM 13–17 Planet Information Sheet

Activity 4.7: Survey of the Cosmos

Appendices

4.8 Student Learning Activity
The Great Astronomical Word Explosion

SYSTH

11.8 Developing Scientific Concepts Using Graphic Displays

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-4-09 Explain how various technologies have extended our ability to explore and understand space.

Examples: robotics, Canadarm, Hubble telescope, Lunar Rover, shuttle, space station, Sojourner Rover, Pathfinder, and Galileo space probes...

GLO: A5, B1, B2, D6

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 1.3.2, 4.3.4

S1-0-2b. Evaluate the reliability, bias, and usefulness of information.
(ELA: S1: 3.2.3, 3.3.3)
GLO: C2, C4, C5, C8; TFS: 2.2.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.3.1, 4.3.4

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

S1-0-8c. Describe examples of how scientific knowledge has evolved in light of new evidence, and the role of technology in this evolution.
GLO: A2, A5

S1-0-8d. Describe examples of how technologies have evolved in response to changing needs and scientific advances.
GLO: A5

S1-0-8e. Discuss how peoples of various cultures have contributed to the development of science and technology.
GLO: A4, A5

S1-0-9a. Appreciate and respect that science and technology have evolved from different views held by women and men from a variety of societies and cultural backgrounds.
GLO: A4

SUGGESTIONS FOR INSTRUCTION
(2 HOURS)

➢ Entry-Level Knowledge

In Grade 6, students focussed on human endeavours in space. Significant emphasis was placed on the technologies and spacecraft uniquely suited to habitation and research in that environment. Students examined how astronauts meet their basic needs in space, the societal impacts arising from space exploration, and the materials and technologies that emerged as a result of sending humans into space. In Senior 1, the new emphasis, however, will be the exploration via robotic, uninhabited spacecraft within the solar system.

➢ Notes for Instruction

New space probe endeavours are continuously being planned by various space agencies. Expose students to current reports of space exploration through websites, newspapers, magazines, etc. Students then use fact-based article analysis frames to analyze the information.

➢ Student Learning Activities

Collaborative Teamwork S1-0-2a, 2b, 8c, 8d

Student groups create a scrapbook of relevant newspaper and magazine articles and describe, using annotations, the connection to the learning outcome and the background knowledge needed to understand the articles.

Journal Writing S1-0-7e

Students complete a fact- or issue-based article analysis of a current newspaper or magazine article related to the topic of technologies and the exploration of space. (See *SYSTH*, pages 11.30, 11.40–11.41)

Students prepare a glossary of new words related to space exploration technologies.

Student Research S1-0-2a, 2c, 8e, 9a

Students engage in independent research of known Canadian and international contributions in this area, for instance

- the Canadarm for the Space Shuttle
- the International Space Station
- recent advances with the Hubble space telescope
- the Apollo program to the lunar surface
- the Mars Pathfinder/Sojourner Rover mission
- the Galileo mission to Jupiter and its largest moons
- the Cassini mission to Saturn and its moon Titan
- Jupiter's moon Europa and the search for new life

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Written Quiz/Test

Students

- describe the International Space Station, and suggest reasons why it is important for understanding human endeavour in space.
- use a Compare and Contrast frame to differentiate between science and technology in terms of their purpose, procedures, and products related to the acquisition of new information about the cosmos. (See *SYSTH*, pages 10.15, 10.24)
- complete a fact- or issue-based article analysis of a current newspaper or magazine article related to the topic. (See *SYSTH*, pages 11.31, 11.40)
- write a newspaper article outlining current research and findings related to the topic.

Research Report/Presentation S1-0-2a, 2b, 2c

Students or student groups investigate a particular contribution to space exploration. Reports can be presented as

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- cartoon/comic books
- newspaper articles

Information can be gathered from a variety of sources. Word processing and desktop publishing software can be used for report writing.

Journals

Assess journal entries using a Journal Evaluation form. (See *SYSTH*, page 13.21)

Suggested Learning Resources

Science 9

13.12: Probes to the Planets, p. 422

14.6: Telescopes, pp. 448–50

The Hubble Deep Field, pp. 480–81

15.7: How Astronomers Use Computers, pp. 482–83

Sciencepower 9

BLM 16-28 Terms and Acronyms

BLM 13-24 The Voyager Probes

BLM 15-11 Hubble Deep Field Photograph

BLM 16-8 The Use of Space

BLM 16-9 Placing a Satellite in Orbit

BLM 16-11 Geosynchronous Satellites

BLM 16-15 Race to the Moon

SYSTH

10.15, 10.24 Building a Scientific Vocabulary

11.30, 11.31
11.40–11.41 Developing Scientific Concepts Using Graphic Displays

13.21 Writing to Learn Science

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-4-10 Investigate ways in which Canada participates in space research and in international space programs, and then use the decision-making process to address a related issue.

Examples: International Space Station, Canadarm…

GLO: A3, A4, B2, C4

Skills and Attitudes Outcomes

S1-0-1c. Identify STSE issues which could be addressed.
GLO: C4

S1-0-1d. Identify stakeholders and initiate research related to an STSE issue.
(ELA: S1: 3.1.4, 4.4.1) GLO: C4

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 1.3.2, 4.3.4

S1-0-2b. Evaluate the reliability, bias, and usefulness of information.
(ELA: S1: 3.2.3, 3.3.3)
GLO: C2, C4, C5, C8; TFS: 2.2.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.3.1, 4.3.4

S1-0-3d. Summarize relevant data and consolidate existing arguments and positions related to an STSE issue.
(ELA: S1: 1.2.1, 3.3.1, 3.3.2) GLO: C4; TFS: 2.3.1, 4.3.4

S1-0-3e. Determine criteria for the evaluation of an STSE decision.
Examples: scientific merit; technological feasibility; social, cultural, economic, and political factors; safety; cost; sustainability...
GLO: B5, C1, C3, C4

S1-0-8d. Describe examples of how technologies have evolved in response to changing needs and scientific advances.
GLO: A5

SUGGESTIONS FOR INSTRUCTION
(3 HOURS)

➢ Entry-Level Knowledge

In K–8 Science, students experienced the design process, but may not have had any experience with formal decision-making processes.

➢ Notes for Instruction

Discuss surveillance satellites and Canada's involvement in space research, while guiding students through the decision-making process.

The Decision-Making Model, as presented in the *Senior 1 Science Framework*, outlines the steps that could be followed. Model the process at first, giving concrete examples. Remember that it is the process as much as the final decision that is important. Use the 0 Cluster (Skills Outcomes) as a guide to the Decision-Making Model.

➢ Student Learning Activities

Class Discussion S1-0-1c

Students brainstorm a list of STSE issues that could be addressed. For example:

- Should the cost of Canada's contribution to a space research program exceed the amount of money spent on health care?
- Should the cost of Canada's contribution to a space research program exceed the amount of money spent on education?
- Should humans be sent into space when the risks and costs are so extreme?
- Should space research be funded only when the research has a direct, tangible benefit to quality of life?

Note: It is important that information for the issue be readily available. Federal organizations may be able to supply some data, but some issues will depend on student opinion and may be more difficult to process.

Student Research/Reports S1-0-1d, 3d, 3e,

Students or student groups brainstorm to identify stakeholders and initiate research related to the STSE issue (e.g., ask an expert like a local MP, use the Internet to ask an expert, perform a general Internet search, etc.).

Students summarize relevant data and consolidate existing arguments and positions related to the selected STSE issue. Students may need assistance to identify two opposing points of view so that their research will have a defined focus.

Students determine which criteria will be used to evaluate the STSE decision (e.g., scientific merit; technological feasibility; social, cultural, economic, and political factors; safety; cost; etc.).

Suggestions for Assessment

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Journals

Students

- complete a Word Cycle of terms related to space exploration. (See *SYSTH*, page 10.21)
- write an essay defending their opinion of the merits of pursuing a particular mission in space, whether inhabited or robotic.
- complete a fact- or issue-based article analysis of a current newspaper or magazine about issues surrounding the human exploration of space or long-distance flights to other planets. (See *SYSTH*, pages 11.30–11.31)
- write a newspaper article outlining current research and findings related to the topic.

Assess journal entries using a Journal Evaluation form. (See *SYSTH*, page 13.21)

Research Report/Presentation

Students or student groups investigate a particular application/issue. Reports can be presented as

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- debates
- newspaper articles
- dramatic presentations
- multimedia presentations

Information can be gathered from a variety of sources. Word processing and desktop publishing software can be used for report writing. Computer-based presentations should be strongly encouraged.

Suggested Learning Resources

Science 9

14.2: Explore an Issue — Who Owns the Solar System?, pp. 440–41

16.3: Earth-Orbit Satellites, pp. 492–95

16.4: Case Study — Radarsat, p. 496

16.6: The International Space Station, pp. 498–99

Sciencepower 9

16.3: Issues in Space Exploration, pp. 536–40

Ask an Expert, pp. 550–51

Issue Analysis: Merits of Space Travel Using Astronauts, pp. 552–53

BLM 16-1 International Space Station

BLM 16-18 Issues in Space Exploration

BLM 16-24 Astronaut Biographies-Investigation 16C

Appendices

4.9 Student Learning Activity Weighing the Benefits and Risks of Space Exploration

4.10 Student Learning Activity Canadian Projects in the Space Sciences

5.6 Rubric for the Assessment of a Decision-Making Process Activity

SYSTH

10.21 Building a Scientific Vocabulary

11.30–11.31 Developing Scientific Concepts Using Graphic Displays

13.21 Journal Evaluation

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-4-11 Evaluate the impact of space science and technologies in terms of their benefits and risks to humans.

Examples: search for extraterrestrial life and habitat, remote sensing, predictions of potentially catastrophic impacts, colonization of space by only a few countries…

GLO: A3, B1, B2, B5

Skills and Attitudes Outcomes

S1-0-1c. Identify STSE issues which could be addressed.
GLO: C4

S1-0-1d. Identify stakeholders and initiate research related to an STSE issue.
(ELA: S1: 3.1.4, 4.4.1) GLO: C4

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 1.3.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.3.1, 4.3.4

S1-0-2d. Review effects of past decisions and various perspectives related to an STSE issue.
Examples: government's, public, environmentalists', and First Nations' positions.
(ELA: S1: 3.2.2) GLO: B1, C4; TFS: 1.3.2, 4.3.4

S1-0-3d. Summarize relevant data and consolidate existing arguments and positions related to an STSE issue.
(ELA: S1: 1.2.1, 3.3.1, 3.3.2) GLO: C4; TFS: 2.3.1, 4.3.4

S1-0-5a. Select and use appropriate methods and tools for collecting data or information.
GLO: C2; TFS: 1.3.1

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2

S1-0-7a. Draw a conclusion that explains the results of an investigation.
Include: cause and effect relationships, alternative explanations, supporting or rejecting the hypothesis or prediction.
(ELA: S1: 3.3.4) GLO: C2, C5, C8

SUGGESTIONS FOR INSTRUCTION
(1-1/2 HOURS)

➢ Entry-Level Knowledge

In Grade 6, students identified technological devices placed in space that helped humans learn more about the Earth.

➢ Notes for Instruction

Teachers may find students making a significant contribution to this topic. The suggested examples of space research should be examined carefully for their benefits and risks to humans and the impact of space science and technologies on society. Students should be able to describe several positive and negative aspects and thereby gain a richer understanding of the issues involved.

Extend the suggested list of examples to reflect your own experience and the experience of your class.

Consult the popular media (motion pictures, television, periodicals, and websites) for examples, as they regularly cover these topics. Students can learn important lessons that will help them sort out good science from trivial, pseudoscientific portrayals.

The Decision-Making Model, as presented in the *Senior 1 Science Framework*, outlines the steps that could be followed. At first, model the process, then act as a guide.

➢ Student Learning Activities

Journal Writing S1-0-1c, 1d, 2c, 2d, 3d, 6d, 7b, 7c, 7d

Students reflect on the pros and cons of

- searching the heavens for radio frequency signals indicative of communicating civilizations.
- the use of near-Earth space by a few industrialized nations.

Students complete a fact- or issue-based article analysis of a current newspaper or magazine article related to one of the examples given in this outcome. The risks associated with Earth-crossing comets and asteroids are often popular in the media. (See *SYSTH*, pages 11.30–11.31, 11.40)

Students compose fictitious accounts of mission to other worlds, including the type of environments encountered, atmospheric composition, geology, potential for novel life forms, etc. A RAFTS format could be used. Students are to be as scientifically credible as possible with the elements in their stories.

(continued)

Suggestions for Assessment

Research Report/Presentation

Students or student groups investigate an example of a space research technology that has been demonstrated to be potentially beneficial/harmful to the environment on Earth. Reports can be presented as

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations

Extraterrestrial Laboratory Report

Students prepare a report outlining the results from a recent probe sent to one of the moons of an outer planet (e.g., Saturn or Neptune), including an argument supporting the return to that world for further research.

Visual Display

Students or student groups prepare visual displays of the most recent events in space exploration, outlining both the successful missions and those that ended in failure. Displays may include

- posters
- diagrams
- information technology presentations
- concept maps
- models of the spacecraft involved
- technical data

Written Test/Quiz

Students answer the following questions:

- What is SETI? Describe its goals and some of the scientific/technological efforts that are involved in its mission.
- What experiments would you set up in order to test a planet's surface materials for "hostile" organisms that could contaminate the Earth's biosphere?
- What risks are posed to the Earth from what are known as "near-Earth objects?" Should we develop a space-based defense system to shield ourselves from such objects?
- Will we face the same fate as the dinosaurs from the risks of being on "spaceship Earth?" Support your answer with evidence.

Suggested Learning Resources

Science 9

Activity 16.9 Spin-offs from the Space Industry, p 506

Investigation 16.11: Experimenting in Free-Fall Conditions, p. 510

Activity 16.12 Explore an Issue — Our Future in Space, p. 511

Sciencepower 9

BLM 16-20 Viking's Tests for Life on Mars

BLM 16-21 Messages to Space

BLM 16-22 SETI: the Arecibo Message

BLM 16-23 Who Might be Picking Up Earth's Signals?

BLM 16-2 The Effect of Celestial Bodies on Earth

BLM 16-11 Geosynchronous Satellites

BLM 16-15 Race to the Moon

BLM 16-17 Space Exploration Spin-offs

BLM 16-19 Joseph Kittinger — The Man Who Fell to Earth

BLM 16-20 Viking's Tests for Life on Mars

BLM 16-27 Space Resumé

BLM 16-28 Terms and Acronyms

SYSTH

11.30–11.31

11.40 Developing Scientific Concepts Using Graphic Displays

13.23 Writing to Learn Science

(continued)

PRESCRIBED LEARNING OUTCOMES

Students will...

(continued)

S1-4-11 Evaluate the impact of space science and technologies in terms of their benefits and risks to humans.

Examples: search for extraterrestrial life and habitat, remote sensing, predictions of potentially catastrophic impacts, colonization of space by only a few countries…

GLO: A3, B1, B2, B5

Skills and Attitudes Outcomes

S1-0-3e. Determine criteria for the evaluation of an STSE decision.
Examples: scientific merit; technological feasibility; social, cultural, economic, and political factors; safety; cost; sustainability...
GLO: B5, C1, C3, C4

S1-0-3f. Formulate and develop options which could lead to an STSE decision.
GLO: C4

S1-0-4d. Use various methods for anticipating the impacts of different options.
Examples: test run, partial implementation, simulation, debate...
GLO: C4, C5, C6, C7

S1-0-5d. Evaluate, using pre-determined criteria, different STSE options leading to a possible decision.
Include: scientific merit; technological feasibility; social, cultural, economic, and political factors; safety; cost; sustainability.
(ELA: S1: 3.3.3) GLO: B5, C1, C3, C4;
TFS: 1.3.2, 3.2.3

S1-0-7b. Select the best option and determine a course of action to implement an STSE decision.
GLO: B5, C4

S1-0-7c. Implement an STSE decision and evaluate its effects.
GLO: B5, C4, C5, C8

S1-0-7d. Reflect on the process used to arrive at or to implement an STSE decision, and suggest improvements.
(ELA: S1: 5.2.4) GLO: C4, C5

SUGGESTIONS FOR INSTRUCTION

(1-1/2 HOURS)

➢ **Student Learning Activities (continued)**

Problem Solving

Students complete a learning activity based on Drake's Equation. (See Appendix 4.6)

Collaborative Teamwork S1-0-1c, 1d, 2d, 3d, 5d, 7b

Students prepare and present mock interviews with people who have been involved in research into the existence of extraterrestrial life (SETI) (e.g., Dr. Frank Drake, Director of the SETI Institute, and the late Dr. Carl Sagan).

Students hold a mock Royal Commission on the issue of Canadian involvement in the development and deployment of space-based weapons systems. Students identify the issue and stakeholders, break into groups representing the stakeholders, research the issue from their point of view, and present their briefs as public hearings. Class discussions are held after all briefs have been presented, and recommendations for a course of action are developed. The Decision-Making Model from the *Senior 1 Science Framework* could be used in this learning activity.

Class Discussion S1-0- 3e, 3f, 4d, 5d

Students debate the pros and cons of investing in the potential applications available from the development of new space-related materials, instruments, and related technologies.

SUGGESTIONS FOR ASSESSMENT

Teacher Background

The search for extraterrestrial life (SETI) is an excellent example of how serious science can be distorted and corrupted by popularized accounts. The UFO debate is just one such situation. It may be instructive for students to know that the SETI program is a well-funded attempt at scanning the heavens for transmissions that may originate from past or presently communicating intelligent lifeforms. One of the founding members of the SETI research community, Dr. Frank Drake, developed an interesting probability relationship that has become known as the Drake Equation. By entering values for certain parameters in this equation, one can determine within statistical error the number of intelligent, communicating civilizations in our galaxy.

SUGGESTED LEARNING RESOURCES

Appendices

4.6 Student Learning Activity
The Search for Extraterrestrial Intelligence — the Drake Equation

4.9 Student Learning Activity
Weighing the Benefits and Risks of Space Exploration

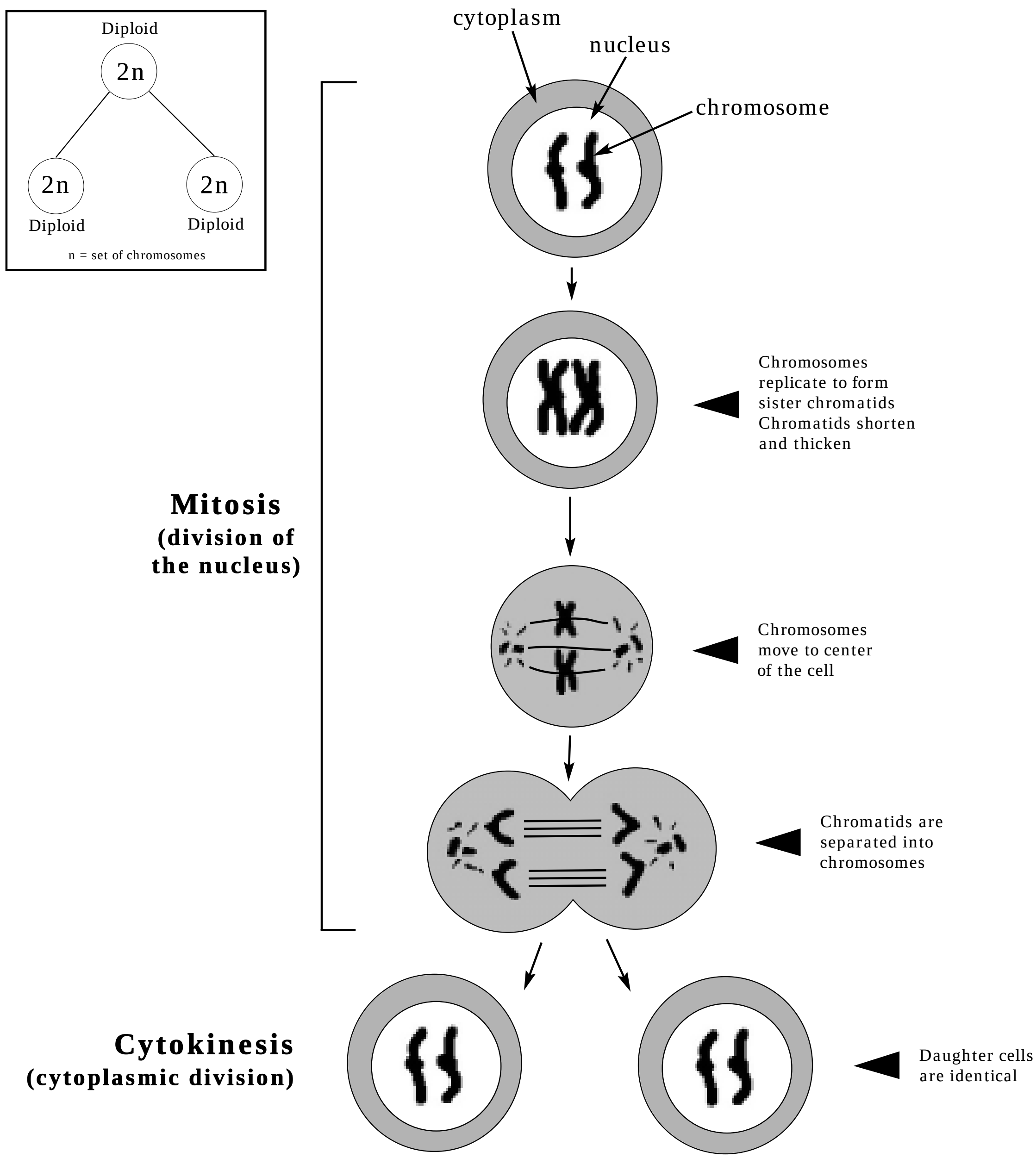
NOTES

Senior 1

Appendices:
Cluster 1
Reproduction

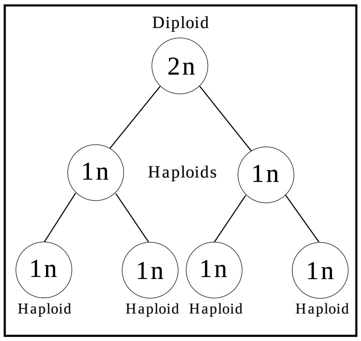
BLM
Blackline Master

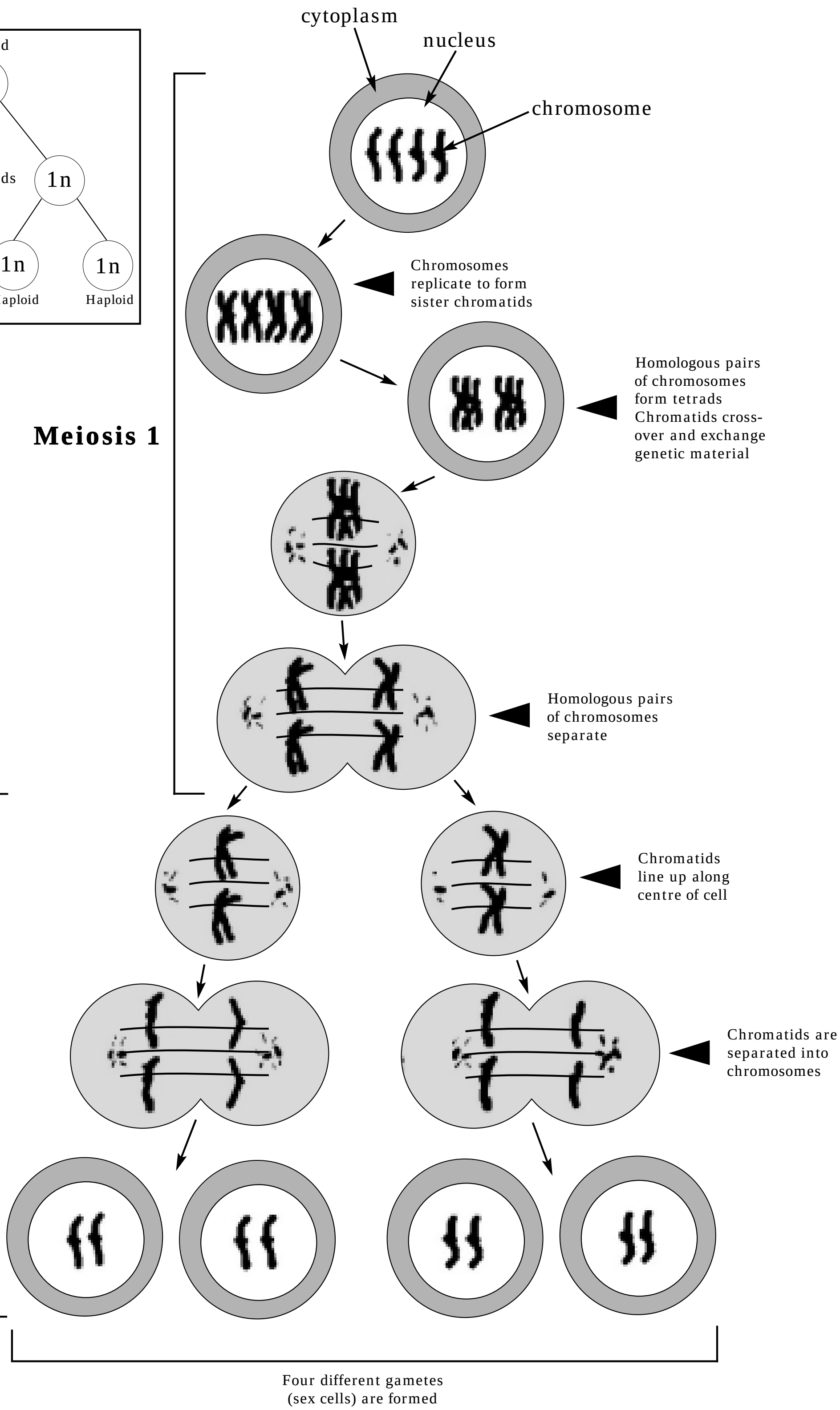
Mitotic Cell Division



BLM
Blackline Master

Meiotic Cell Division

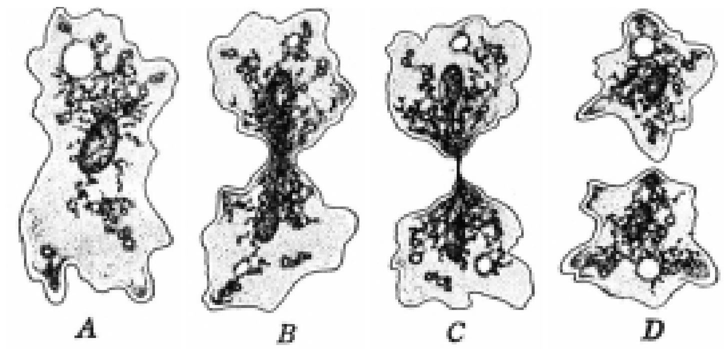




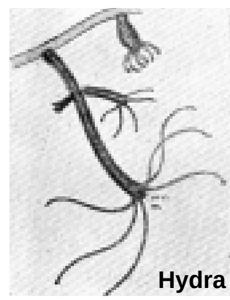
BLM Blackline Master

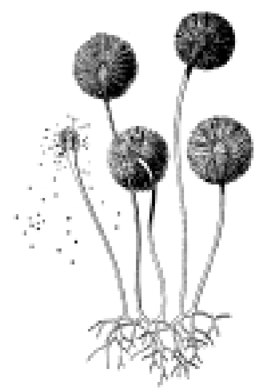
Types of Asexual Reproduction

1. **Binary fission:** This is the process by which a unicellular organism divides by mitosis into two equal halves. A parent cell becomes two genetically identical offspring cells (e.g., bacteria, algae, and protists).



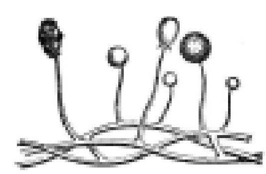
2. **Budding:** In unicellular organisms, this process is similar to binary fission, but the parent cell keeps most of the cytoplasm (yeast). In multicellular organisms, a miniature version of the organism (e.g., the bud) grows directly on the body of the adult. When it is big enough, it can detach from the parent to become an independent organism (e.g., Hydra).



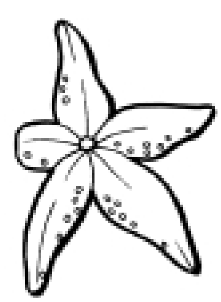


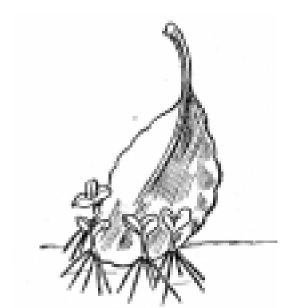
3. **Sporulation:** This is the process by which an organism produces reproductive cells (spores) by mitosis. The organism stores these cells in sporangia, which burst open to release spores that are capable of producing adult organisms (e.g., bread mould, Penicillium). Sporulation can also be a sexual type of reproduction (e.g., gametophytes).

4. **Vegetative propagation:** This is the process by which a new organism is created from the roots, stems, or leaves of plants (e.g., rhizoids in moulds, willow branches can develop roots and grow into a new tree, runners in strawberry plants can sprout roots and develop into a new plant).



5. **Regeneration:** This is the process by which a multicellular organism is divided into fragments. Each fragment becomes a new organism by regenerating the parts that are missing (e.g., flatworms, sea stars, sponges).





BLM
Blackline Master

Advantages and Disadvantages of Sexual and Asexual Reproduction

	Advantages	Disadvantages
Asexual Reproduction	• produces a new organism that is genetically identical to its parent • it is not necessary to find a partner • energy can be used to produce offspring • offspring is usually well adapted to its environment because of the success of its parent • an area favourable to the parent can quickly be colonized due to the high number of offspring the parent can generate in little time • offspring are often already multicellular and more viable	• does not give rise to genetic variability in organisms of a same species • the species does not adapt at all or adapts very slowly when circumstances change • there is only one parent to take care of offspring • the parent sometimes disappears because its body no longer exists (fission) • an asexual species runs the risk of suddenly disappearing because of a catastrophy that affects all organisms of the species that are genetically identical
Sexual Reproduction	• produces a new organism that results from a combination of traits of two parents • increases the genetic variability in organisms of the same species and even within the offspring of one couple • in the long run, allows the best adaptations to be widespread within a species, especially in changing circumstances • the variability of organisms within a species guarantees that a higher proportion will survive in perilous circumstances • two parents can watch over offspring	• finding a reproductive partner and producing gametes demands the output of a lot of energy • mechanisms for the transportation of gametes for fertilization, for the attraction of the opposite sex, and for competition within a species must be put in place • not only do you need two gametes for fertilization, one has to be male, the other female • the genetic results of meiosis, and often of fertilization, are unpredictable • genetic “errors” happen more frequently because meiosis is more complex than mitosis and diploid organisms have more chromosomes to double • offspring are not necessarily as well adapted to their environment as the parents • many organisms never become parents because they can’t find a partner; many gametes are lost, because they aren’t fertilized

BLM
Blackline Master

Human Development

Name: ____ Date: ________________

Predict the month in which the following developments will occur in a human fetus by writing the letter preceding each statement in the appropriate box. Then consult various sources to verify your predictions.

A. Weighs 500 grams

B. Measures 7 mm in length

C. Teeth are formed

D. Nervous system is formed

E. Heart is beating

F. Genitals are formed

G. All organs are well formed but are not completely developed

H. Can open eyes

I. Viable if born prematurely

J. A spermatozoon fertilizes an ovum to form a zygote

K. Comprises 64 cells

L. The cartilage of the skeleton is transformed into bone

M. Heart is developed

N. Can hiccup

O. Covered in fine hairs

P. Arms and legs move; has developed a sucking reflex

Q. Now growing quickly, and organs are rapidly starting to function

R. Full-term and the mother is now in labour

	I predict	I checked it out	Sources of Information
1st month			
2nd month			
3rd month			
4th month			
5th month			
6th month			
7th month			
8th month			
9th month			

BLM Blackline Master

Human Traits — Punnett Squares

DOMINANT	RECESSIVE
brown eye colour	blue eye colour
free earlobes	attached earlobes
cleft chin	smooth chin
tongue roller	non-roller
dimples	no dimples
freckles	no freckles
dark hair	light hair
widow's peak hairline	straight hairline
curly hair	straight hair
PTC taster	non-taster
long eyelashes	short eyelashes
	cystic fibrosis
non-red hair	red hair
normal vision	nearsightedness
normal pigmentation	albino
green or hazel eye colour	blue eye colour
bushy eyebrows	fine eyebrows
round face	square face
normal blood clotting	hemophilia (sex-linked)
almond-shaped eyes	round-shaped eyes
large ears	small ears
large nose	small nose
large eyes	small eyes
normal vision	red-green colour blindness (sex-linked)
Huntington disease	
Rh+ blood	Rh– blood

Single Trait Inheritance Problems

Complete the following problems using Punnett squares. Give the genotype, phenotype, percentage, and ratio (if applicable) of the offspring from each cross.

1. In pea plants, yellow seeds are dominant over green seeds. If a purebred yellow seed plant and a green seed plant are crossed, predict what the offspring will be like. (Practice Question — see Process Notes for sample solution.)
2. Cross two hybrid yellow seed plants.
3. Cross a hybrid yellow seed plant with a green seed plant.
4. In pea plants, smooth seeds are dominant over wrinkled seeds. Predict the offspring resulting from the cross of a hybrid smooth seed plant with a purebred smooth seed plant.
5. Cross a wrinkled seed plant with a hybrid smooth seed plant.
6. Cross two wrinkled seed plants.

Process Notes for Punnett Squares

Sample solution for practice question 1:

<table>
<tr><th>Questions</th><th>Solutions</th></tr>
<tr><td>a) Which trait is dominant?</td><td>a) yellow = dominant
b) green = recessive</td></tr>
<tr><td>b) Assign letters to traits.</td><td>b) yellow = Y
green = y</td></tr>
<tr><td>c) Decide on letter combinations, (e.g., pure/hybrid).</td><td>c) YY and yy</td></tr>
<tr><td>d) Write parental genotype around square.</td><td>d)
<table>
<tr><td></td><td>Y</td><td>Y</td></tr>
<tr><td>y</td><td></td><td></td></tr>
<tr><td>y</td><td></td><td></td></tr>
</table></td></tr>
<tr><td>e) Determine possible offspring (complete square).</td><td>e)
<table>
<tr><td></td><td>Y</td><td>Y</td></tr>
<tr><td>y</td><td>Yy</td><td>Yy</td></tr>
<tr><td>y</td><td>Yy</td><td>Yy</td></tr>
</table></td></tr>
<tr><td>f) Determine offspring genotypes (letters).</td><td>f) geno = Yy (100%)</td></tr>
<tr><td>g) Determine offspring phenotypes (looks).</td><td>g) pheno = yellow (100%)</td></tr>
<tr><td>h) Record percentage of phenotypes in offspring (yellow versus green).</td><td>h) see f & g above</td></tr>
</table>

*Upper and lower case letters must look different.

SLA
Student Learning Activity

Genetics — Punnett Squares

Solve problems using the dominant and recessive human traits listed in Appendix 1.6.

Procedure:

1. Create a word problem using the word problem frame below as a guide.
2. Provide a written answer key on a separate sheet of paper. The key must include the genotype, phenotype, percentages, and ratio (if applicable).
3. Include the following crosses:
   - purebred dominant x purebred dominant
   - purebred dominant x recessive
   - recessive x recessive
   - recessive x hybrid
   - purebred dominant x hybrid
   - hybrid x hybrid
4. Have your work checked and signed by another student.
5. Write one of your problems on an overhead and present it to the class.

Word Problem Frame:

In humans, *brown eyes* are dominant over *blue/grey eyes*. What offspring would result from a cross between a *pure dominant* individual and a *pure recessive* individual?

Note: The words in italics will vary with the trait selected. Replace the information in italics to suit the trait being studied.

SLA
Student Learning Activity

Vocabulary Review on Genes

Name: ____ Date: ________________

In the following statements, G represents the dominant gene for curly hair and g represents the recessive gene for straight hair.

Part A

Check the answer that correctly completes each statement. Make sure you can explain your answer.

If an ovule G and a sperm cell G unite:

1. the genotype of the resulting zygote will be:

   ❒ GG ❒ gg ❒ Gg

2. the zygote will be:

   ❒ heterozygous ❒ homozygous

3. the resulting human will have the following phenotype:

   ❒ curly hair ❒ straight hair ❒ part curly, part straight hair

4. the resulting human will be able to produce the following gametes:

   ❒ G ❒ g ❒ G or g

If an ovule g and a sperm cell g unite:

5. the genotype of the resulting zygote will be:

   ❒ GG ❒ gg ❒ Gg

6. the zygote will be:

   ❒ heterozygous ❒ homozygous

7. the resulting human will have the following phenotype:

   ❒ curly hair ❒ straight hair ❒ part curly, part straight hair

8. the resulting human will be able to produce the following gametes:

   ❒ G ❒ g ❒ G or g

If an ovule G and a sperm cell g unite:

9. the genotype of the resulting zygote will be:

   ❒ GG ❒ gg ❒ Gg

10. the zygote will be:

   ❒ heterozygous ❒ homozygous

11. the resulting human will have the following phenotype:

    ❒ curly hair ❒ straight hair ❒ part curly, part straight hair

12. the resulting human will be able to produce the following gametes:

    ❒ G ❒ g ❒ G or g

If an ovule g and a sperm cell G unite:

13. the genotype of the resulting zygote will be:

    ❒ GG ❒ gg ❒ Gg

14. the zygote will be:

    ❒ heterozygous ❒ homozygous

15. the resulting human will have the following phenotype:

    ❒ curly hair ❒ straight hair ❒ part curly, part straight hair

16. the resulting human will be able to produce the following gametes:

    ❒ G ❒ g ❒ G or g

Part B

State your answer to the following questions in the form of a fraction or as a percentage.

17. If a father (GG) and a mother (gg) have children, what will be the expected proportions of the following genotypes?

    GG ______ gg ______ Gg ______

18. If a father (gg) and a mother (Gg) have children, what will be the expected proportions of the following genotypes?

    GG ______ gg ______ Gg ______

19. If a father (Gg) and a mother (GG) have children, what will be the expected proportions of the following genotypes?

    GG ______ gg ______ Gg ______

20. If a father (Gg) and a mother (Gg) have children, what will be the expected proportions of the following genotypes?

    GG ______ gg ______ Gg ______

SLA Student Learning Activity

It Runs in the Family

Introduction:

Many human traits are controlled by a single pair of genes, which may have contrasting forms — dominant and recessive. Dominant genes are identified with a capital letter, while the contrasting recessive form uses the lower case version of the same letter. Examples of single inheritance traits include the ability to roll one's tongue, the shape of the hairline, and earlobe attachment.

The term phenotype refers to an individual's physical appearance, while genotype refers to his or her genetic makeup. It is not always possible to determine a person's genotype from observing his or her phenotype. A pedigree is a diagram that shows how the phenotype of a genetic trait appears in a family from one generation to the next.

Purpose:

To collect family data of single inheritance traits and to construct a pedigree.

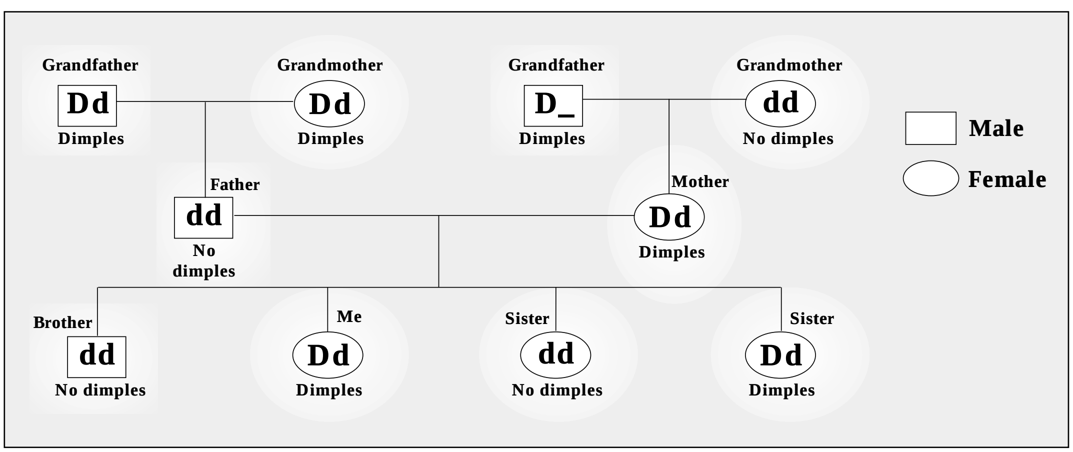
Procedure:

1. Examine the sample data table on the following page, and construct a similar table that will accommodate the members of your family.
   Note: "Family" in this instance, means any of the people living in your home or with whom you are in close contact, regardless of whether this includes your biological parents. The titles at the top of the Data Table can be changed to reflect your home situation.

2. Record your family's characteristics in your data table.

3. Construct a pedigree to represent one of the traits studied. Use different phenotypes and genotypes (e.g., dimples/no dimples, DD, Dd, dd) for each trait. The pedigree must be neat and must contain a legend of the trait studied and a title (your family name). Pedigrees can be adapted to reflect the makeup of your family situation if desired.

Sample Pedigree: The Simpsons



Data Table: The "Sample" Family

	Trait	Description				You	Mother	Father	Brother	Sister	Maternal Grandparents GF	GM	Paternal Grandparents GF	GM
1	Dimples	Yes		No										
2	Freckles	Yes		No										
3	Allergies	Yes		No										
4	Hair Whorl	Clockwise		Counter CW										
5	P.T.C.	Taste		No taste										
6	Earlobes	Attached		Free										
7	Sight	Near sighted		Normal										
8	Thumb	Not bent		Bent										
9	Tongue	Roller		Non-roller										
10	Eye colour	Blue		Not blue										

SLA
Student Learning Activity

Making Sense of Sex-Linked Traits

Background Information:

Sex-linked traits are carried on the X-chromosome. A sex-linked trait is a recessive trait that shows up more often in men than in women.

Hemophilia is an inherited disease of the blood. Affected persons do not have the ability to form blood clots. The letter H represents the dominant, normal gene. The recessive gene is represented by the letter h. Is hemophilia sex-linked or not sex-linked?

How do we know if a disease is sex-linked or not?

If a trait is sex-linked, the gene is located on the X-chromosome. If the trait is NOT sex-linked, the gene is located on a chromosomal pair other than the sex chromosomes.

Purpose:

To determine the probability that an inherited disease is sex-linked or NOT sex-linked.

Materials:

- masking tape
- two pennies
- two nickels
- pen

Part 1: Trait is sex-linked

Genes for sex-linked traits are located on the X-chromosome. A heterozygous female ($X^H X^h$) has a 50/50 chance that her egg cells will receive either an X^H or an X^h during meiosis. Normal males have the genotype X^HY. The chances that their sperm cells will receive either X^H or Y during meiosis are 50/50. You can determine the offspring of the cross between a heterozygous female and a normal male by coin tossing.

- put tape on both sides of two pennies
- mark one penny as the heterozygous female (i.e., mark one side of the penny X^H and the other side of the penny X^h)
- mark the second penny as the normal male (i.e., mark one side of the penny X^H and the other side of the penny Y)
- toss both pennies together 50 times. Record the combination that results after each toss in the chart below
- total the results of each genotype and record the totals in the table

Results if the Trait is Sex-Linked

Offspring Phenotype	Offspring Genotype	Result of Each Toss	Totals
Normal female	X^HX^H or X^HX^h		
Female with hemophilia	X^hX^h		
Normal male	X^HY		
Male with hemophilia	X^hY		

Part 2: Trait is not sex-linked

If the trait is not sex-linked, the genes for hemophilia are not located on the sex chromosomes. This means that there are two sets of chromosomes involved — one set for determining the sex of the offspring and another set that determines if the offspring will have hemophilia or not.

Four coins are needed to represent the two pairs of chromosomes.

The following cross will be made XXHh x XYHh.

Results if the Trait is Not Sex-Linked

Offspring Phenotype	Offspring Genotype	Result of Each Toss	Totals Observed
Normal female	X^HX^H or X^HX^h		
Female with hemophilia	X^hX^h		
Normal male	X^HY^H or X^HY^h		
Male with hemophilia	X^hY^h		

Questions for Understanding:

(Use the information from your tosses to answer the questions below.)

1. If a trait is sex-linked, how many genes must a male have to inherit the trait? __________,
   How many genes must a female have? _____________
2. If a trait is not sex-linked, how many genes must a male have to inherit the trait? __________,
   How many genes must a female have? _____________
3. If the father is normal and the mother is heterozygous, how many normal female children were observed when the trait was considered to be sex-linked? _______________
4. If both parents were heterozygous, how many normal female children were observed if the trait was not considered to be sex-linked? _________________

5. If both parents were heterozygous, how many diseased female children were observed if the trait was not considered to be sex-linked? ________________

6. If the mother was heterozygous and the father was normal, how many diseased female children were observed if the trait is considered to be sex-linked? _______________

7. Which inheritance pattern results in no diseased females? ________________

8. If the father is normal and the mother is heterozygous, how many normal male children were observed when the trait was considered to be sex-linked? ______________

9. If both parents were heterozygous, how many normal male children were observed if the trait was not considered to be sex-linked? _______________

10. If both parents were heterozygous, how many diseased male children were observed if the trait was not considered to be sex-linked? ________________

11. If the mother was heterozygous and the father was normal, how many diseased male children were observed if the trait is considered to be sex-linked? _______________

12. Which inheritance pattern provides equal numbers of normal and diseased male children? ___________________

13. Write a short paragraph that explains how sex-linked traits are different from other inherited traits. Be sure to include such words as genotype, phenotype, dominant, recessive, and carrier.

SLA
Student Learning Activity

Mutations

Name: ____ Date: ________________

Included below are various imaginary scenarios about accidental mutations. Think about the possible consequences of each situation.

Scenario 1

Manon regularly visits tanning salons. She does not realize that an ultraviolet ray has caused a mutation in one of the cells of her big toe. The modified gene produces green skin with big white polka-dots.

- Is Manon in danger?
- Will she have problems?
- If she gives birth to a baby in a few months, will her child have a green toe? Explain.

Scenario 2

Patrick liked to sunbathe at his cottage. Unfortunately, he was unaware of the fact that the Sun's rays irradiated one of the chromosomes in the germinal cells of his testicles (the cells that produce sperm). This resulted in a mutation that caused his son to have a nose with three nostrils. Also, the water in which he liked to swim contained a mutagenic pesticide that changed the cells in his lungs, causing Patrick to develop asthma. Five years later, Patrick wonders if his children will also be sick.

- Will Patrick's children also be asthmatic?
- What kind of problems do his children risk having? Why? Why won't all his children develop problems?
- Can Patrick prevent having children with three nostrils? How could this mutation be an advantage to his children?

Scenario 3

Rebecca has been pregnant for three months. Her fetus's cells have begun to differentiate and its brain is in full development. Rebecca eats too much meat that contains preservatives. These preservatives circulate in her bloodstream, causing a mutation of nervous cells that provide both with an extraordinary musical talent. Thirty years later, Rebecca's child, Peter, is internationally renowned, is married, and has many children.

- Will Peter's children become musically talented as well? Explain.
- Will his children necessarily have little musical talent? Explain.
- Is there a way to produce offspring who would have Peter's musical mutation?

Scenario 4

Freddy the frog is lazy and always hungry. His diet has many deficiencies, so much so that he is lacking ingredients for the proper mitosis of his germinal cells. Freddy does not realize that one of his sperm cells contains a gene that produces wings, and that he has fertilized an ovule that also contains a bizarre mutation that produces antennas.

- Will the flying frog with antennas also be lazy?
- Will the frog be able to feed more easily than Freddy?
- Will Freddy produce more flying frogs with antennas?

Scenario 5

Yok and Yik come from the same zygote. They are twins who are experiencing the effects of a drug taken by their mother during an emergency operation while she was pregnant. In Yok's body, the drug caused a mutation in her gland cells, which provoked an overproduction of growth hormones. In Yik's body, the same gene is subjected to this mutation, but only in the ovules she already has.

- Are Yik and Yok identical twins?
- At birth, Yok is twice as heavy as Yik. Why?
- Will Yok's children be bigger than Yik's? Explain.

SLA Student Learning Activity

Biotechnology Organizer

Name: ____ Date: ________________

Complete the following table, based on your own knowledge. You will be able to fill in a second one later, after the class has shared answers and you have done some research on biotechnology.

	Genetic Engineering	Genetic Screening	Cloning	Genetic Fingerprinting
What is it?				
In which circumstances is this type of biotechnology used?				
What are actual or eventual repercussions of this type of biotechnology?				

Senior 1

Appendices:
Cluster 2
Atoms and Elements

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Vocabulary

Atomic Structure	Periodic Table	Elements and Compounds	Properties and Changes of Matter
· Particle Theory of Matter · Dalton's Atomic Theory · Greek Philosophers · Alchemist · Atom · Element · Element Symbol · Nucleus · Subatomic Particles [electron, proton, neutron] · Electron Shells · Electron Cloud · Bohr's Model · Bohr Atomic Model Diagrams · Thomson's Model · Rutherford's Model · Dalton's Model · Quantum Model · Atomic Mass · Atomic Number · Standard Atomic Notation · Atomic Mass Unit (A.M.U.)	· Periodic Table · Period · Group · Chemical Family · Electron Shell · Mendeleev · Moseley · Periodic Law · Alkali Metals · Alkaline Earth Metals · Halogens · Chalcogens · Noble Gases · Valence Electrons · Metals · Nonmetals · Metalloids · Ductile · Malleable · WHMIS · MSDS · Reactivity · Metallurgy	· Pure Substance · Mixture · Atom · Element · Compound · Molecule · Stable Octet · Chemical Formulas · Electrolysis	· Physical Change · Chemical Change · Physical Property · Chemical Property · Precipitate · Combustion · Oxidation · Corrosion

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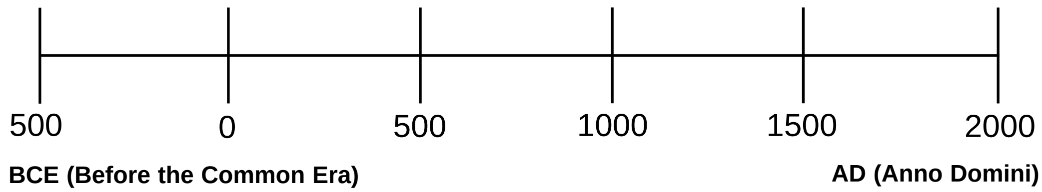
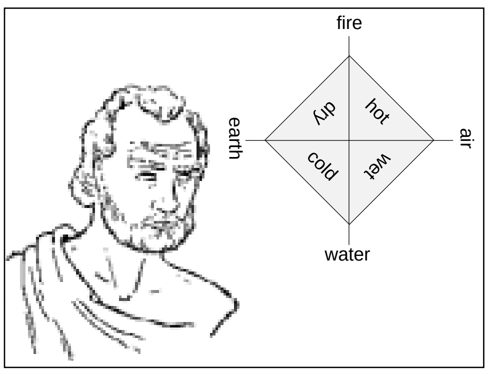
Historical Ideas About the Nature of Matter



Ancient Greek Philosophers:

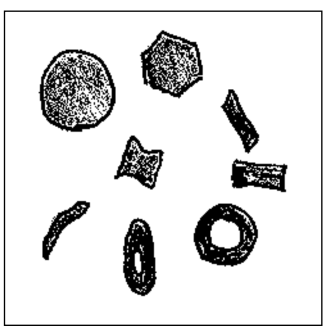
- The ancient Greek philosophers wondered why matter behaves as it does and manipulated ideas in their minds but did almost no experimentation.

Empedocles



- 450 BCE
- Empedocles proposed that matter was composed of four elements: Earth, Water, Air, Fire.

Democritus



- 400 BCE
- Democritus suggested matter was made of tiny particles that could not be broken down further. He called these particles “atomos,” which means indivisible.

Aristotle

- 350 BCE
- After the death of Democritus, Aristotle and Socrates rejected the atomic model and adopted Empedocles’ “four element” model. This model influenced and dominated scientific thinking for almost 2000 years.

Alchemists

- 500–1600 AD
- The alchemists were the first people to perform hands-on experimentation. They were part philosopher, mystic, magician, and chemist.
- They had three main beliefs:
  - i. They believed that some elements could be changed into others. They attempted to change base metals (lead, tin) into valuable ones like gold, but in the process discovered new elements as well as many facts about existing materials.
  - ii. They believed they could find a substance that would give them eternal life.
  - iii. They believed they could produce a universal solvent that would dissolve all substances.

Modern Chemists:

- 1600–Present
- These chemists used the scientific method to investigate the physical world. This began in the 17th and 18th centuries where the focus was on determining the properties of pure substances and attempting to explain their composition.

Sir Francis Bacon (1600s)

- Bacon was one of the first scientists to develop new knowledge as a result of experimentation.

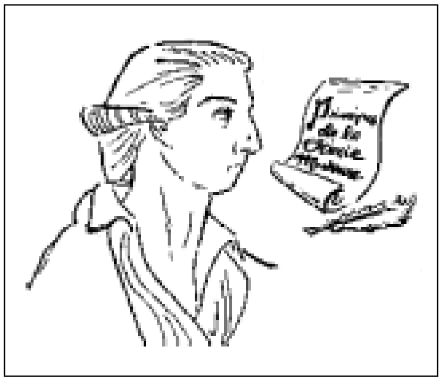
Robert Boyle (1650)

- Boyle believed that the Greek philosophers' "four element" theory could be improved upon. He published "The Skeptical Chemist" in which he defined an element as "certain simple unmingled bodies…." Boyle also helped lay the foundation for the concepts of elements and compounds. He recognized that elements could be combined to form compounds. Boyle also believed that air was not an element but a mixture.

Joseph Priestly (late 1700s)

- Priestly was the first person to isolate oxygen scientifically, but did not know that oxygen was an element.

Antoine de Lavoisier (late 1700s)



- Lavoisier defined the term “element” as a pure substance that cannot be chemically broken down into simpler substances.
- He discovered and identified 23 elements. He based his investigations on careful measurement and observations.
- He recognized mixtures exist and identified air as a mixture of oxygen and some other gas. (Air is at least two gases: one that does not burn and one that does).

Henry Cavendish (late 1700s)

- Cavendish experimented by mixing metal with acid, which produced a flammable gas (hydrogen). He discovered that his gas would burn in oxygen and produce water. Until that time, water was thought to be an element.

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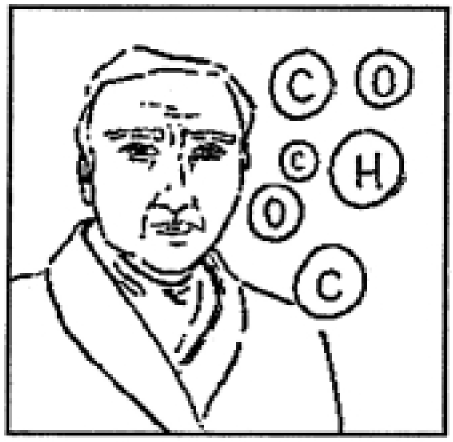
Models of Atomic Structure

Dalton's Model of the Atom (early 1800s):



The model that resulted from Dalton's theory is referred to as a "billiard ball" model.

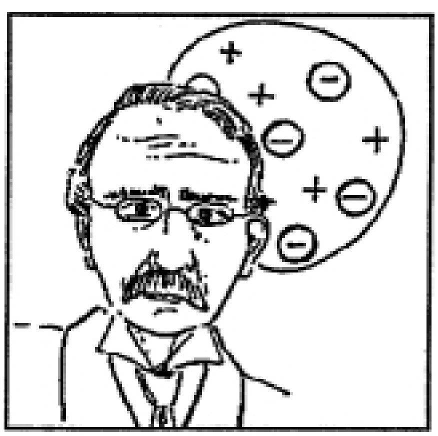
Dalton proposed the following:

- The atom is a solid, indivisible, indestructible sphere.
- The atom contains no subatomic particles.

Dalton's Atomic Theory:

1. All elements are composed of atoms. Atoms are indivisible and indestructible particles.
2. Atoms of the same element are exactly alike. They all have the same mass and chemically behave the same way.
3. Each element is characterized by the mass of its atoms. Different elements have atoms that differ in mass and chemical properties from the atoms of every other element. Atoms of different elements are different.
4. The joining of atoms of two or more elements forms compounds.
5. Atoms are neither created nor destroyed in a chemical change.

Thomson's Model of the Atom (1904):



The model that resulted from Thomson's theory is referred to as the "raisin bun" or "plum pudding" model.

Thomson's experiments with a Crook's tube, while he was studying the passage of an electric current through a gas, led to his discovery of very light negative particles called electrons. This disproved Dalton's theory that the atom was indivisible.

Thomson's further experiments with gas discharge tubes led to the discovery of much heavier positive particles, later identified as protons.

Thomson proposed the following:

- Electrons have a small mass and a negative charge.
- An atom is a sphere of positive electricity.
- Negative electrons are embedded in the positive sphere, so that the resulting atom is neutral or uncharged.

Rutherford's Model of the Atom (1911):

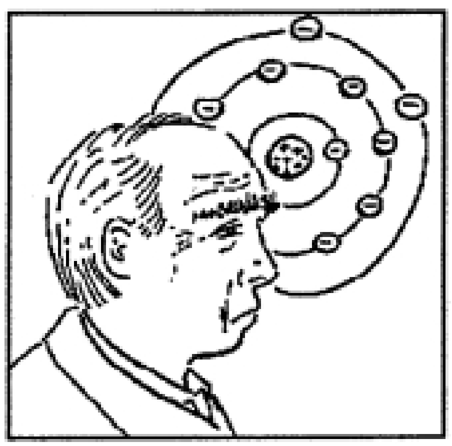
The model that resulted from Rutherford's theory is referred to as the "nuclear" model.

Rutherford attempted to test Thomson's model with radioactivity in an experiment using gold foil and a type of radiation called alpha particles. He discovered the existence of a dense, positively charged core in the atom called the nucleus.

Rutherford proposed the following:

- The nucleus is a very tiny, dense, and positively charged core of an atom.
- All of the atom's positively charged particles, called protons, are contained in the nucleus.
- The nucleus is surrounded by mostly empty space.
- Rapidly moving, negatively charged electrons are scattered outside the nucleus around the atom's edge in what is referred to as an electron cloud.

Bohr's Model of the Atom (1913):



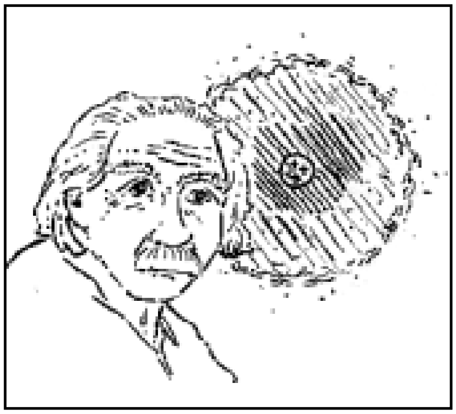
The model that resulted from Bohr's theory is referred to as the "planetary" model.

Bohr proposed an improvement on Rutherford's model by placing electrons in specific orbits about the nucleus.

Bohr proposed the following:

- Electrons move around the nucleus in nearly circular paths called orbits, much like how the planets circle the Sun.
- Each electron in an orbit has a definite amount of energy. Electrons can move within these energy levels without loss of energy.
- The further the electron is from the nucleus, the greater its energy.
- Electrons cannot exist between these orbits, but can move up or down from one orbit to another if excited by heat, light, or electrical energy.
- Each orbit or energy level is located at a certain distance from the nucleus.
- Electrons are more stable when they are at lower energy levels, closer to the nucleus.
- The order of filling the first three orbits with electrons is 2, 8, and 8.

Quantum Model of the Atom:



The model that resulted from several discoveries in the field of physics by various scientists is referred to as the "wave" model.

Bohr's model worked well in explaining the behaviour of simple atoms, such as hydrogen, that contained few electrons, but it did not explain the more complex atoms.

The discovery that particles sometimes exhibit wave properties, called the wave-particle duality, has led to the currently accepted theory of atomic structure called quantum mechanics.

The Quantum model proposed the following:

- According to the theory of wave mechanics, electrons do not move about the atom's nucleus in a definite path like planets around the Sun.
- It is impossible to determine the exact location of an electron.
- The probable location of an electron is based on its energy.
- Energy levels are divided into four sublevels, and each sublevel is made up of several pairs of electrons called orbitals.
- The quantum model of the atom shows how electrons move randomly in electron clouds called orbitals.

SLA
Student Learning Activity

Chemical Symbol Bingo

Arrange element symbols randomly on the bingo card. Any element symbol shown below can be used only once.

H	**He**	**Li**	**Be**	**B**	**C**	**N**	**O**
F	**Ne**	**Na**	**Mg**	**Al**	**Si**	**P**	**S**
Cl	**Ar**	**K**	**Ca**	**Fe**	**Ni**	**Cu**	**Zn**
I	**Ag**	**Sn**	**Au**	**W**	**Hg**	**Pb**	**U**

B	I	N	G	O

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Chemical Symbol Bingo (Teacher Support)

Call out the name for the elements and ask students to locate the symbol on the bingo card. Bingo cards can be designed by randomly placing elements in open squares. When a row of element symbols is covered, "bingo" is called and a student wins.

H	**He**	**Li**	**Be**	**B**	**C**	**N**	**O**
F	**Ne**	**Na**	**Mg**	**Al**	**Si**	**P**	**S**
Cl	**Ar**	**K**	**Ca**	**Fe**	**Ni**	**Cu**	**Zn**
I	**Ag**	**Sn**	**Au**	**W**	**Hg**	**Pb**	**U**

B	I	N	G	O
He	Cu	P	Si	K
B	Cl	Au	U	F
Ar	C	Ca	Be	W
Mg	I	Ne	Zn	Sn
H	S	Hg	N	Fe

SLA
Student Learning Activity

Determining the Number of Atomic Particles

1. Each row in the table represents a different element. Use the information provided to fill in the required information for that element.

Number of protons in the atom	Number of electrons in the atom	Number of neutrons in the atom	Atomic mass of the atom	Atomic number of the atom	Element name	Chemical symbol
7	7					
5	5	6				
1	1	0				
						Ca
30		35				
	13		27	13		
9			19			
	23	28			Vanadium	V
	17		35	17		
	3					Li
	79					Au
	11		23	11		
	33			33		
					tin	
	19					K

2. Create a similar exercise to the one above and exchange with one of your classmates.

Protons	Electrons	Neutrons	Atomic mass	Atomic number	Element name	Chemical symbol

TSM
Teacher Support Material

Determining the Number of Atomic Particles (Teacher Version with Answers)

1. Each row in the table represents a different element. Use the information provided to fill in the required information for that element.

Number of protons in the atom	Number of electrons in the atom	Number of neutrons in the atom	Atomic mass of the atom	Atomic number of the atom	Element name	Chemical symbol
7	7	7	14	7	Nitrogen	N
5	5	6	11	5	Boron	B
1	1	0	1	1	Hydrogen	H
20	20	20	40	20	Calcium	Ca
30	30	35	65	30	Zinc	Zn
13	13	14	27	13	Aluminum	Al
9	9	10	19	9	Fluorine	F
23	23	28	51	23	Vanadium	V
17	17	18	35	17	Chlorine	Cl
3	3	4	7	3	Lithium	Li
79	79	118	197	79	Gold	Au
11	11	12	23	11	Sodium	Na
33	33	42	75	33	Arsenic	As
50	50	69	119	50	Tin	Sn
19	19	20	39	19	Potassium	K

2. Create a similar exercise to the one above and exchange with one of your classmates.

Protons	Electrons	Neutrons	Atomic mass	Atomic number	Element name	Chemical symbol

Answers will vary

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Bohr Model Diagrams

Examples of Bohr Model Diagrams:

FLUORINE $^{19}_{9}\text{F}$

Step 1: Determine the number of fundamental particles found in the element.

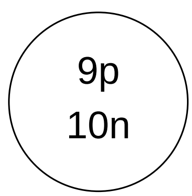
- Number of electrons is equal to the number of protons in a neutral atom. This value is equal to the atomic number.
- Number of neutrons is calculated using the equation: atomic mass minus atomic number.

Number of protons = 9 (equal to atomic number)

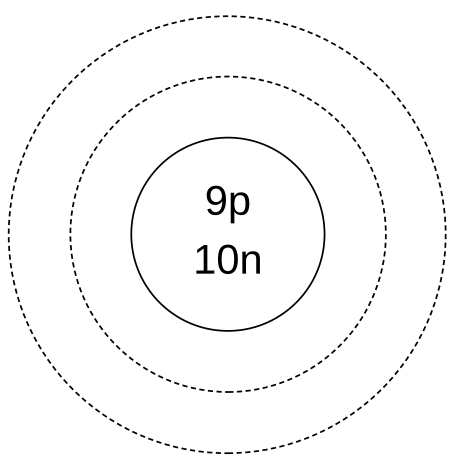
Number of electrons = 9 (equal to atomic number)

Number of neutrons = 10 (atomic mass – atomic number)

Step 2: Draw a circular nucleus with the correct number of and symbol for both protons and neutrons. The nucleus contains both neutrons and protons.



Step 3: Draw the correct number of electron shells. The number of shells/orbits is equal to the period of the element on the periodic table. Therefore, fluorine is found in period #2 and contains two electron shells.

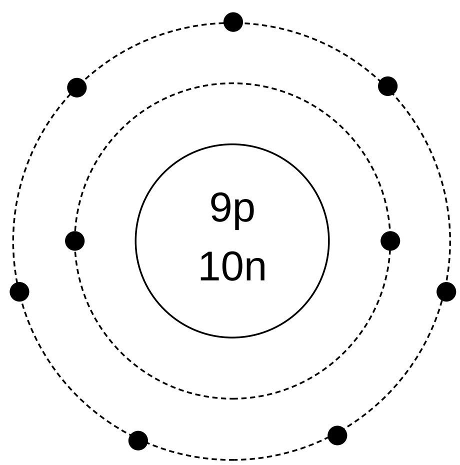


Step 4: Represent electrons as dots and position electrons in orbits or energy levels/shells.

- The electrons will fill the orbit of lowest energy first (i.e., first electron shell closest to nucleus). The first shell can hold a maximum of two electrons.
- An electron shell must be filled with its maximum number of electrons before any subsequent electron shell can be filled.
- Electrons should be distributed equally and symmetrically throughout shell.

Therefore, in the fluorine atom, the first shell contains two electrons, and the second shell contains seven electrons.

Notice that the number of valence electrons or outer shell electrons is equal to the Roman Numeral (A VII) of the group in which the fluorine is located.



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Student Learning Activity

Drawing Bohr Model Diagrams

Element Name : ___________________

Chemical Symbol : ______ Atomic Number : ______

Diagram the Bohr atom which contains:

protons neutrons electrons

Element Name : ___________________

Chemical Symbol : ______ Atomic Number : ______

Diagram the Bohr atom which contains:

protons neutrons electrons

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Drawing Bohr Model Diagrams (Teacher Version with Answers)

Element Name : Beryllium

Chemical Symbol : Be   Atomic Number : 4

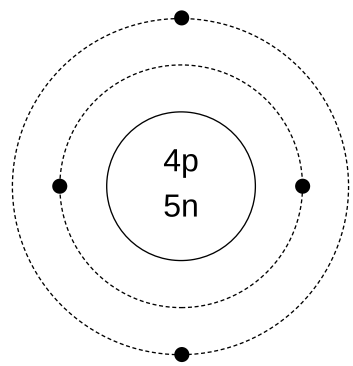

Diagram the Bohr atom which contains:

4 protons   5 neutrons   4 electrons

Element Name : Potassium

Chemical Symbol : K   Atomic Number : 19

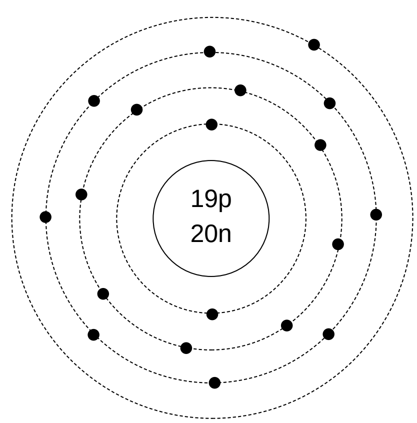

Diagram the Bohr atom which contains:

19 protons   20 neutrons   19 electrons

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Development of the Periodic Table

Early Attempts at Classification:

Dobereiner → Newlands → Meyer → Mendeleev → Moseley
1817 1863 1865 1869 1901

Both Dobereiner and Newlands observed that the atomic masses of elements seemed to be related to their chemical properties.

Meyer proposed there was some repeating pattern of the properties when they were arranged in order of atomic mass.

Dmitri Mendeleev (1869):

- systematically placed the elements into an organized table.
- stated that the properties of elements are a periodic function of their **atomic masses** and that the relationship among the elements is called **periodic law**.
- arranged the 63 elements known at that time in order of their atomic mass so that elements with the same valence (outermost electron) appeared in the same row. He found that with repeating rows, vertical columns contained elements with similar properties. He called those related elements **families or groups**.

Not all the elements had been discovered at that time, but once Mendeleev had established a pattern, he left spaces for undiscovered elements, correctly predicting that elements would be found to fill those spaces. Mendeleev's periodic table was instrumental in the discovery of 23 new elements during the three decades following its publication.

Mendeleev's First Periodic Table:

			Ti = 50	Zr = 90	? = 180
			V = 51	Nb = 94	Ta = 182
			Cr = 52	Mo = 96	W = 186
			Mn = 55	Rh = 104.4	Pt = 197.4
			Fe = 56	Rn = 104.4	Ir = 198
			Ni = Co = 59	Pl = 106.6	Os = 199
			Cu = 63.4	Ag = 108	Hg = 200
H = 1	Be = 9.4	Mg = 24	Zn = 65.2	Cd = 112	
	B = 11	Al = 27.4	? = 68	Ur = 116	Au = 197?
	C = 12	Si = 28	? = 70	Sn = 118	
	N = 14	P = 31	As = 75	Sb = 122	Bi = 210
	O = 16	S = 32	Se = 79.4	Te = 128?	
	F = 19	Cl = 35.3	Br = 80	I = 127	
Li = 7	Na = 23	K = 39	Rb = 85.4	Cs = 138	Tl = 204
		Ca = 40	Sr = 87.6	Ba = 137	Pb = 207
		? = 45	Ce = 92		
		?Er = 56	La = 94		
		?Yt = 60	Di = 95		

Henry Moseley (1901):

- stated that physical and chemical properties are a periodic function of their atomic number, rather than mass. This better explained the gaps in the table.
- created the modern periodic table in which each succeeding element has one more proton and electron than the former element.

Today, we know that it is the electron that determines properties, with the number of electrons directly related to atomic number not atomic mass.

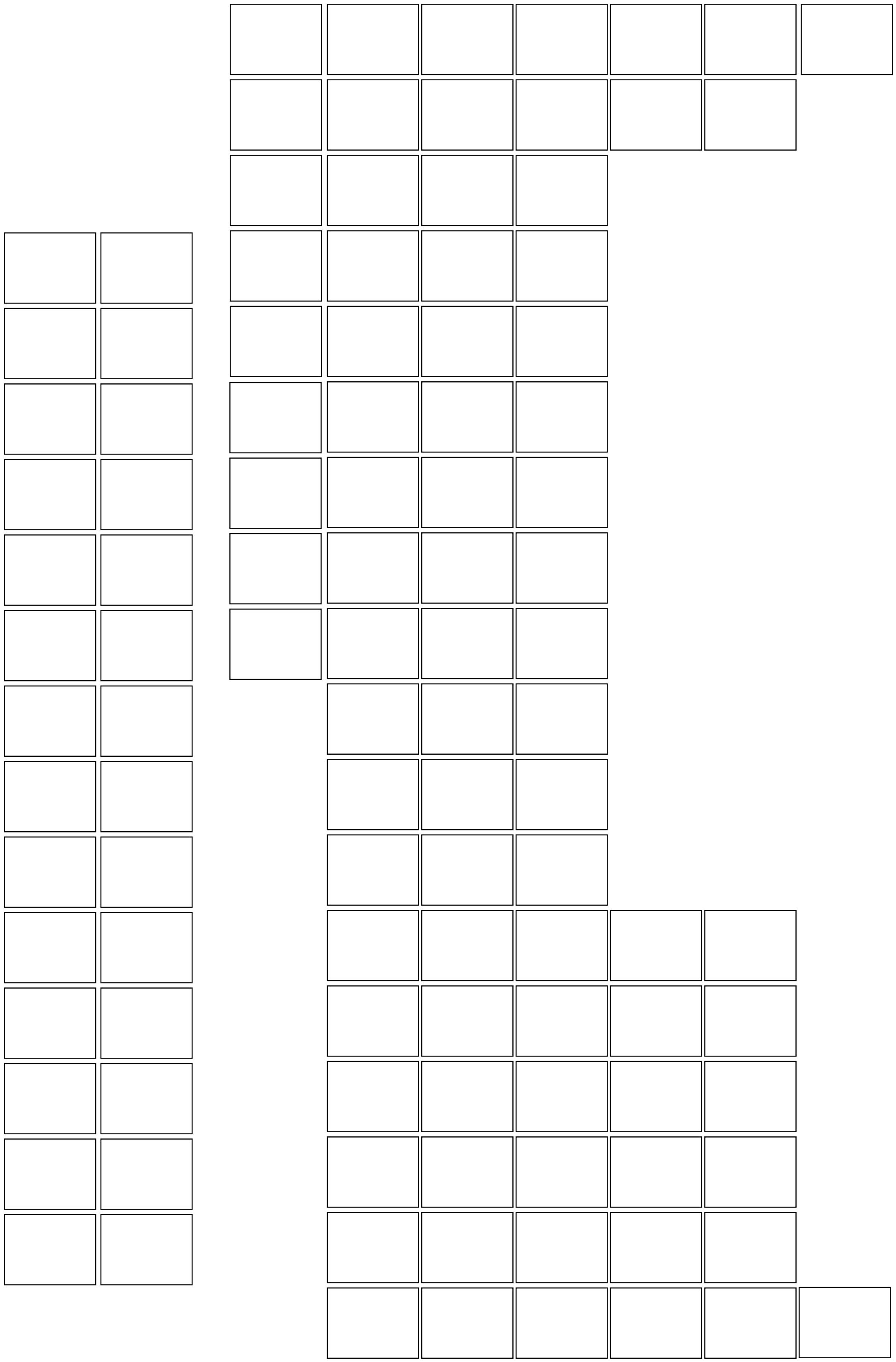
Period:

- Horizontal rows on the periodic table, with the numbering system 1-7 from top to bottom of the table.
- Each period represents an energy level in the quantum model of the atom.

Groups:

- Vertical columns on the periodic table.
- International Union of Pure and Applied Chemistry (IUPAC) labelling/numbering system 1–18 from left to right across the table.
- Old labelling system: Roman Numerals I–VIII followed by the letter “A” or “B”.
- Groups contain elements with similar chemical properties.
- The elements in a group all have the same number of electrons in their outermost shell/level. Electrons found in the outermost shell are called **valence electrons**.
- Roman numeral group number = number of valence electrons.
- Groups are sometimes referred to as families.

Blank Periodic Table



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Chemical Families of Elements

1 **H**																	2 **He**
3 **Li**	4 **Be**											5 **B**	6 **C**	7 **N**	8 **O**	9 **F**	10 **Ne**
11 **Na**	12 **Mg**											13 **Al**	14 **Si**	15 **P**	16 **S**	17 **Cl**	18 **Ar**
19 **K**	20 **Ca**	21 **Sc**	22 **Ti**	23 **V**	24 **Cr**	25 **Mn**	26 **Fe**	27 **Co**	28 **Ni**	29 **Cu**	30 **Zn**	31 **Ga**	32 **Ge**	33 **As**	34 **Se**	35 **Br**	36 **Kr**
37 **Rb**	38 **Sr**	39 **Y**	40 **Zr**	41 **Nb**	42 **Mo**	43 **Tc**	44 **Ru**	45 **Rh**	46 **Pd**	47 **Ag**	48 **Cd**	49 **In**	50 **Sn**	51 **Sb**	52 **Te**	53 **I**	54 **Xe**
55 **Cs**	56 **Ba**	71 **Lu**	72 **Hf**	73 **Ta**	74 **W**	75 **Re**	76 **Os**	77 **Ir**	78 **Pt**	79 **Au**	80 **Hg**	81 **Tl**	82 **Pb**	83 **Bi**	84 **Po**	85 **At**	86 **Rn**
87 **Fr**	88 **Ra**	103 **Lr**	104 **Unq**	105 **Unp**	106 **Unh**	107 **Uns**	108 **Uno**	109 **Une**									

57 **La**	58 **Ce**	59 **Pr**	60 **Nd**	61 **Pm**	62 **Sm**	63 **Eu**	64 **Gd**	65 **Tb**	66 **Dy**	67 **Ho**	68 **Er**	69 **Tm**	70 **Yb**
89 **Ac**	90 **Th**	91 **Pa**	92 **U**	93 **Np**	94 **Pu**	95 **Am**	96 **Cm**	97 **Bk**	98 **Cf**	99 **Es**	100 **Fm**	101 **Md**	102 **No**

- Alkali Metals
- Alkaline earth metals
- Lanthanides
- Actinides
- Transition Metals
- Chalcogens
- Halogens
- Noble Gases

BLM
Blackline Master

Organization of the Periodic Table

Periods

Groups

	IA	IIA	IIA	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	IIIA
1	1 **H** Hydrogen 1.0079																	2 **He** Helium 4.00260
2	3 **Li** Lithium 6.941	4 **Be** Beryllium 9.01218											5 **B** Boron 10.82	6 **C** Carbon 12.011	7 **N** Nitrogen 14.0067	8 **O** Oxygen 15.9994	9 **F** Fluorine 18.9964	10 **Ne** Neon 20.179
3	11 **Na** Sodium 22.98977	12 **Mg** Magnesium 24.305											13 **Al** Aluminum 26.98154	14 **Si** Silicon 28.0855	15 **P** Phosphorus 30.97376	16 **S** Sulphur 32.06	17 **Cl** Chlorine 35.453	18 **Ar** Argon 39.948
4	19 **K** Potassium 39.0983	20 **Ca** Calcium 40.06	21 **Sc** Scandium 44.9559	22 **Ti** Titanium 47.90	23 **V** Vanadium 50.9414	24 **Cr** Chromium 51.996	25 **Mn** Manganese 54.9380	26 **Fe** Iron 55.847	27 **Co** Cobalt 58.9332	28 **Ni** Nickel 58.70	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.36	31 **Ga** Gallium 69.72	32 **Ge** Germanium 72.59	33 **As** Arsenic 74.9216	34 **Se** Selenium 78.96	35 **Br** Bromine 79.904	36 **Kr** Krypton 83.80
5	37 **Rb** Rubidium 85.4678	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.9059	40 **Zr** Zirconium 91.22	41 **Nb** Niobium 92.9064	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium 96.90639	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.9055	46 **Pd** Palladium 106.4	47 **Ag** Silver 107.868	48 **Cd** Cadmium 112.41	49 **In** Indium 114.82	50 **Sn** Tin 118.69	51 **Sb** Antimony 121.75	52 **Te** Tellurium 127.60	53 **I** Iodine 126.9045	54 **Xe** Xenon 131.30
6	55 **Cs** Cesium 132.9054	56 **Ba** Barium 137.34	71 **Lu** Lutetium 174.97	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.9479	74 **W** Tungsten 183.85	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.2	77 **Ir** Iridium 192.22	78 **Pt** Platinum 195.09	79 **Au** Gold 196.9665	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.37	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.9804	84 **Po** Polonium 208.9624	85 **At** Astatine 209.987	86 **Rn** Radon 222
7	87 **Fr** Francium 223.09176	88 **Ra** Radium 226	103 **Lr** Lawrencium 256.099	104 **Unq** 261	105 **Unp** 262	106 **Unh** 263	107 **Uns** 262	108 **Uno** 265	109 **Une** 266									

6	57 **La** Lanthanum 138.9055	58 **Ce** Cerium 140.12	59 **Pr** Praseodymium 140.9077	60 **Nd** Neodymium 144.24	61 **Pm** Promethium 144.9127	62 **Sm** Samarium 150.4	63 **Eu** Europium 151.96	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.9254	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.9304	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.9342	70 **Yb** Ytterbium 173.04
7	89 **Ac** Actinium 227.0274	90 **Th** Thorium 232.0381	91 **Pa** Protactinium 231.0359	92 **U** Uranium 238.029	93 **Np** Neptunium 237.0481	94 **Pu** Plutonium 244.0642	95 **Am** Americum 243.061	96 **Cm** Curium 247.0703	97 **Bk** Berkelium 247.0703	98 **Cf** Californium 251.0796	99 **Es** Einsteinium 254.088	100 **Fm** Fermium 257.0951	101 **Md** Mendelevium 258	102 **No** Nobelium 255.093

SLA
Student Learning Activity

"What Element Am I?"

Respond to each statement by writing the symbol of the element best matching the clue.

Statement	Element Symbol
1. The element found in Period 3, Group VIIA.	
2. The element used in weather balloons.	
3. The element found in cheaper light bulbs.	
4. The element used in water purification.	
5. The element used in photographic film.	
6. The element used in dental crowns.	
7. A liquid element sometimes used in thermometers.	
8. The element used as a radiation shield.	
9. The element most used as an electrical conductor.	
10. The element once used as an antiseptic.	
11. The element found in Period 2, Group 13.	
12. The element used in the production of fertilizers.	
13. The metal element used in electroplating.	
14. The element used in pencil leads (not lead).	
15. The element used to absorb heat in spacecrafts.	
16. The element used in modern batteries.	
17. The gas element used in deep-sea diving.	
18. The element found in Period 4, Group 12.	
19. The element used in the making of steel.	
20. The element used as a fuel component in nuclear reactors.	

TSM Teacher Support Material

"What Element Am I?" (Teacher Version with Answers)

Statement	Element Symbol
1. The element found in Period 3, Group VIIA.	Cl
2. The element used in weather balloons.	He
3. The element found in cheaper light bulbs.	Ne
4. The element used in water purification.	Cl
5. The element used in photographic film.	Ag
6. The element used in dental crowns.	Au
7. A liquid element sometimes used in thermometers.	Hg
8. The element used as a radiation shield.	Pb
9. The element most used as an electrical conductor.	Cu
10. The element once used as an antiseptic.	I
11. The element found in Period 2, Group 13.	B
12. The element used in the production of fertilizers.	P
13. The metal element used in electroplating.	Ni
14. The element used in pencil leads (not lead).	C
15. The element used to absorb heat in spacecrafts.	Be
16. The element used in modern batteries.	Li
17. The gas element used in deep-sea diving.	He
18. The element found in Period 4, Group 12.	Zn
19. The element used in the making of steel.	O
20. The element used as a fuel component in nuclear reactors.	U

Metals — Nonmetals — Metalloids

BLM Blackline Master

Metals

Nonmetals

Noble Gases

Transition Elements

IA	IIA	IIA	IVB	VB	VIB	VIIB	VIIIB	VIIIB	VIIIB	IB	IIB	IIIA	IVA	VA	VIA	VIIA	IIIA
1 **H** Hydrogen 1.0079																	2 **He** Helium 4.00260
3 **Li** Lithium 6.941	4 **Be** Berylium 9.01218											5 **B** Boron 10.82	6 **C** Carbon 12.011	7 **N** Nitrogen 14.0067	8 **O** Oxygen 15.9994	9 **F** Fluorine 18.9964	10 **Ne** Neon 20.179
11 **Na** Sodium 22.98977	12 **Mg** Magnesium 24.305											13 **Al** Aluminum 26.98154	14 **Si** Silicon 28.0855	15 **P** Phosphorus 30.97376	16 **S** Sulphur 32.06	17 **Cl** Chlorine 35.453	18 **Ar** Argon 39.948
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87 **Fr** Francium 223.09176	88 **Ra** Radium 226	103 **Lr** Lawrencium 256.099	104 **Unq** 261	105 **Unp** 262	106 **Unh** 263	107 **Uns** 262	108 **Uno** 265	109 **Une** 266									

*Metalloids lie along this heavy stairstep line and shaded in.

Metalloids

Larthanide Series

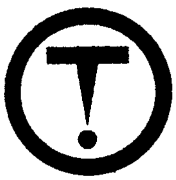
Actinide Series

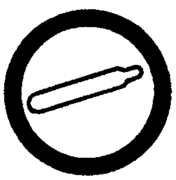
57 **La** Lanthanum 138.9055	58 **Ce** Cerium 140.12	59 **Pr** Praseodymium 140.9077	60 **Nd** Neodymium 144.24	61 **Pm** Promethium 144.9127	62 **Sm** Samarium 150.4	63 **Eu** Europium 151.96	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.9254	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.9304	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.9342	70 **Yb** Ytterbium 173.04
89 **Ac** Actinium 227.0274	90 **Th** Thorium 232.0381	91 **Pa** Protactinium 231.0359	92 **U** Uranium 238.029	93 **Np** Neptunium 237.0481	94 **Pu** Plutonium 244.0642	95 **Am** Americum 243.061	96 **Cm** Curium 247.0703	97 **Bk** Berkelium 247.0703	98 **Cf** Californium 251.0796	99 **Es** Einsteinium 254.088	100 **Fm** Fermium 257.0951	101 **Md** Mendelevium 258	102 **No** Nobelium 255.093

SLA
Student Learning Activity

WHMIS Symbols

In the space provided, give the meaning of the following symbols:





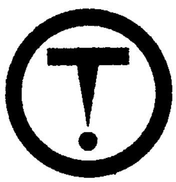
TSM
Teacher Support Material

WHMIS Symbols (Teacher Version with Answers)

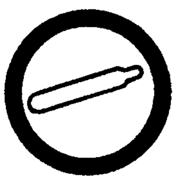
In the space provided, give the meaning of the following symbols:

Flammable and combustible material

Dangerously reactive material



Poisonous and infectious material causing other toxic effects



Compressed gas

Oxidizing material

Corrosive material

Biohazard infectious material

SLA
Student Learning Activity

Chemical Formulas

For each of the molecules in the left column, answer the questions that appear in the other columns.

Chemical Formula	a) How many different kinds of atoms are in this molecule? b) How many atoms of each kind are in this molecule? c) What is the total number of all atoms in this molecule?	What does this molecule represent?
Na_2O	a) b) c)	❑ a pure substance ❑ a compound ❑ a monatomic element ❑ a diatomic element ❑ a polyatomic element
H_2	a) b) c)	❑ a pure substance ❑ a compound ❑ a monatomic element ❑ a diatomic element ❑ a polyatomic element
Al	a) b) c)	❑ a pure substance ❑ a compound ❑ a monatomic element ❑ a diatomic element ❑ a polyatomic element
S_8	a) b) c)	❑ a pure substance ❑ a compound ❑ a monatomic element ❑ a diatomic element ❑ a polyatomic element
H_3PO_4	a) b) c)	❑ a pure substance ❑ a compound ❑ a monatomic element ❑ a diatomic element ❑ a polyatomic element

TSM
Teacher Support Material

Chemical Formulas (Teacher Version with Answers)

For each of the molecules in the left column, answer the questions that appear in the other columns.

Chemical Formula	a) How many different kinds of atoms are in this molecule? b) How many atoms of each kind are in this molecule? c) What is the total number of all atoms in this molecule?	What does this molecule represent?
Na_2O	a) 2 kinds of atoms b) Na = 2, O = 1 c) 3 atoms total	☐ a pure substance ☑ a compound ☐ a monatomic element ☐ a diatomic element ☐ a polyatomic element
H_2	a) 1 kind of atom b) H = 2 c) 2 atoms total	☑ a pure substance ☐ a compound ☐ a monatomic element ☑ a diatomic element ☐ a polyatomic element
Al	a) 1 kind of atom b) Al = 1 c) 1 atom total	☐ a pure substance ☐ a compound ☑ a monatomic element ☐ a diatomic element ☐ a polyatomic element
S_8	a) 1 kind of atom b) S = 8 c) 8 atoms total	☐ a pure substance ☐ a compound ☐ a monatomic element ☐ a diatomic element ☑ a polyatomic element
H_3PO_4	a) 3 kinds of atoms b) H = 3, P = 1, O = 4 c) 8 atoms total	☐ a pure substance ☑ a compound ☐ a monatomic element ☐ a diatomic element ☐ a polyatomic element

SLA
Student Learning Activity

Physical and Chemical Changes

Classify each of the following changes as either physical or chemical. Provide an explanation for your choice.

SITUATION	TYPE OF CHANGE	EXPLANATION
1. A piece of dry ice (solid carbon dioxide) is dropped into hot water. Large amounts of white vapour bubble out of the water.	__ Physical __ Chemical	
2. When George's father makes wine from crabapples, bubbles form on the surface of the yeast and fruit mixture.	__ Physical __ Chemical	
3. When margarine is left in a warm place for an extended period of time, it tastes sour.	__ Physical __ Chemical	
4. Jane's father opens up a new deodorant product. The room quickly smells like fresh flowers.	__ Physical __ Chemical	
5. During a school volleyball game, Jennifer sprains her ankle. Her coach squeezes a bag at room temperature that quickly becomes very cold.	__ Physical __ Chemical	

Senior 1

Appendices:
Cluster 3
The Nature of Electricity

Developing a Conceptual Model of Electricity

Introduction

Students are often fascinated with electricity. This guide is a resource for Senior 1 Science teachers and is provided to help students develop a conceptual model of electricity, following the transition from static to current electricity.

TSM
Teacher Support Material

Pre-Model Activities (Teacher Support)

No one forgets an electrical shock. Ask students to describe and record their own experiences with electricity in their journals. Discuss as a class. Many students are already familiar with the following experiences:

1. “Static cling” — Ask students if they’ve ever taken off a sweater (especially wool) in the dark. Suggest they try it. They should hear and see the static sparks. Ask them about static cling in the clothes dryer. Include this as part of the home experiment.
2. Electric shocks when walking across a carpet and touching a door knob...OUCH!
3. Touching their tongues to a nine-volt battery and getting a tingling feeling. (Don’t recommend this activity. Although it’s harmless, if you extend this activity to higher voltages it can be extremely dangerous. When students raise this, they should by cautioned. Safety should be emphasized at all times).
4. Rubbing a balloon on their hair, and sticking it to the wall. Suggest that students try to bring together two balloons which have been rubbed on their (or someone else’s) hair.
5. Running a comb or brush through their hair and bringing it near bits of paper or straw. They should find that the bits are attracted to the comb.

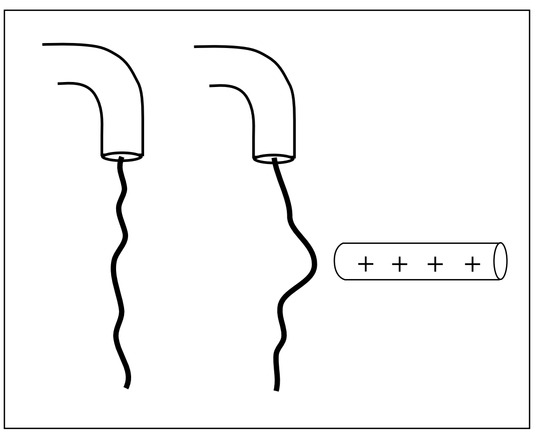


Figure 1

6. Bringing a charged object near a thin stream of water. The flow of water should bend toward the stream (See Figure 1 above).

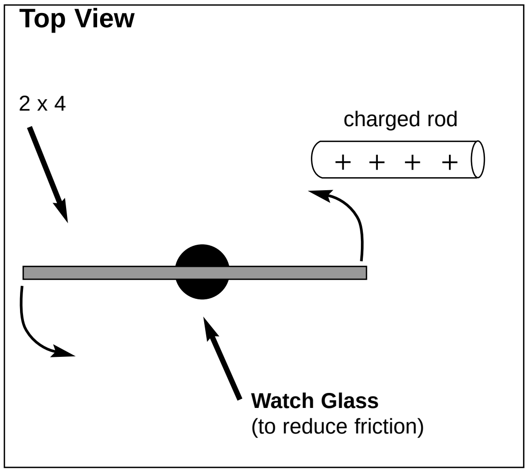


Figure 2

7. Students will likely not have experienced this phenomenon, so a demonstration could be performed. Balance a 2" x 4" x 8' piece of lumber on a watch glass. Bring a charged object near one end of the 2 x 4. It should move towards the charged object (See Figure 2 above).

SLA Student Learning Activity

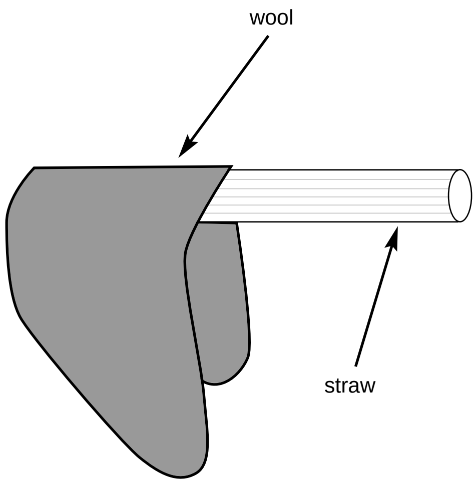
An Introduction to Electrostatics — Home Experiment (Student Version)

Materials:

- plastic straw
- paper bits
- wool
- transparent tape

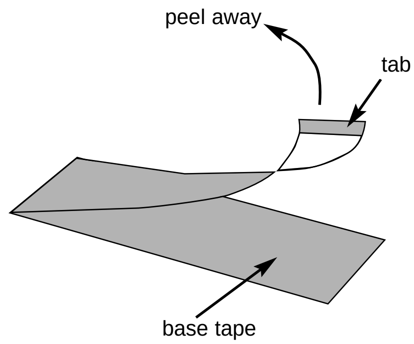
Perform the following experiments at home and discuss with a partner (e.g., mom, dad, sibling, friend). Record your observations and explanations.

1. Scatter paper bits on a table. Rub a plastic straw with the wool material and bring the straw near the paper bits. Record and explain your observations.

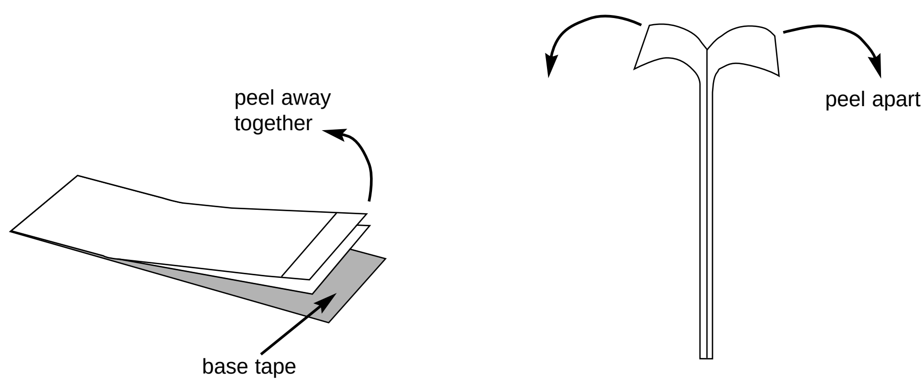


2. Find two materials at home to replace the plastic straw and wool, which demonstrate the same effects.

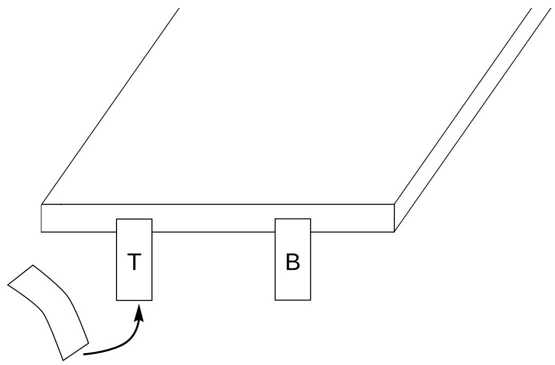
3. Stick a piece of transparent tape (about 30 cm long) on the table (base tape). On certain surfaces, this tape is not needed. Take a second piece about 10 cm long and fold over the first centimetre of tape to make a tab. Stick this tape to the base tape and press it down well with your finger. Now peel the short tape briskly from the base tape. Bring the tape near the paper bits. What can you conclude about the tape?



4. Make another 10-cm strip with a tab as before. Press them both down on the base tape, one on top of the other, and then peel them away together. Peel the tapes from one another. What happens when you bring the tapes near each other?



5. Stick the tapes from step #4 to the edge of the table. Call them tape T (top when peeled apart) and tape B (bottom when peeled away). Make another pair of tapes as in step #4 (i.e., another T and B tape) and bring each tape, one at a time, near the tapes on the edge of the table. Summarize your results. How many kinds of “charge” can you identify? Name them. Formulate a simple rule for the interaction of charge.



bring tape nearby

6. Now bring each tape (T and B) near the paper bits. What charge is on the paper bits?

TSM Teacher Support Material

An Introduction to Electrostatics — Home Experiment (Teacher Version with Answers)

The home experiment is an excellent way to introduce students to static electricity. After the preceding discussion of common phenomena, let the students explore common household materials at home on their own. Students should discuss their observations, explanations, and possible models with a partner (e.g., mom, dad, sibling, friend). This encourages home involvement at the beginning of this cluster.

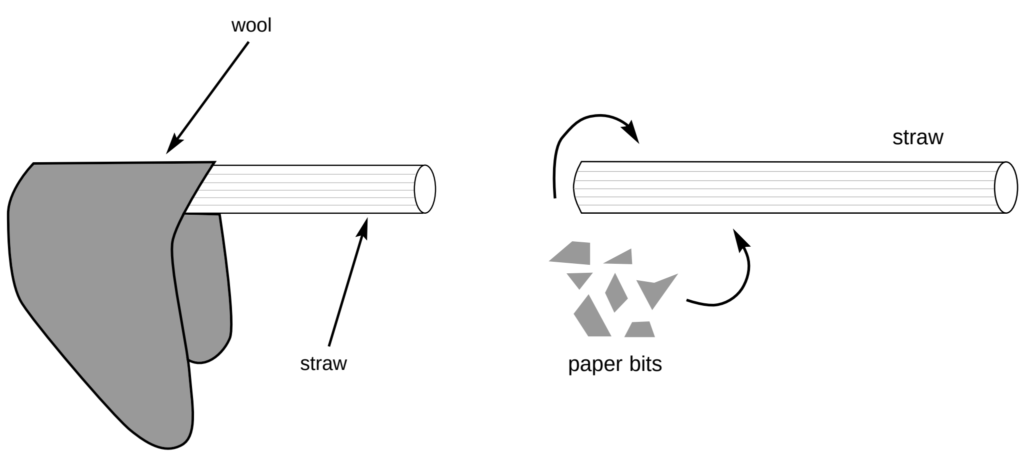
Materials:

- plastic straw
- paper bits
- wool
- transparent tape

Perform the following experiments at home and discuss with a partner (e.g., mom, dad, sibling, friend). Record your observations and explanations.

1. Scatter paper bits on a table. Rub a plastic straw with the wool material and bring the straw near the paper bits. Record and explain your observations.

   The plastic straw becomes charged when rubbed. The paper bits are attracted to the charged rod. After touching the rod, the paper bits may be repelled away. Early model: Charge is the name we give to the "something" the rod acquires when rubbed.

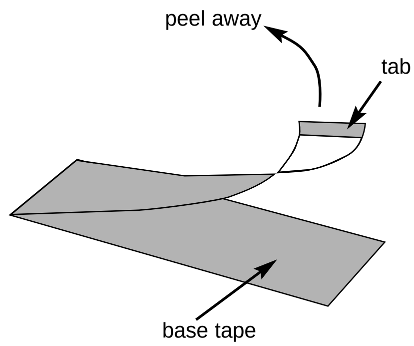


2. Find two materials at home to replace the plastic straw and wool, which demonstrate the same effects.

   Try a toothbrush, pen, CD jewel case, silk, polyester, etc.

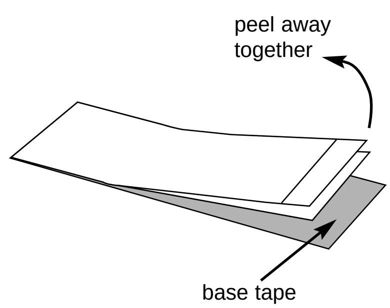
3. Stick a piece of transparent tape (about 30 cm long) on the table (base tape). Take a second piece about 10 cm long and fold over the first centimetre of tape to make a tab. Stick this tape to the base tape and press it down well with your finger. Now peel the short tape briskly from the base tape. Bring the tape near the paper bits. What can you conclude about the tape?

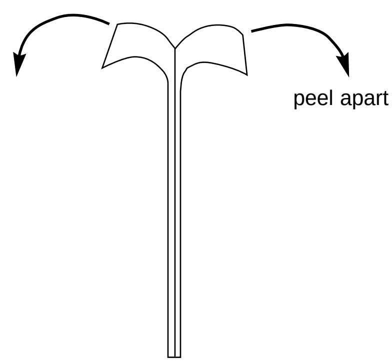
   The tape becomes "charged." It attracts the bits of paper.



4. Make another 10-cm strip with a tab as before. Press them both down on the base tape, one on top of the other, and then peel them away together. Peel the tapes from one another. What happens when you bring the tapes near each other?

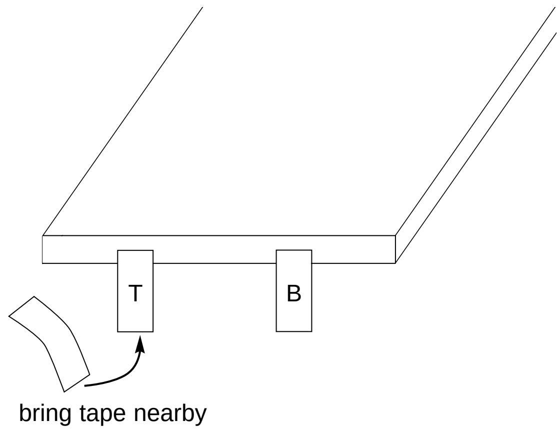
   The tapes are attracted to each other.





5. Stick the tapes (from step #4) to the edge of the table. Call them tape T (top when peeled apart) and tape B (bottom when peeled away). Make another pair of tapes as in step #4 (i.e., another T and B tape) and bring each tape, one at a time, near the tapes on the edge of the table. Summarize your results. How many kinds of "charge" can you identify? Name them. Formulate a simple rule for the interaction of charge.

   Tape T repels tape T, tape B repels tape B, tape T attracts tape B, and tape B attracts tape T. There are two kinds of charges, positive and negative (you can also name them Fred and Barney if you wish; positive and negative are terms which were coined by Ben Franklin). A simple rule for the interaction of charge is like charges repel and unlike charges attract.



6. Now bring each tape (T and B) near the paper bits. What charge is on the paper bits?

   The paper is attracted by tape T and is also attracted by tape B. Two bits of paper have no effect on each other. The paper is neutral and neutral objects are attracted to both kinds of charge.

Home Experiment Summary (a pre-model)

1. Many different materials can be “electrified” by friction.
2. “Charge” is the name we apply to the property we have observed. An object can be “charged” by friction, and charge gives rise to forces of attraction and repulsion.
3. Given the observations of attraction and repulsion, we can say two charge states exist.
4. Charges which are like (that is, created in similar circumstances) repel, and charges which are unlike (that is, created in different circumstances) attract.
5. A neutral object is attracted to both positive and negative charges.
6. The existence of two charge states can be explained by three models:
   a. **one-fluid model** — a neutral object has a “natural” amount of electric fluid. A charged object has either too much or too little fluid. This is Ben Franklin’s model. As a result, Franklin coined the terms positive and negative.
   b. **two-fluid model** — a neutral object has equal amounts of each fluid. A charged object has more of one or the other.
   c. **particle model** — there are two kinds of particles, positive or negative. A charged object has more of one particle or the other.

We have come to accept the particle model of electricity because of later discoveries, including Rutherford’s gold foil experiment and Millikan’s oil drop experiment.

Charging by Contact

The next step is to demonstrate that we can charge an object by contact. Touch a charged positive rod to a neutral pith ball. The pith ball is attracted to the rod (just like the neutral bits of paper). The pith ball sticks to the rod momentarily, and then repels away from the rod. Our model suggests “something” is transferred from one object to the other (i.e., the “charge” flows from the rod to the pith ball). When the pith ball becomes charged, the pith ball and rod repel each other. Because we have come to accept the particle model of matter, we “fix” the positive charge and allow the negative charges to move. (**Note**: This applies to the cases we describe (i.e., solids). In some liquids and gases, both charges — positive and negative — can and do move). Therefore, an object becomes positively charged if it loses negative charges, and becomes negatively charged if it gains negative charges.

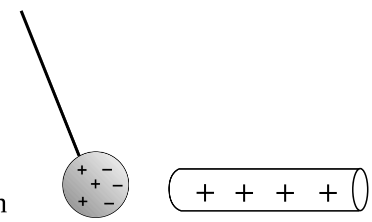
TSM
Teacher Support Material

Attraction of a Neutral Object

The attraction of a neutral object is a discrepant event that challenges students to refine their model.

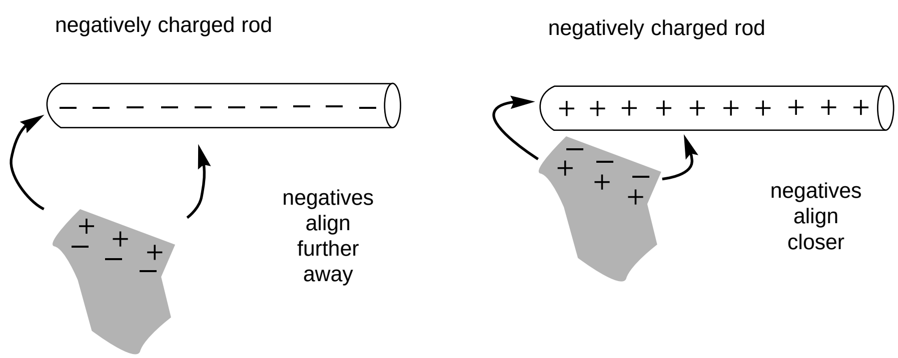
Caution: Introduce this topic clearly and carefully!

1. Bring a positively charged rod near a neutral pith ball. The pith ball is attracted to the rod. Explain using the model of electric charge. Since the negatives on the pith ball are free to move, they move closer to one side attracted by the positives on the rod. The negatives are closer to the positive rod than the positives on the pith, so there is a net force of attraction. When the pith ball and rod touch, the negatives on the pith ball are attracted onto the rod, making the rod less positive and the pith ball more positive.



2. Bring a positively charged rod near some bits of paper. The paper will be attracted to the rod. Students will often conclude (incorrectly) that the paper is charged negatively. But if the paper bits were negatively charged, they would repel each other. Now bring a negative rod nearby the bits. The paper will be attracted to the negative rod.

   We modify the model of electric charge to include reference to materials (like the pith ball) which freely allow the movement of negative charges. When another charge is brought near the pith ball, a charge separation occurs. We call these materials conductors. Materials like paper, which do not allow the free movement of negatives, are called insulators. The charges on insulators do not separate readily but polarize (align themselves). Since opposite charges are always closer to each other, there is a net force of attraction.



   Materials have varying degrees of conductivity. In fact, paper may occasionally acquire a charge and fly off the rod. Demonstrate this by bringing a charged rod near the paper confetti from a hole punch. The pieces of confetti will often oscillate between the table and the rod, alternately attracted and repelled by the rod.

SLA
Student Learning Activity

Electrostatics Lab (Student Version)

Purpose:

To investigate and explain electrostatic phenomena.

Materials:

Contents of electrostatics kit:

- plastic rod
- ebony rod
- acetate strip
- vinyl strip
- silk
- wool
- canvas
- neoprene
- polyester
- two metal spheres or two 6" pieces of half-inch copper pipe
- insulating stand (can be 250 ml beaker or other insulator of similar size)
- pith ball electroscope

Procedure:

Perform the following steps and record your observations, using **diagrams** to explain the results in terms of the charge, charge movement, and the effects of the charge.

1. Touch a suspended pith ball with a charged plastic rod (positive). Draw three diagrams indicating the movement of the negative charges and the effects when

   a. the rod is near the pith ball.

   b. the rod touches the pith ball.

c. the rod and pith ball repel.

2. What charge does the pith ball have? How do you know?

3. Repeat steps 1 and 2 using a negative rod and a pith ball. (Note: You can remove the charge on the pith ball by touching it with your hand.) Explain your results.

4. How can you definitively test an unknown object for charge?

5. Bring a positively charged rod close to one end of a copper pipe on a glass beaker. Touch the other end of the pipe briefly with your finger. Remove your finger first, and then withdraw the nearby rod. Test the pipe for charge. Explain using the model for electric charge.

6. Place a metal pipe on a glass beaker. Suspend a pith ball so that it touches one end of the pipe. Touch the other end of the pipe with a charged rod. Repeat using a wooden dowel in place of the metal pipe. Explain using the model for electric charge.

7. Place two copper pipes on glass beakers so their ends are touching. Bring a charged rod nearby one end and then separate the pipes. Test each pipe for charge. Explain using the model for electric charge.

TSM
Teacher
Support
Material

Electrostatics Lab (Teacher Version with Answers)

Purpose:

To investigate and explain electric phenomena.

Materials:

Contents of electrostatics kit:

- plastic rod
- ebony rod
- acetate strip
- vinyl strip
- silk
- wool
- canvas
- neoprene
- polyester
- two metal spheres or two 6" pieces of half-inch copper pipe
- insulating stand (can be 250 ml beaker or other insulator of similar size)
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Procedure:

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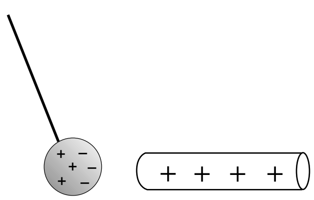
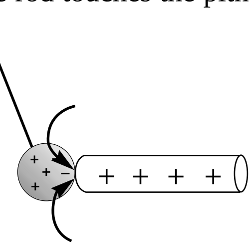
1. Touch a suspended pith ball with a charged plastic rod (positive). Draw three diagrams indicating the movement of the negative charges and the effects when

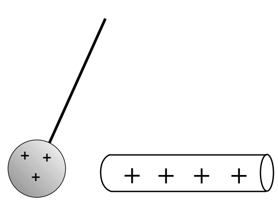
   a. the rod is near the pith ball.

   b. the rod touches the pith ball.

   c. the rod and pith ball repel.

2. What charge does the pith ball have? How do you know?

   The pith ball is positive because it is repelled by the positive rod.

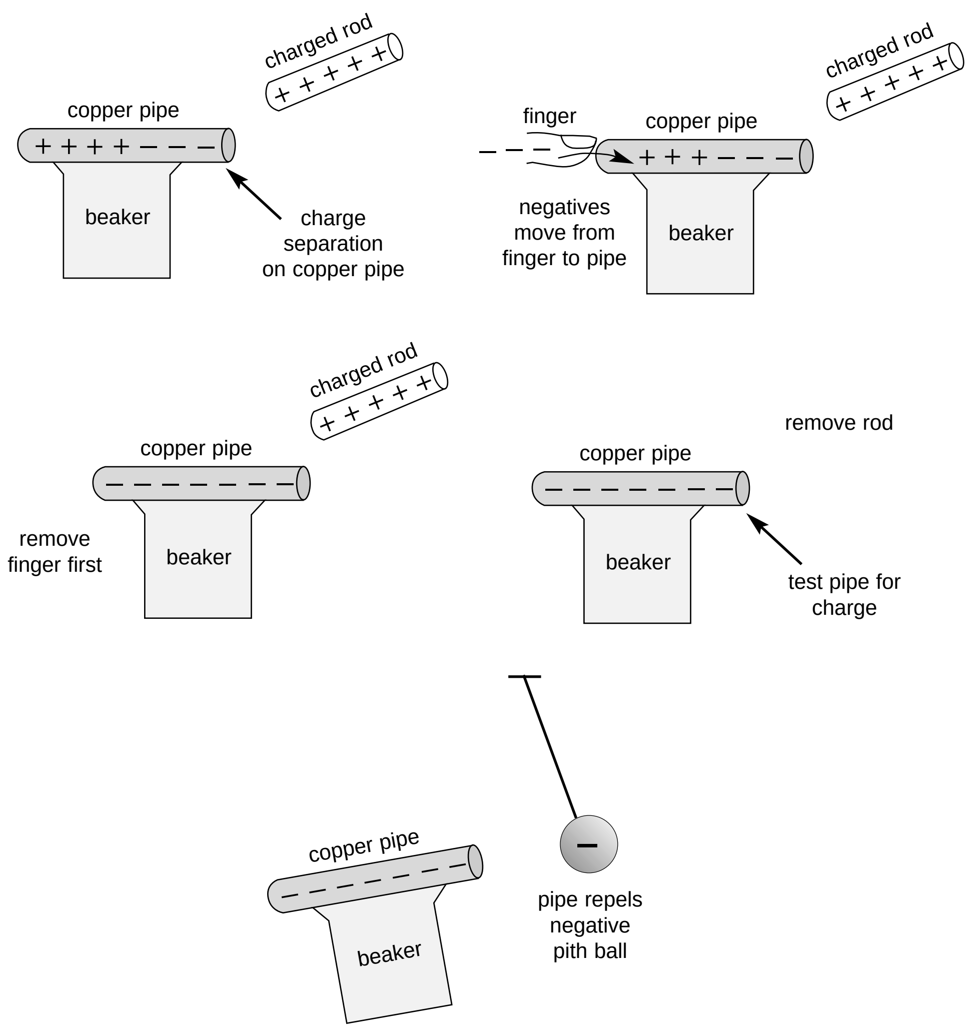
3. Repeat steps 1 and 2 using a negative rod and a pith ball. (Note: You can remove the charge on the pith ball by touching it with your hand.) Explain your results.

   Negatives move from the rod to the pith ball. The pith ball becomes negatively charged and is repelled by the rod.

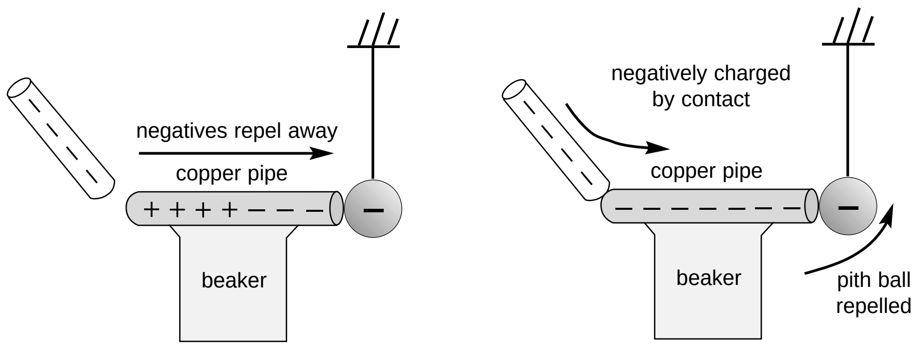
4. How can you definitively test an unknown object for charge?

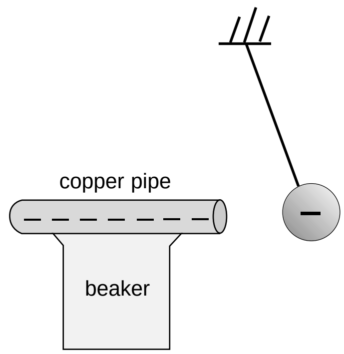
   A positive rod will attract negatives and a neutral body. A negative rod will attract positives and a neutral body. Therefore, the definitive test for charge is one of repulsion.

5. Bring a positively charged rod close to one end of a copper pipe on a glass beaker. Touch the other end of the pipe briefly with your finger. Remove your finger first, and then withdraw the nearby rod. Test the pipe for charge. Explain using the model for electric charge.



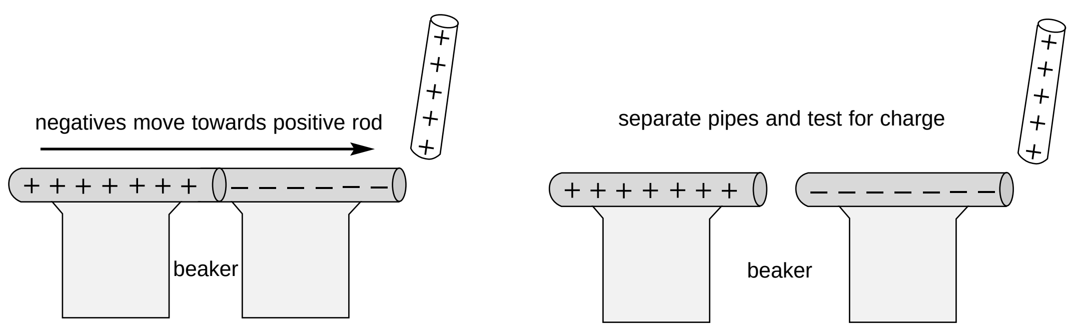
6. Place a metal pipe on a glass beaker. Suspend a pith ball so that it touches one end of the pipe. Touch the other end of the pipe with a charged rod. Repeat using a wooden dowel in place of the metal pipe. Explain using the model for electric charge.





Since a wooden dowel is an insulator, no charge is conducted to the pith ball. Hence, it does not move.

7. Place two copper pipes on glass beakers so that their ends are touching. Bring a charged rod nearby one end and then separate the pipes. Test each pipe for charge. Explain using the model for electric charge.



Post-Lab Discussion

Reinforce the previous activities with a post-lab discussion. Students should be able to:

1. Observe the effects of friction.
2. Discuss the concept of charge (it is the name of a property; it leaks away; it moves through metal objects; it is transferable by contact.)
3. Outline experimental evidence that two charges exist.
4. Operationally define positive and negative and discuss how we can test for charge. Because of the attraction of a neutral insulator, the only definitive test of charge is one of repulsion. Positive charges repel a pith ball that has been charged by a glass rod rubbed with silk. Negative charges repel a pith ball charged by an ebony rod rubbed with neoprene.
5. Define grounding as the sharing of charge with a large object (often the Earth, hence the name). Grounding can neutralize a charged object or serve as a “reservoir of charge” (i.e., charges may be attracted from or repelled to the ground by induction).
6. Discuss the mobility of negative charge. Many students know electrons are negative without understanding that one way we know this is because electrons are repelled by negatively charged objects.
7. Identify the properties of conductors and non-conductors.
8. Diagram charging an object by induction.

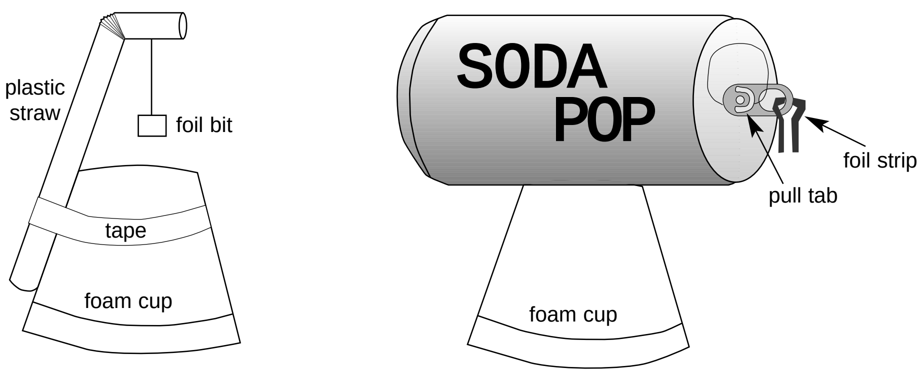
BLM Blackline Master

Electrostatic Devices — Background Information

After observing electrostatic phenomena, students should consider an historical perspective. In the industrial revolution of the 1700s, machines and machinery were studied extensively. Studies included the detection of electricity, the production of large amounts of electricity, and the storage of electricity. Some early useful devices include the electroscope, the electrophorus, and the leyden jar. These devices can be easily produced in class (see instructions below).

E.g., Electroscope

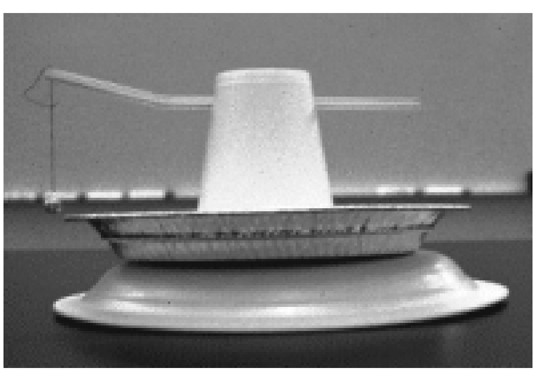
An electroscope is a device which is used to detect charge. The simplest kind of electroscope is the pith ball or foil bit electroscope which can be constructed with common materials (see below). Many commercially made devices, including models on overheads, are also readily available.



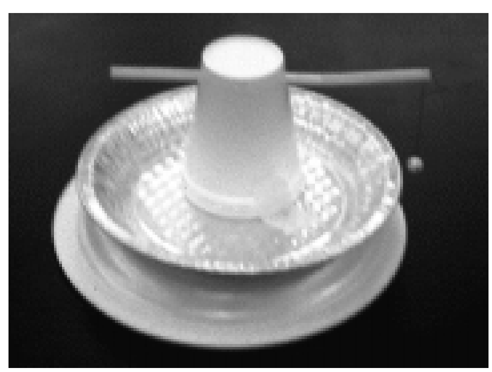
Homemade "foil bit" electroscope

E.g., Electrophorus

The electrophorus is most often used to produce a stronger charge than by simply rubbing a rod. A very inexpensive and reliable electrophorus can be made from a plastic foam plate, an aluminum plate, a foam cup, and some tape, as shown in the diagram below.



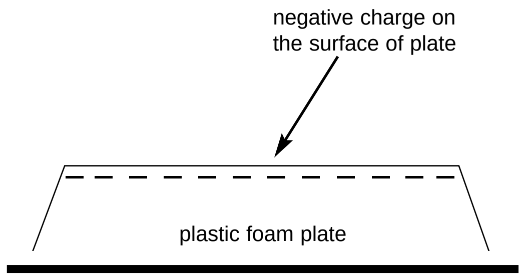
Side View



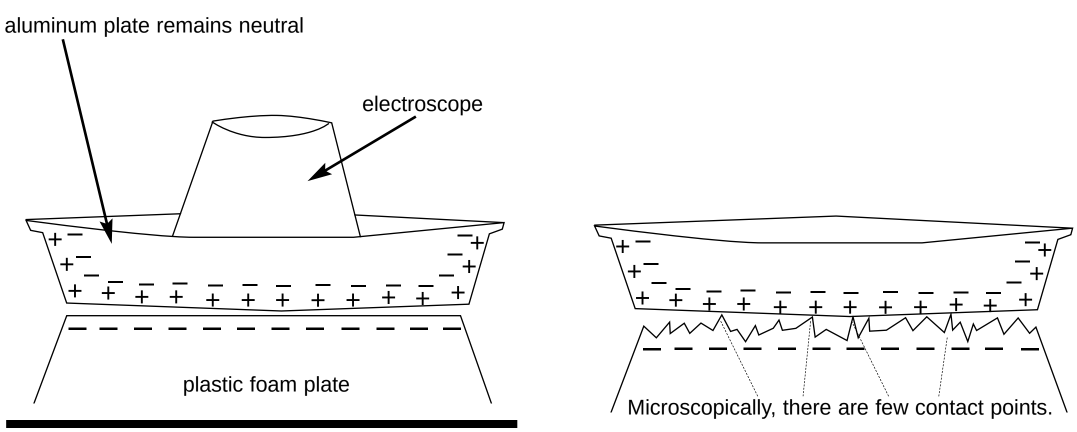
Top View

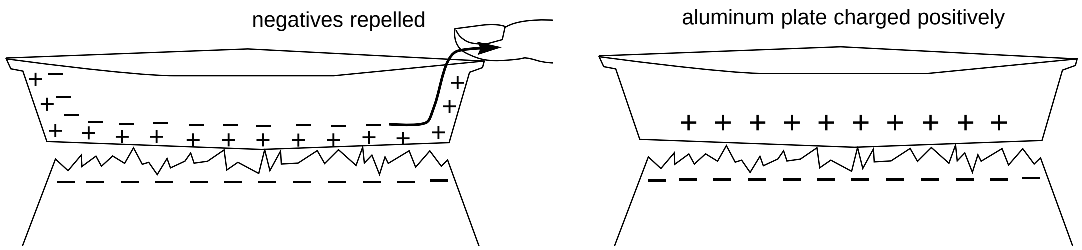
To charge the electrophorus:

1. Rub the plastic foam with wool (or a similar material). This will place a negative charge on the plate. Test for charge using the electroscope as follows:

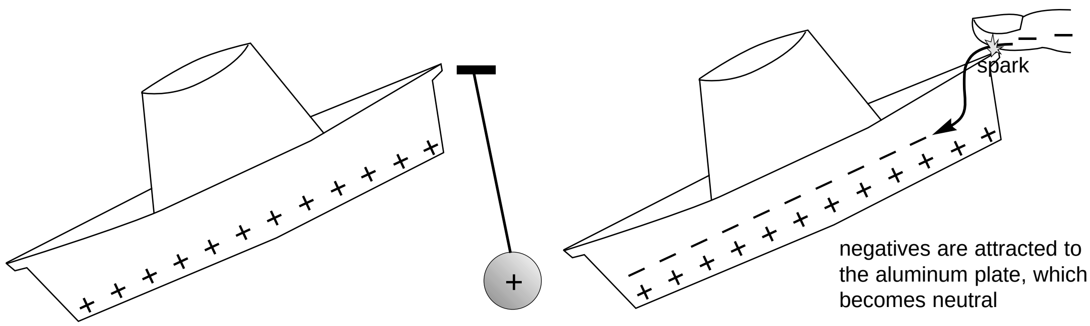


- Place the aluminum plate on the plastic foam plate, and then try to remove the aluminum plate. You will find there is a force of attraction between the two plates (they try to hold together), but the aluminum plate remains neutral. No charge from the plastic foam has moved onto the aluminum plate because very few contact points exist through which the negatives can move to the aluminum plate. The plate is charged by induction. The negative charge on the plastic foam will repel the negatives on the aluminum plate towards the inner surface.
- Now ground the aluminum plate. The negatives are repelled to the ground and the aluminum plate becomes positive. Ground the pieplate again by touching it with your finger. A spark will jump from the pieplate to your finger as the negatives are repelled to ground through your finger. While this is harmless for simple electrostatic demonstrations, it is NOT generally a safe practice to become a ground (more on this later). See the following diagrams which illustrate the tests described above.

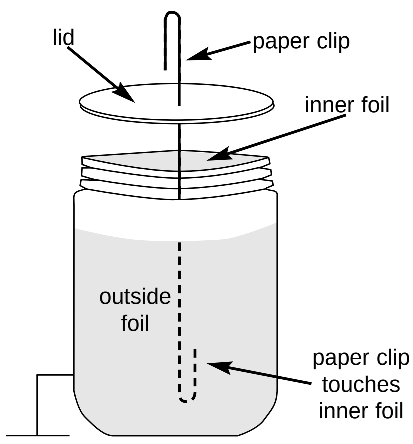




- Test the aluminum plate for charge by bringing it near an electroscope.
- Discharge the aluminum plate, by touching it again with your finger. Negatives are attracted to the aluminum plate and it becomes neutral.
- Charge the electrophorus again by placing it on the plastic foam and touching it with your finger. You can charge the aluminum plate repeatedly without having to continually rub the plastic foam.



E.g., Leyden Jar



Students can make small leyden jars with plastic cups, plastic film canisters, or any other container constructed of glass or plastic. Commercial leyden jars are also available.

The film canister leyden jar is easy to assemble. Cover the inside of a film canister with tin foil. A glue stick can be used to apply a small amount of glue to hold the foil in place. Cover the outside of the film canister with tin foil. Push a paper clip through the lid so that it touches the bottom of the canister when the lid is on. Now charge the leyden jar using a charged rod or an electrophorus. The charge on the inside induces the opposite charge on the outside. The opposite charges “hold” the charge. The charge is transferred through the paper clip to the inner foil lining, giving it the same charge. This charge induces an opposite charge on the outer foil lining, and will remain for a fairly long time. Disconnect the leyden jar by touching the paper clip and the outside foil at the same time. You will feel a small shock. Large leyden jars can hold a considerable amount of charge. Caution should be exercised when discharging.

TSM
Teacher
Support
Material

Transition from Static to Current Electricity

In a discussion of the pedagogical order of statics and current electricity, Arons (1991) suggests that the order of the topics is not critical but that a connection between the two sets of phenomena is important. The historical order is valid and the intellectual struggle which took place provides a useful pedagogical model to develop a transition between static and current electricity.

Historical Order

A significant problem of the 18th century was the identification of different kinds of electricity — animal electricity, chemical electricity, static electricity, and current electricity. Faraday performed countless experiments to demonstrate the characteristics and similar nature of the various electricities. Consider the following table constructed by Michael Faraday in his experiments.

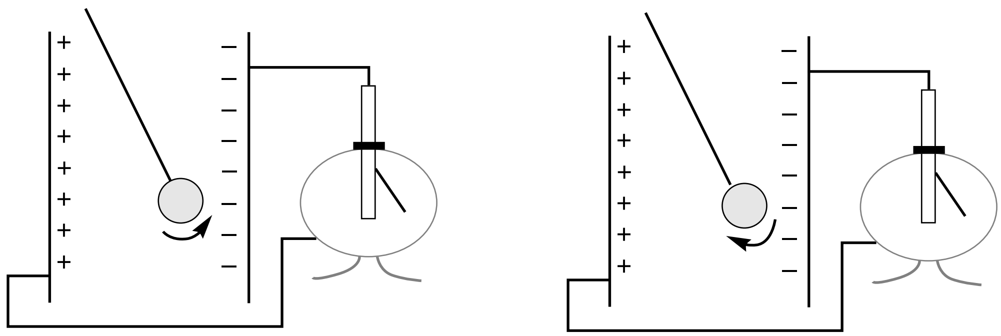
Faraday's Table*

Type of Electricity	Physiological Effects	Magnetic Deflection	Magnets Made	Spark	Heating Power	True Chemical Action	Attraction and Repulsion	Discharge by Hot Air
Voltaic	X	X	X	X	X	X	X	X
Common	X	X	X	X	X	X	X	X
Magneto	X	X	X	X	X	X	X	
Thermo	X	X	+	+	+	+		
Animal	X	X	X	+	+	X		

* 'x' denotes a characteristic found by Faraday.

To provide a transition from static to current electricity, we try to establish as many links as possible from Faraday's table (remember Faraday took many years to establish his table). The easiest to demonstrate in the classroom is the connection between static electricity, voltaic batteries, and ultimately the household outlet.

Arons (1991) began demonstrating the dynamic nature of charge by suspending a positively charged pith ball between two parallel conducting plates (see below). The electroscope monitors the charge on the plates.



When the plates are charged, the pith ball is attracted to the negative plate. When it touches the plate, negative charges move from the plate to the ball, charging it negatively. (The ball becomes a little more negative as the plate becomes a little less negative, as indicated by the leaves on the electroscope which move closer together.) The negatively charged ball is repelled by the negative plate and attracted by the positive plate and, therefore, swings towards the positive plate.

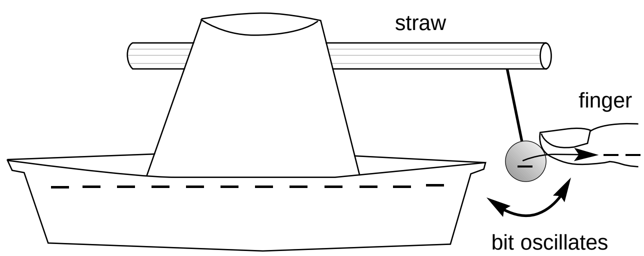
When it touches the positive plate, negative charges are transferred from the pith ball to the positive plate. The pith ball loses negative charges and becomes more positive. The plate gains negatives and becomes less positive. The positively charged pith ball is then repelled by the positive plate and attracted to the negative plate. As the pith ball touches the negative plate, the process is repeated until the plates are discharged. The leaves on the electroscope gradually come together as the swinging slows to a stop. This illustrates the dynamic nature of charge (i.e., the pith ball oscillates back and forth, transporting charge between the two plates, sort of like an electrostatic "motor").

TSM
Teacher
Support
Material

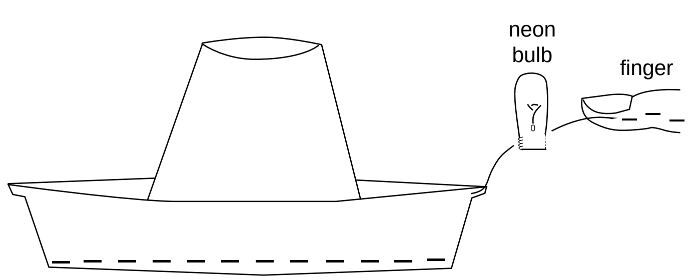
Pieplate Electrophorus

This demonstration can be easily adapted to the classroom using the aluminum plate electrophorus. To begin, charge the aluminum plate. The foil bit will be repelled from the plate, indicating the negative foil bit is repelled by the negative aluminum plate. Bring your finger nearby the foil bit. Charge is then transferred from the bit to the finger. The bit is then attracted back to the plate, and negatives are transferred from the plate to the bit. The bit oscillates back and forth between the plate and finger until the plate is discharged. (See the diagram below.) This demonstrates the dynamic nature of charge effectively.

To continue to do as Faraday did, replace your finger with a metal plate which is attached to a Wimshurst machine. By generating a charge on the Wimshurst, we can do work oscillating the ball between the metal plate and the aluminum plate. In other words, the system maintains a continuous transport of charge.



You can further extend the connection between static and current electricity by using a neon bulb (model NH–2), batteries, and an electrophorus. Connect the neon bulb in a simple circuit (requires about 70 v). The bulb flashes. Hold one terminal of the bulb between your fingers and bring it near a charged electrophorus. The bulb flashes in a similar fashion. The neon bulb emits electrons from the negative electrode which crash into the neon atoms emitting a reddish-orange glow at the negative electrode. By observing which electrode flashes, you can determine the direction of the current flow.



TSM
Teacher
Support
Material

Batteries and Bulbs

Conceptually tieing together static and current electricity permits the model for current electricity to be developed further.

Elaboration of our Model of Electricity

After the previous discussion of the transition from static to current electricity, extend the model to include basic circuits. Using batteries and bulbs, try to establish the following postulates.

1. An electric current is moving charges (electrons). The brightness of a bulb depends on the current through the bulb. As the electrons move through the conductor, they collide with the fixed particles of the conductor and the kinetic energy is transferred into heat and light in the resistance. More current means more electrons collide and, therefore, more energy is dissipated in the resistance. The brightness of the bulb is a qualitative measure of current.

2. Current is conserved. What goes in one end must come out the other end (Kirchhoff's current rule).

Use the brightness and conservation postulates to predict the lighting of bulbs in simple circuits. Resistance should be considered an obstacle to flow. Less resistance implies more flow and vice versa.

Current Summary:

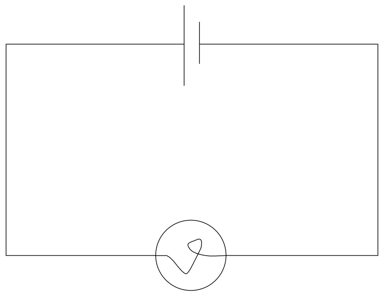
1. The greater the current, the brighter the glow.
2. Current is conserved.
3. Current is determined by the resistance.
4. Two objects in series are a larger resistance than one.
5. Two objects in parallel are a smaller resistance than one.

SLA
Student Learning Activity

Simple Circuits Lab (Student Version)

Build the following circuits one at a time. Record your observations in terms of the brightness of the bulb and the current through the bulb. Use the circuit in Question #1 as your standard (i.e., the brightness of the bulb, and consequently the magnitude of the current, is the same, less than, or greater than circuit #1).

1. Schematic of a Simple Circuit



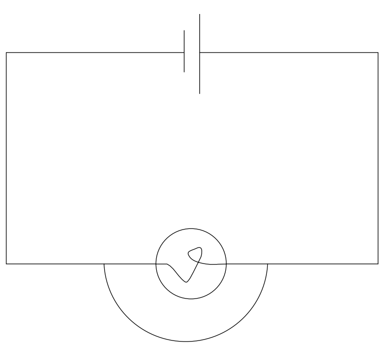
Observation:

2. Reverse the direction of the current in circuit #1, and illustrate the result in a schematic diagram. Compare your results to circuit #1.

Observation:

3. Short Circuit

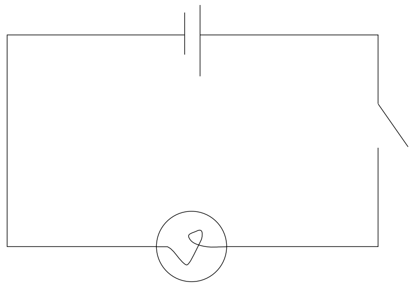
   Connect a wire across the terminals of the bulb. What happens to the light?



Observation:

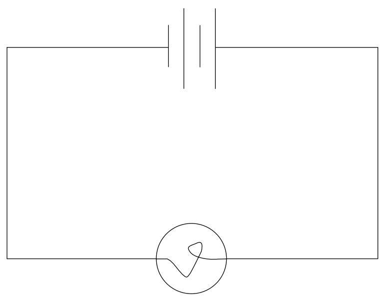
4. **Simple Circuit (Switched)**

   When does the light go off? Explain.



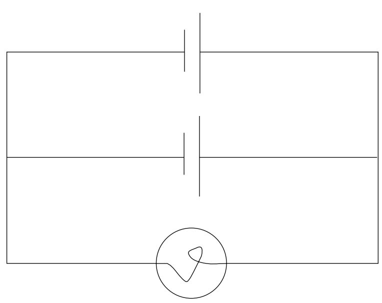
5. **Cells in Series**

   Compare to circuit #1.

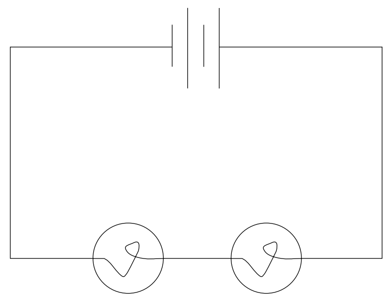


6. **Cells in Parallel**

   Compare to circuit #1.

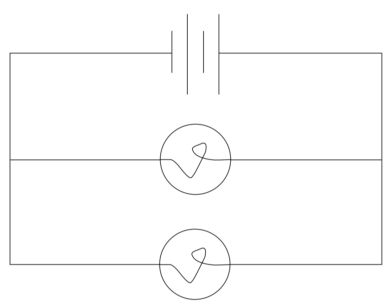


7. a. Make and compare the following circuit to circuit #1. Explain your observations in terms of the resistance of the circuit, brightness of the bulbs, and the current delivered to each bulb.



   b. Unscrew one of the bulbs. Explain what happens.

8. a. Make and compare the following circuit to circuit #1. Explain your observations in terms of resistance of the circuit, brightness of the bulbs, and the current delivered to each bulb.



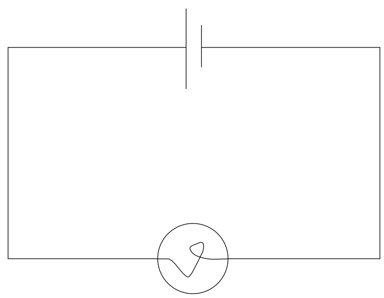
   b. Unscrew one of the bulbs. Explain what happens.

TSM
Teacher Support Material

Simple Circuits Lab (Teacher Version with Answers)

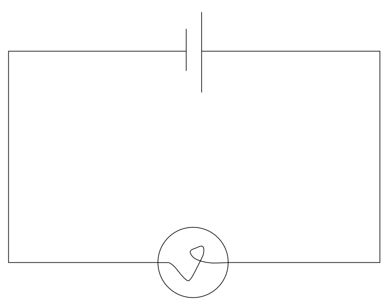
Build the following circuits one at a time. Record your observations in terms of the brightness of the bulb and the current through the bulb. Use circuit #1 as your standard (i.e., the brightness of the bulb, and consequently the magnitude of the current, is the same, less than, or greater than circuit #1).

1. **Simple Circuit**



The light goes on.

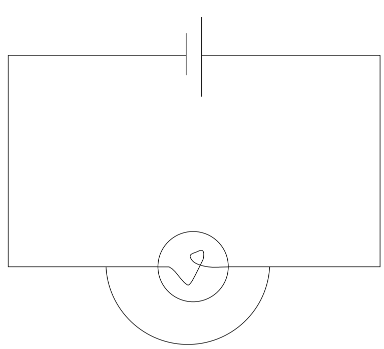
2. Reverse the direction of the current in circuit #1 and compare your results to circuit #1.



The direction of the current does not matter as the negative charges still pass through the bulb.

3. **Short Circuit**

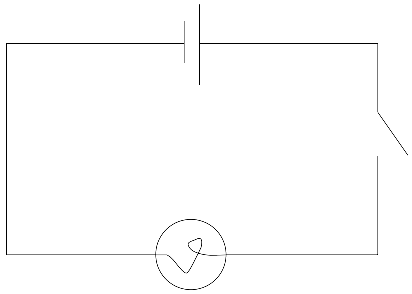
   Connect a wire across the terminals of the bulb. What happens to the light?



The bulb goes out. The bulb has a high resistance and the wire has a very low resistance. Most of the electrons take the path of least resistance.

4. **Simple Circuit (Switched)**

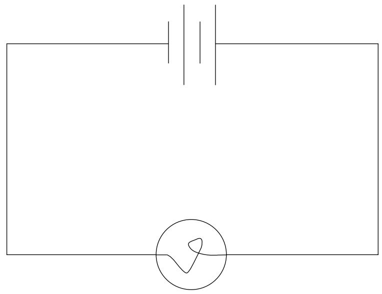
   When does the light go on? Explain.



The light goes on when the switch is closed and the electrons have a complete path.

5. **Cells in Series**

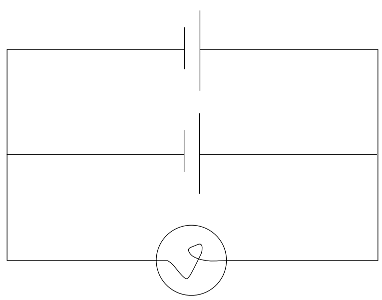
   Compare to circuit #1.



The bulb is brighter than circuit #1. Therefore, more current passes through the bulb for cells in series.

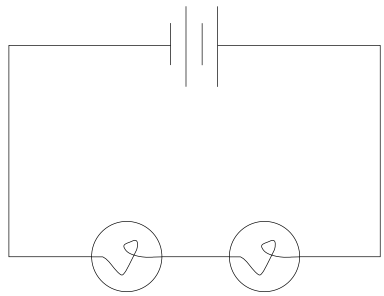
6. **Cells in Parallel**

   Compare to circuit #1.



The bulb is the same brightness as circuit #1. Therefore, the same amount of current must pass through the bulb.

7. a. Make and compare the following circuit to circuit #1. Explain your observations in terms of the resistance of the circuit, brightness of the bulbs, and the current delivered to each bulb.

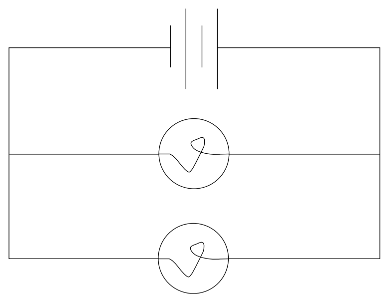


The brightness of the bulbs is the same as circuit #1. The voltage increases but the resistance also increases and the current is the same.

b. Unscrew one of the bulbs. Explain what happens.

The bulbs go out. The circuit is broken (like a switch) and the current does not have a complete path.

8. a. Make and compare the following circuit to circuit #1. Explain your observations in terms of resistance of the circuit, brightness of the bulbs, and the current delivered to each bulb.



Both bulbs are brighter than the bulb in circuit #1. The resistance is less and the voltage and current are greater.

b. Unscrew one of the bulbs. Explain what happens.

The bulb that is unscrewed will go out but the other bulb stays lit. The lighted bulb still makes a complete path with the battery.

BLM
Blackline Master

DC Circuits and Schematic Diagrams

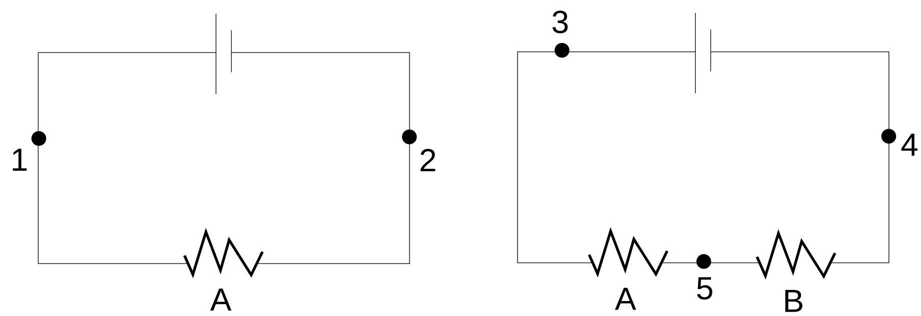
Use the following questions to assess your understanding of DC circuits.

1. Are charges used up in the production of light in a light bulb?

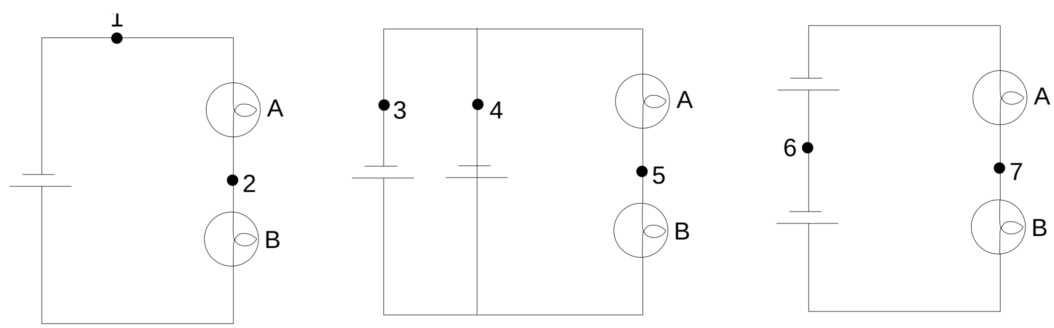
2. How can birds rest on a high voltage line without being electrocuted?

3. When you turn the tap on at home, the water comes out of the tap immediately. You do not have to wait for it to flow down from the water tower, reservoir, or well. Explain.

4. Suppose the current at point 1 is I. What value will the current be at points 1, 2, 3, 4, 5?

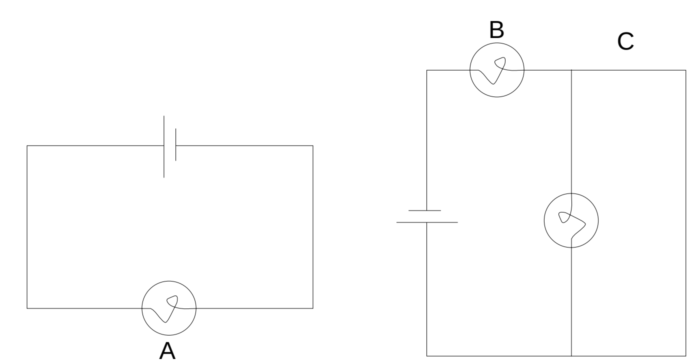


5. Suppose the current at point 1 is I. What value is the current at points 2, 3, 4, 5, 6, 7?

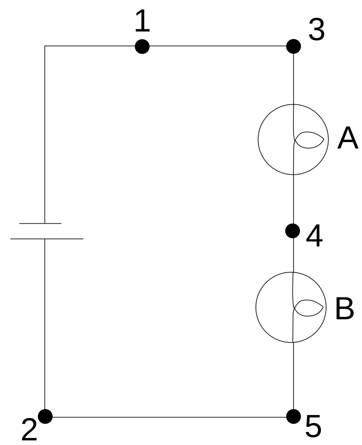


6. Why do the bulbs in the circuits built earlier come on instantaneously when you complete the circuit?

7. Compare the brightness of bulbs A, B, and C.

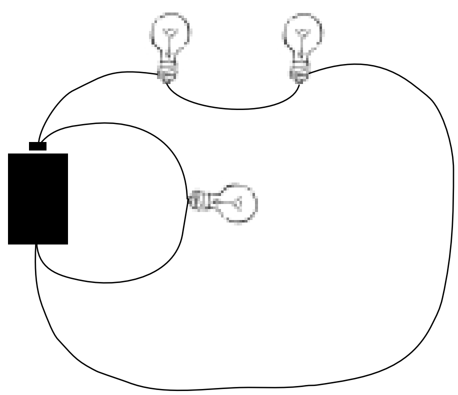


8. If the potential difference across the battery is V, what is the potential difference between the following points?



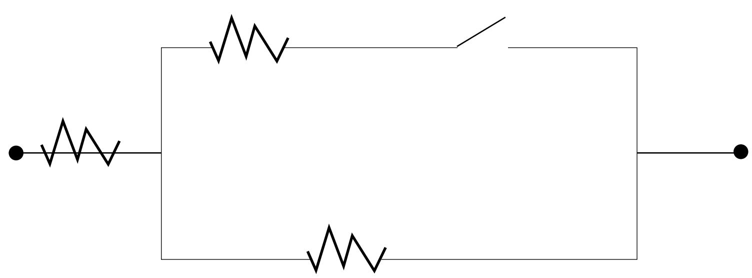
a. 1 and 2
b. 1 and 3
c. 3 and 4
d. 4 and 5
e. 2 and 5

9. Draw a schematic for the following circuit.



Schematic

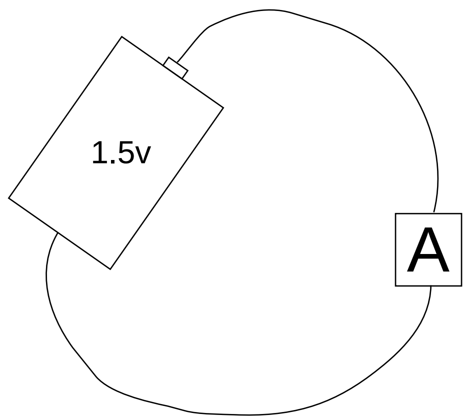
10. What is the resistance between the endpoints before and after the switch is closed if each resistance has a value of R?



SLA
Student Learning Activity

Circuits Lab 2 — Measuring Current, Voltage, and Resistance (Student Version)

1. Measure the current between the electrodes of a 1.5 volt battery.



2. Measure the current through a single bulb. Infer a rule for current and resistance.

   Draw a Schematic.

3. Compare the voltage across the battery in a simple circuit (circuit #1 from Activity 3.9) to the voltage across the resistance. Infer a rule for the voltage supplied to the cell and the voltage used in the circuit. What happens if you apply a large voltage to a circuit?

   Draw a Schematic.

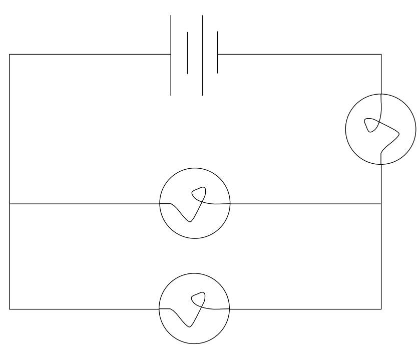
4. Measure the voltage and current in a simple circuit with one bulb and one cell.

   Draw a Schematic.

5. Measure the voltage and current in a simple circuit with one bulb and two cells. Compare to question #4. Infer a rule between voltage and current if resistance remains constant.

   Draw a Schematic.

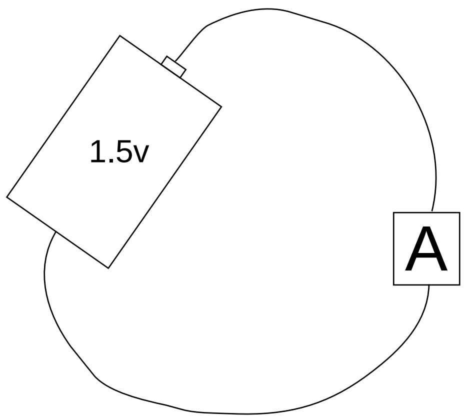
6. *Optional*. Combine the relations from question #2 and question #5 to make a simple law relating voltage, current, and resistance. Check your law using the following circuit. Draw a schematic to show where you would place the meters.



TSM
Teacher Support Material

Circuits Lab 2 — Measuring Current, Voltage, and Resistance (Teacher Version with Answers)

1. Measure the current between the electrodes of a 1.5 volt battery.



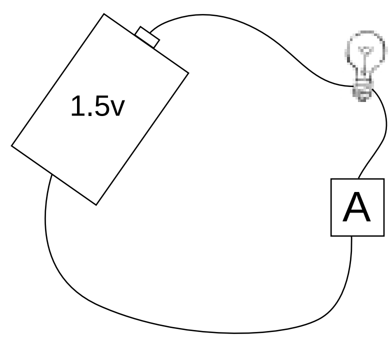
The current is about 3-4 A (be sure to use an ammeter which is capable of measuring up to 5 Amperes).

2. Measure the current through a single bulb. Infer a rule for current and resistance.

   The current is approximately 0.2 A. If resistance increases, current decreases.

Draw a Schematic.

Draw a diagram like this:

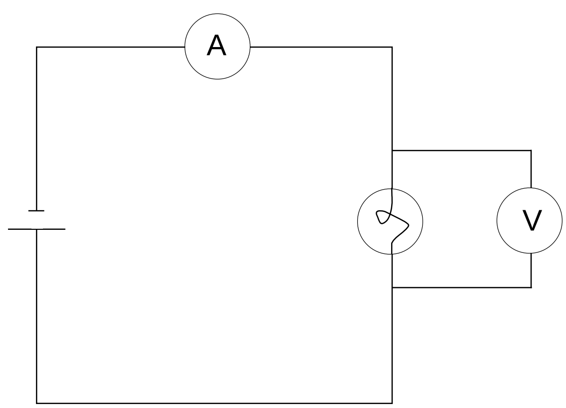


3. Compare the voltage across the battery in a simple circuit (circuit #1 from Activity 3.9) to the voltage across the resistance. Infer a rule for the voltage supplied to the cell and the voltage used in the circuit. What happens if you apply a large voltage to a circuit?

   Draw a Schematic.

   The voltages are equal. The voltage supplied to a circuit is used in the circuit. If a large voltage is applied, it will be dissipated in the circuit. If it is too large, the wires will burn.

4. Measure the voltage and current in a simple circuit with one bulb and one cell.

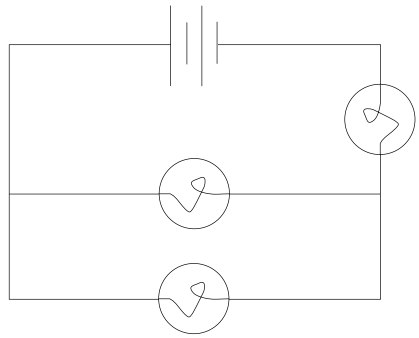


5. Measure the voltage and current in a simple circuit with one bulb and two cells. Compare to question #4. Infer a rule between voltage and current if resistance remains constant.

   Draw a Schematic.

   The voltage increases for cells in series (about 3.0 v for two flashlight batteries). The current is about 0.4 A. Therefore, for a constant resistance, if the voltage increases, the current increases.

6. *Optional*. Combine the relations from question #2 and question #5 to make a simple law relating voltage, current, and resistance. Check your law using the following circuit. Draw a schematic to show where you would place the meters.



V = IR.

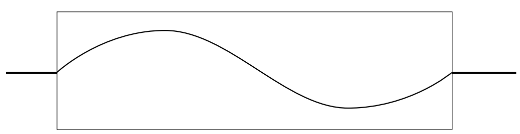
From #2, $I \propto \frac{1}{R}$

From #4, $V \propto I$

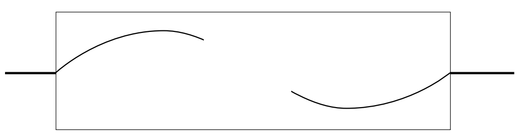
Therefore, $V = I \cdot R$ *(Ohm's Law)*

The Electric Panel

Fuse



Fuse burns and circuit breaks



SLA
Student Learning Activity

Power Calculations

Questions:

1. Calculate the power of each appliance.
   a. A 120 V can opener draws 2.5 A of current.

   b. A TV connected to a 120 V line draws 1.2 A.

   c. A flashlight using four 1.5 V cells draws 80 mA.

2. Find the potential drop across a 1200 W toaster which draws 9.8 A of current.

3. What current is drawn by a 1400 kW iron in a 120 V circuit?

4. Rationalize the units of Volts x Amperes to Joules (i.e., show that a Volt-Ampere is the same unit as a Joule).

Senior 1

Appendices:
Cluster 4
Exploring the Universe

SLA
Student Learning Activity

Astrolabe Construction

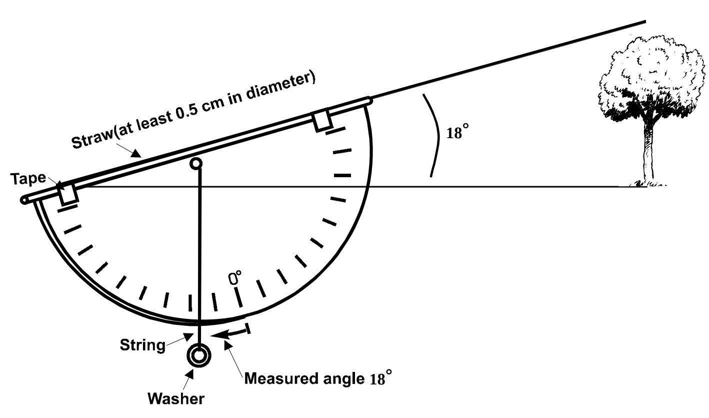
Materials:

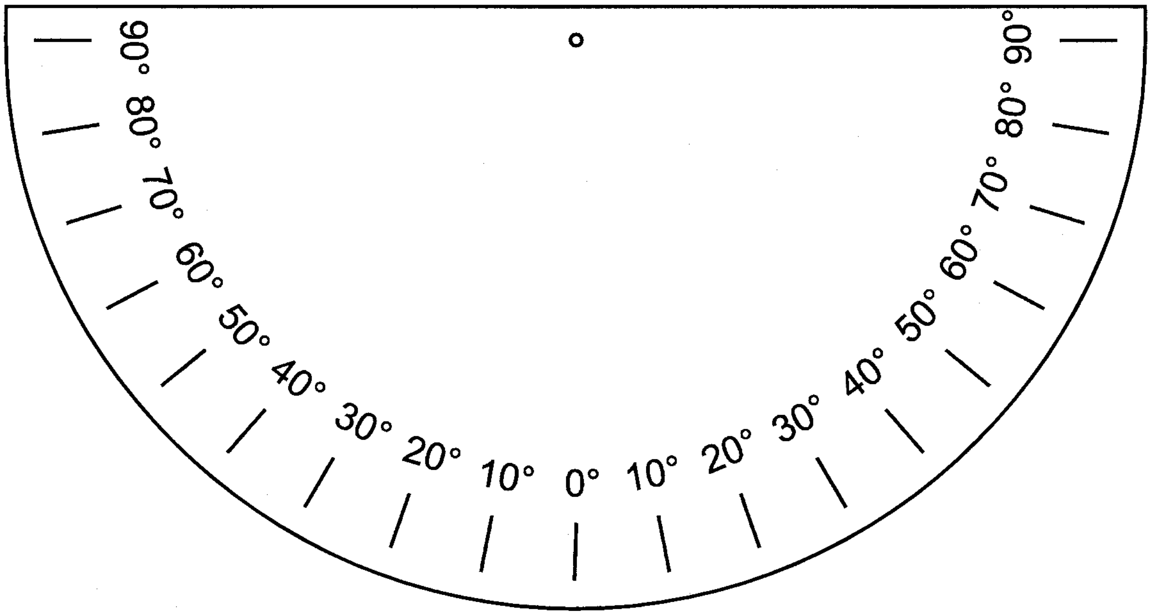
- thick corrugated cardboard (about 8.5" x 11" or similar)
- scissors
- 20 cm of thin string or coloured fishing line
- weight (washer, nut, lead sinker, or similar object that can be tied onto the string)
- large drinking straw (at least 0.5 cm in diameter)
- glue
- transparent tape
- small block of 0.5" plywood or pressboard (optional)

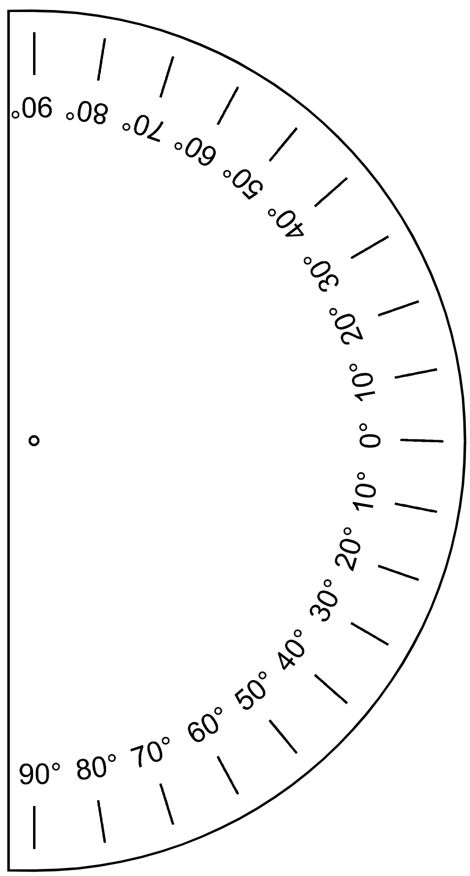
Directions:

1. Carefully cut out one of the astrolabe templates on the following page, according to desired size.
2. Glue the template securely to the cardboard, and then cut out the template/cardboard in the semi-circular shape of the template. Discard the remainder appropriately.
3. Carefully pierce a hole at the ‘o’ in the centre of the template. You may wish to ask for assistance in this.
4. Put the string through the hole and tie a knot, then tape it in place on the reverse side of the template. The string should now hang freely on the front side of the template.
5. Tie the weight to the end of the string so that it hangs at least 10 cm below the edge of the astrolabe.
6. Tape (or glue) the straw securely along the flat side of the astrolabe, and test to ensure that you can see through the straw.
7. For a longer-lasting device, you may wish to mount it on a semi-circular piece of plywood that has been carefully cut to fit the size of the template. **Use caution when working with hand tools.**

The astrolabe that you have constructed should appear similar to the one pictured below. You should easily be able to sight large objects through the straw. Your device is now ready to be field-tested with an activity involving the *altitude* of objects above the horizon.




90° 80° 70° 60° 50° 40° 30° 20° 10° 0° 10° 20° 30° 40° 50° 60° 70° 80° 90°


90° 80° 70° 60° 50° 40° 30° 20° 10° 0° 10° 20° 30° 40° 50° 60° 70° 80° 90°

SLA Student Learning Activity

Locating Celestial Objects Using a System of Coordinates

Purpose:

To use the constructed astrolabe and an orienteering-type compass to locate and determine the *altitude* and *azimuth* of a selection of objects in the night sky.

Note: If the activity cannot be done at night, substitute objects that are visible around you during the day, (e.g., buildings, trees, etc.). This is not, however, the most desirable option.

Caution: DO NOT directly observe the Sun as part of this activity.

Materials:

- student-constructed astrolabe
- orienteering-type compass for measuring azimuth
- logbook or chart to record measurements (see sample below)
- simplified star chart or planisphere

Procedure:

1. Select at least five objects in the night sky that you wish to locate and that will be visible at the time you are doing the activity: the Moon; bright planets such as Venus, Mars, Jupiter and Saturn; easy to find stars such as Polaris (the North Star), Vega, and Arcturus are the easiest to locate until you are more familiar with the night sky at your location.
2. Using the compass, determine the *azimuth* of the object by visually tracing a line from the object in the sky straight down to the nearest horizon point, and reading its compass bearing (e.g., 90 degrees would be due east, 180 degrees would be due south, etc.). Record this in your chart or logbook.
3. Using the "hand-angle technique" that you have learned and practised, estimate the *altitude* of the object of interest. Record your estimates in the chart or a personal observation logbook.
4. Using the astrolabe, look through the straw until you can see the object centred in the field of view. While holding the instrument steady, use your free hand to pinch the string against the scale on the astrolabe until you are able to record the *altitude*. Repeat this at least two more times for the same object, and average the three readings in order to increase the precision.
5. Be prepared to discuss with a classmate or group how you determined your readings. It may be useful to arrange for you and another classmate to observe the same selection of objects at the same time, and compare your results.

Data Chart: Azimuth and Altitude Readings

Date and Time of Observation	Object Viewed	Azimuth (in degrees) from Compass	Altitude Estimate Using Hand-Angle Technique	Altitude as Measured by Astrolabe

SLA
Student Learning Activity

Observing and Charting the Motions of Celestial Objects

Purpose:

To observe and record, over a period of time, the apparent motions of easily visible celestial objects, and to organize data for eventual display. The three objects of interest here will be the Sun, Moon, and at least one bright planet (e.g., Venus, Mars, Jupiter, Saturn).

Materials:

- student-constructed astrolabe
- orienteering-type compass
- logbook or data chart for recording (see below)
- seasonal star charts (or planetarium software)
- plotting software such as *Excel™* or *Curve Expert™*

Procedure:

Tracking the Moon:

1. Use a calendar to determine when the next “New Moon” occurs. This will be Day 1 of the observation program.
2. Over a period of 14 days (or longer if possible), and always observing at the *same time* each evening, determine the altitude and azimuth of the Moon using your astrolabe and compass. A convenient time may be 8 p.m. in the fall or spring or 6 p.m. in the winter months.
3. In your data chart or logbook, record the position of the Moon as co-ordinates (e.g., *altitude* 12°, *azimuth* 175°) (see chart below).
4. Sketch the appearance of the Moon and record the percentage of its face that is illuminated (i.e., First Quarter Moon is 50% illuminated from our point of view, Full Moon is 100% illuminated, etc.).
5. Continue to record these data for 14 successive nights. If cloudiness is a problem, skip that day in the data entries. If you cannot observe, obtain a classmate’s data.
6. Plot your data (see graphs below). On the first graph, plot the Moon’s *Azimuth* vs. the *Day Number*. On the second graph, plot the Moon’s *Altitude* vs. *Day Number*. Make your dots large enough to see clearly on the graph, and join them together with straight lines.

Extension:

1. Create a “rose petal diagram” by plotting your data on circular *polar graph paper* if available. Use the outer circle to mark off your azimuth directions (i.e., 0° is north, 90° is east, etc.). The lines that go out from the centre will be your altitude (with 0° altitude at the centre of the circle and 90° altitude at the outer edge of the circle).

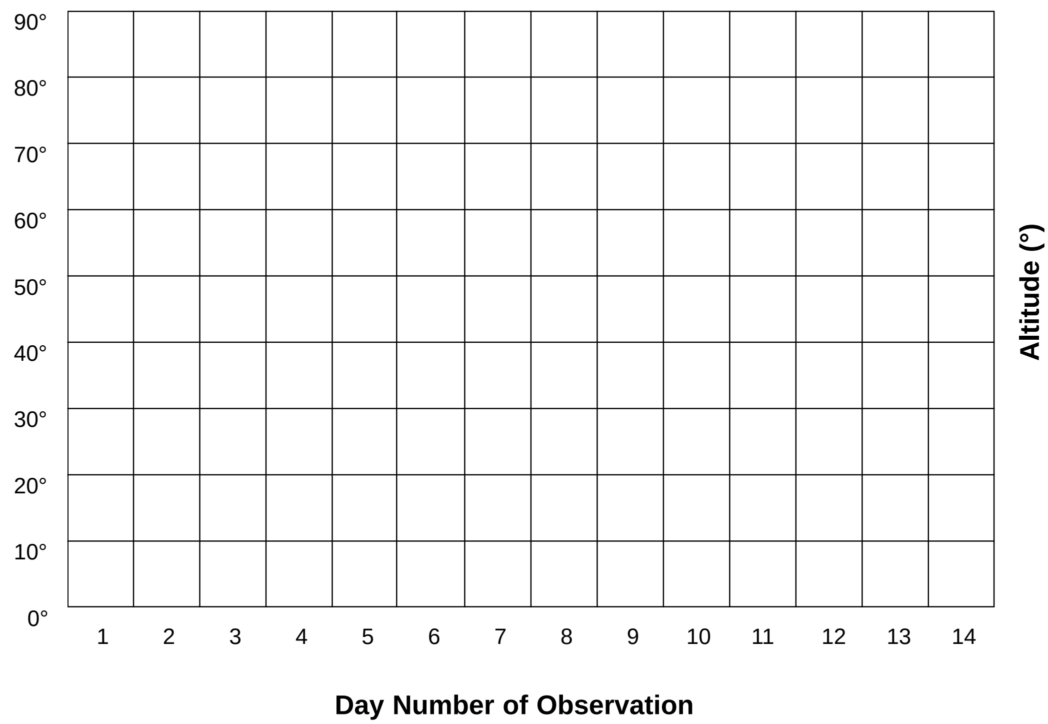
2. Investigate a second set of co-ordinates used by astronomers — *Right Ascension* and *Declination*. Instead of changing with time as altitude and azimuth do, these co-ordinates are similar to longitude and latitude on the Earth. They remain constant as the Earth rotates and revolves around the Sun. Good star charts will include the grid lines of right ascension and declination.
3. Plot the position of the Moon or planets over a series of evenings directly on a simplified star map. This is a good way of tracking the apparent movements of these solar system objects. If you are really adventurous, get some data on large asteroids (e.g., Vesta, Ceres) and follow their movements from night to night.

Data Table: Lunar Observations Over 14 Days

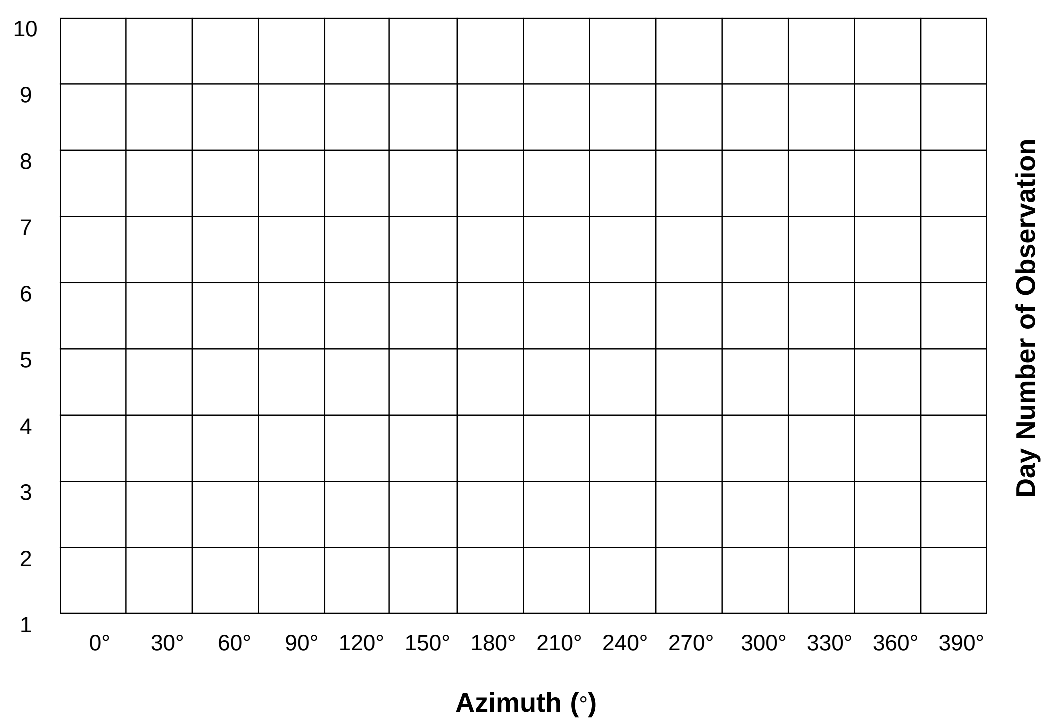
Date and Time of Observation	Altitude of Moon	Azimuth of Moon	Moon's Appearance	Percentage of Illumination of Moon

Data Plots of Lunar Observations:

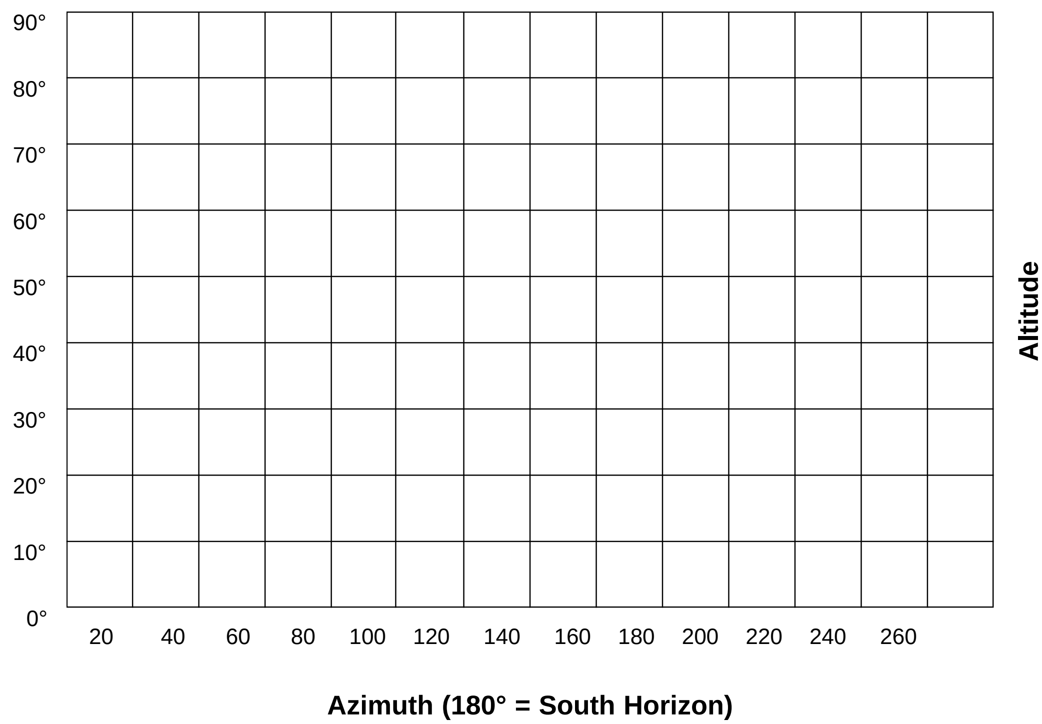
Altitude of Moon Above Horizon Over 14-Day Period



Azimuth of Moon Above Horizon Over 14-Day Period



Altitude vs. Azimuth for the Moon Over 14-Day Period



Extension:

Plot additional graphs from the data you've collected on the position of a planet such as Venus, Mars, or Jupiter. If you choose to plot position data for the Sun, it is strongly recommended that you consult tables of data available from such sources as the Royal Astronomical Association of Canada (http://www.rasc.ca).

Make copies of the following blank chart to collect and organize your data.

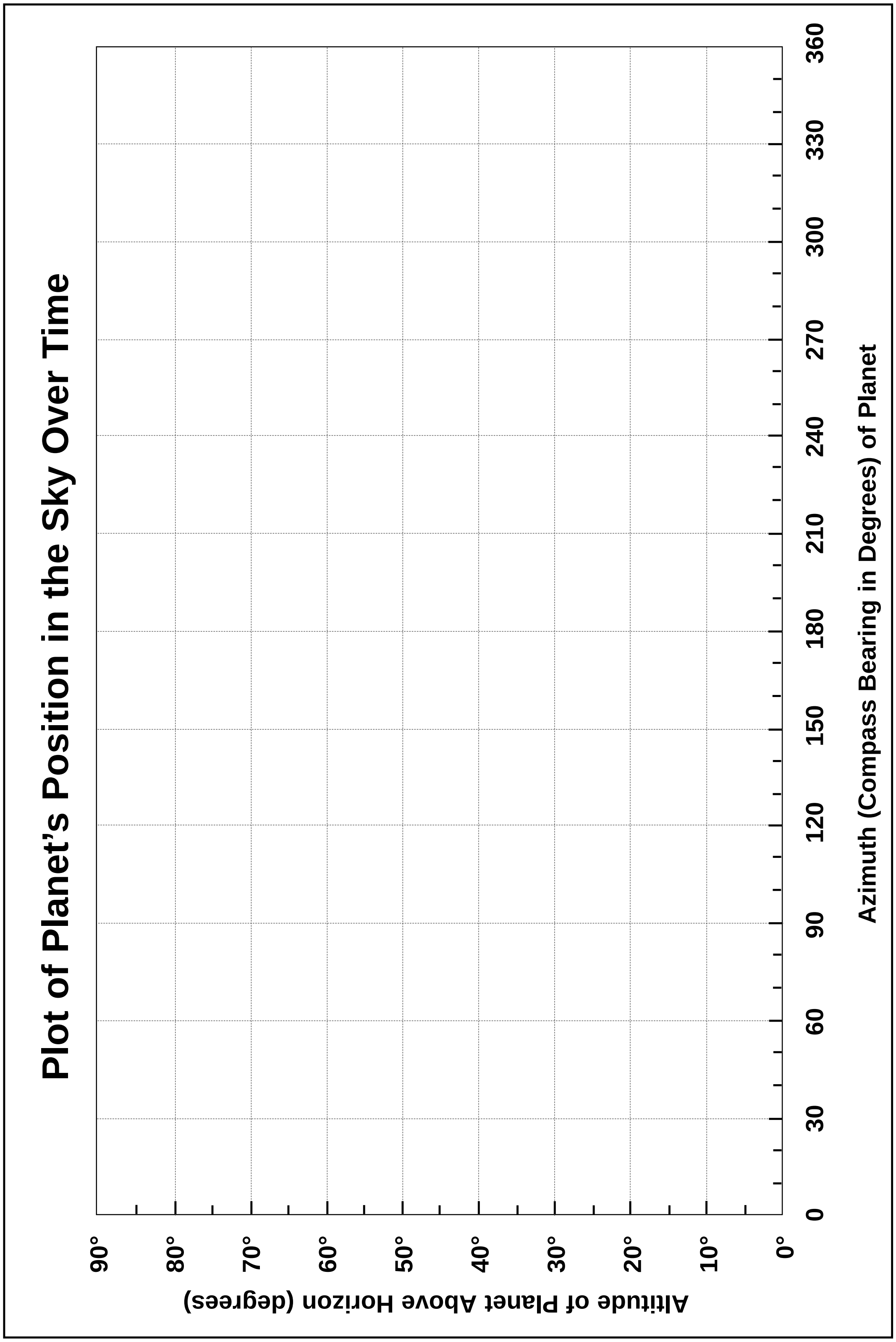
Data Table #__: Planet Observations Over Time

Name of Planet or Other Celestial Object: ______________________________________

Date and Time of Observation	Altitude of Planet or Object	Azimuth of Planet or Object	Right Ascension (optional)	Declination (optional)

Planet's Position Over Time: Altitude/Azimuth

Plot #___:



Questions:

1. You see a certain star directly overhead while you are observing. What is the name given to this location in the sky, and what would the star's altitude be?

   ____

   ____

2. What are the co-ordinates of a planet that is visible in the southeast and is estimated to be halfway up in the sky from the horizon?

   Altitude: __________________________ Azimuth: __________________________

3. What are the co-ordinates of the Moon when its position is due east and 10° above the horizon?

   Altitude: __________________________ Azimuth: __________________________

4. Wherever you are in the Northern Hemisphere, Polaris (the "North Star") always approximates true north. (It is actually off true north by about one-fourth of a degree.) You can also determine your latitude by measuring the altitude of Polaris using the techniques you have already learned.

   If you lived at Cross Lake, Manitoba (latitude is 54.0° N), what would be the altitude/azimuth of Polaris at all times?

   Altitude: __________________________ Azimuth: __________________________

5. Based on your observation of the Moon's position over a 14-day period, describe the changes you observed in its position from night to night (all observations made at the same time each night).

   ____

   ____

   ____

   ____

   ____

   ____

   ____

6. If you observed the Moon's azimuth to be 240° at 8 p.m. on one night, predict what its azimuth would be on the next two consecutive nights at the same time.

   Azimuth Day 2: ____________________ Azimuth Day 3: _____________________

Motion of the Sun as Seen from Earth

SLA
Student Learning Activity

Purpose:

To collect, graphically present, and interpret data on the position of the Sun over the course of a school year. If time does not permit this, it is advisable, at the very least, to collect data on the Sun's position during the course of a single day.

Note: If you are observing for a period of hours over just one day, use the last two columns of the data chart only.

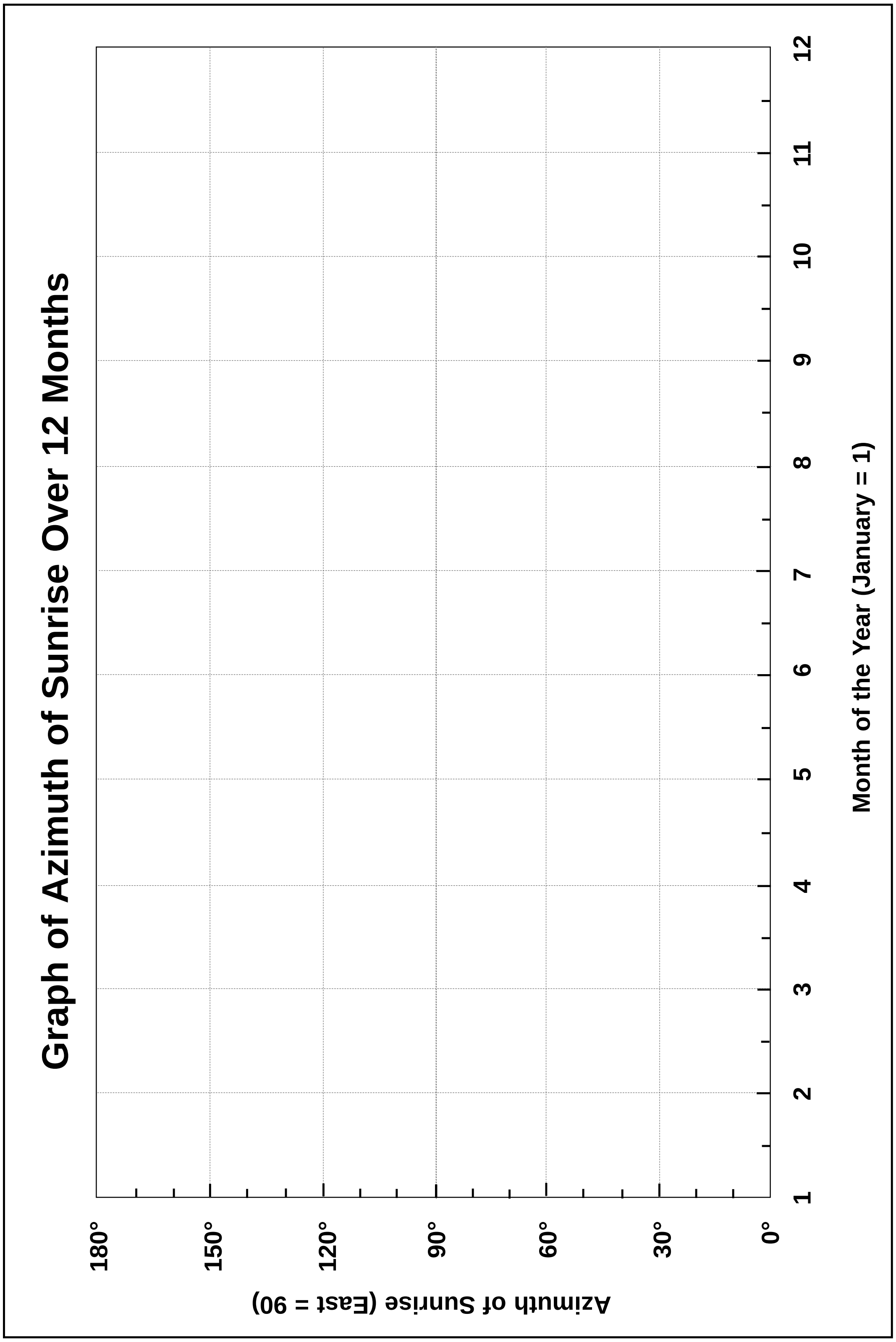
Materials:

- access to a database of the Sun's rising/setting positions or direct observations (conducted with all necessary safety precautions)
- student-constructed astrolabe
- orienteering-type compass
- logbook or data chart (see chart on the following page)
- sunrise/sunset charts (or a planetarium software program)
- plotting software such as *Excel™* or *Curve Expert™*

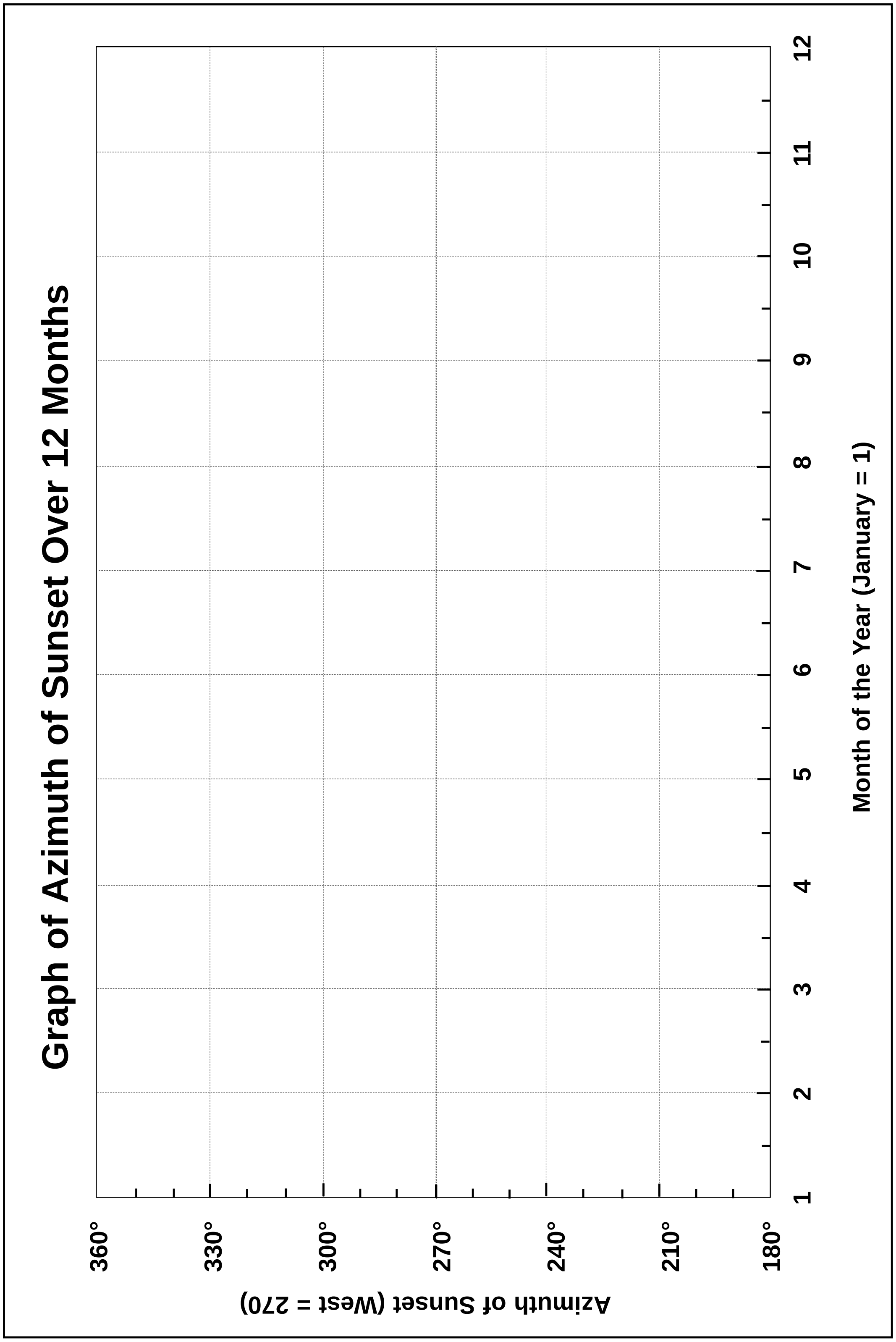
Data Table: Solar Observations Over Time

Date and Time of Observation	Azimuth of Sunrise	Azimuth of Sunset	Altitude of Sun (for single day observing)	Azimuth of Sun (for single day observing)

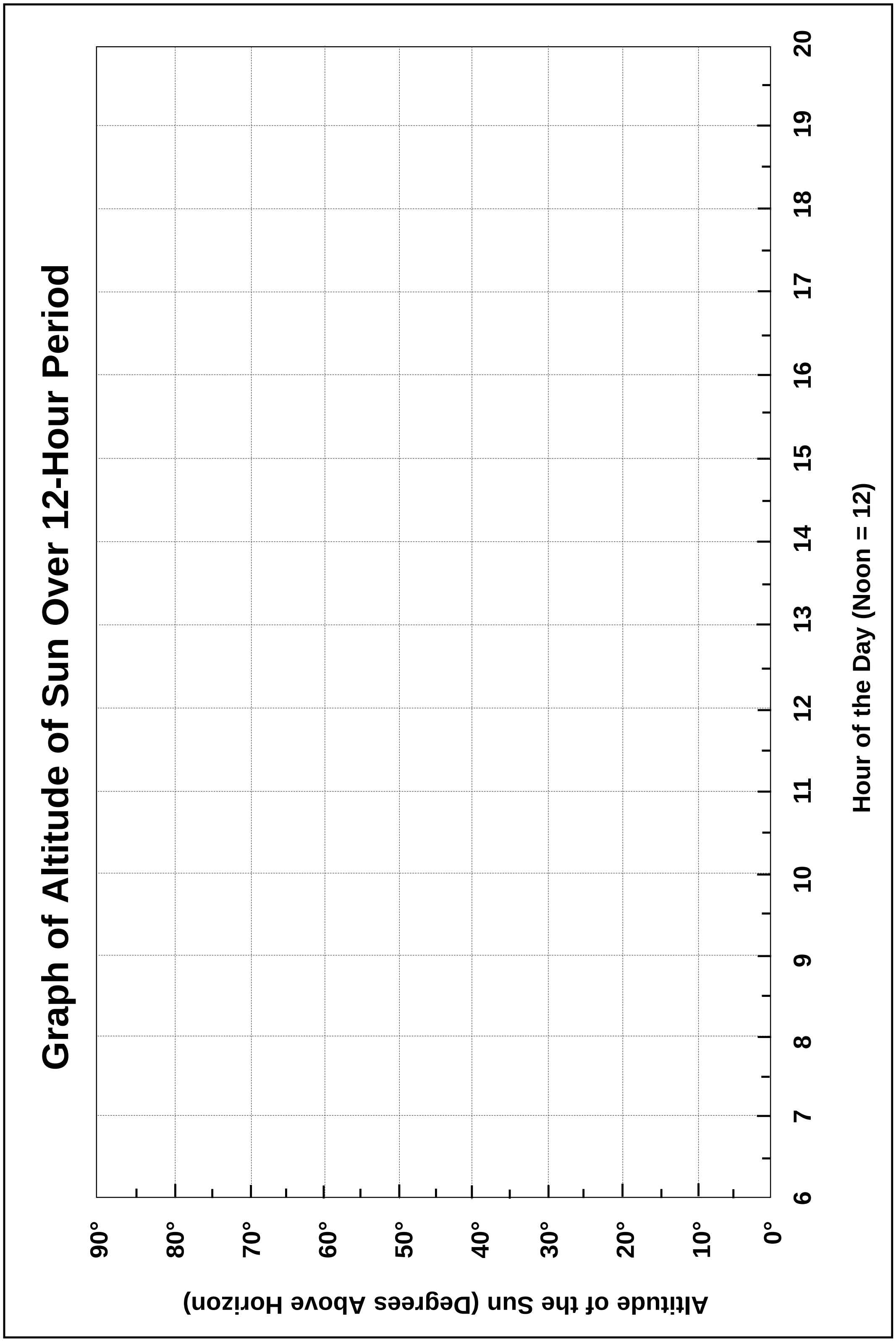
Azimuth of Sunrise



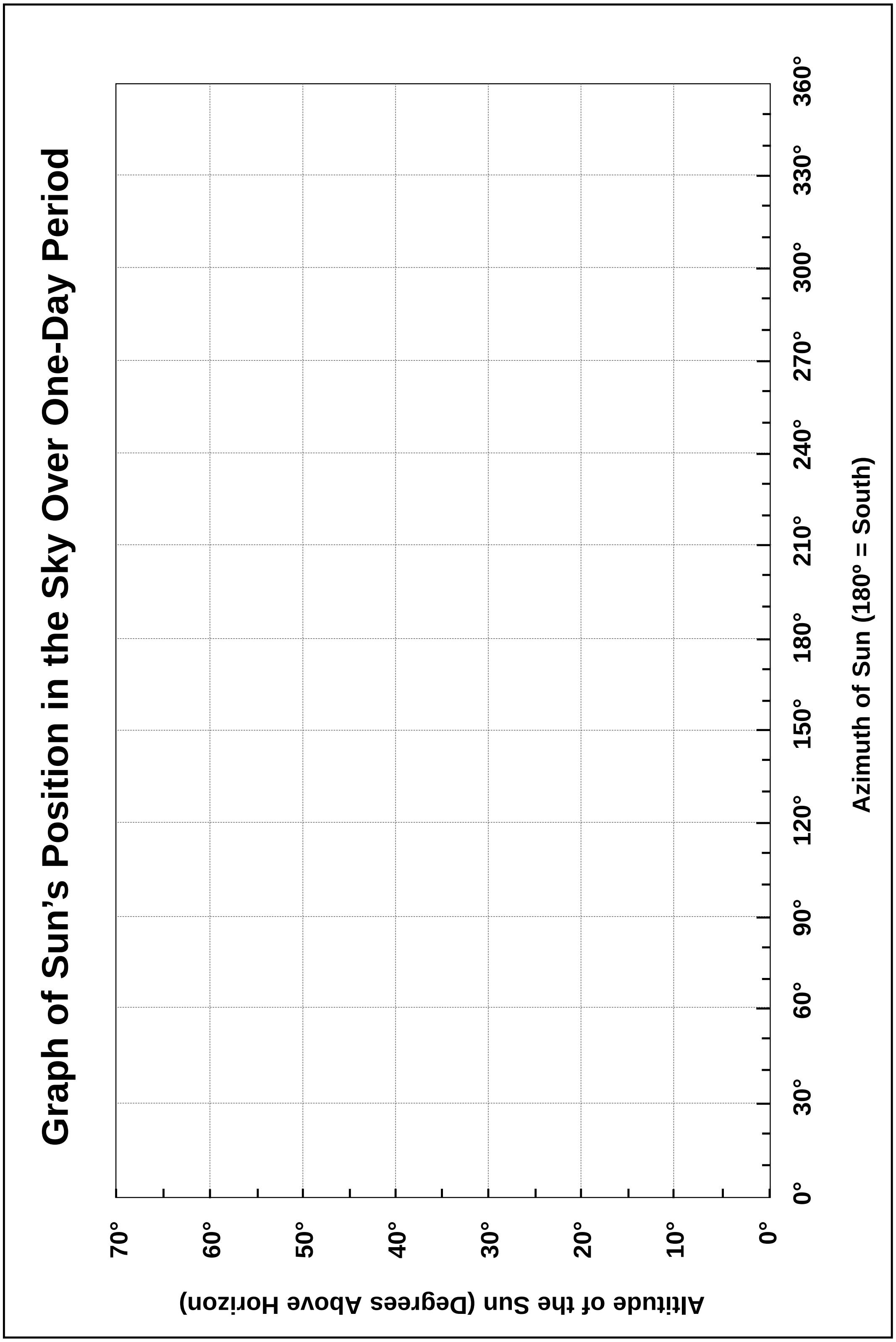
Azimuth of Sunset



Sun's Altitude



Sun's Altitude and Azimuth



Follow-up Questions:

1. Over the course of a period of months, what changes did you observe in

   the position of the Sun at sunrise?____

   ____

   ____

   the position of the Sun at sunset? ____

   ____

   ____

2. In which two months of the year does the Sun rise and set *exactly* in the east (90) and west (270) respectively?

   ___________________________________ and ____________________________________

3. What is the significance of the two times of year mentioned in your answer to #2 above? What is the significance to the calendar?

   ____

   ____

   ____

   ____

4a. During what season of the year does the Sun rise furthest to the *north* on the horizon?

   ____

4b. During what season of the year does the Sun set furthest to the *south* on the horizon?

   ____

4c. Using your own background knowledge or independent research, what is responsible for the changes you observed in the rising/setting of the Sun over a period of months?

   ____

   ____

   ____

   ____

5. If you completed the data set on the altitude/azimuth of the Sun over a 12-hour period, answer the following based on your observations.
   a. During what season of the year did you make these observations and/or collect your data?

      ____

   b. At what time of day did the Sun reach its maximum altitude according to your data?

      ____

   c. If your time in part (b) above was not 12:00 noon local time, how would you explain this to a friend?

      ____

6. The planet Venus is unique in the solar system — its day is actually *longer* than its year! A day (sunrise to sunrise) on Venus lasts 243 days. Venus also has *retrograde rotation*, which means the planet rotates in a direction opposite to that of the Earth. On Venus, the Sun rises in the west and sets in the east! If you were an observer on Venus, what changes would you expect to see in your graphs completed for this learning activity?
   - ____
     ____
     ____
   - ____
     ____
     ____
   - ____
     ____
     ____
   - ____
     ____
     ____

SLA
Student Learning Activity

Monitoring the Retrograde Motion of the Planet Mars

Background Information:

The graph below (Figure 1) is a representation of the movement of the planet Mars over an 18-month period during 1988 — the last time the retrograde motion of Mars was easily visible to Earth observers. The next best time will be in 2005, and every 17 years after that. Although this phenomenon can always be seen, it is best observed when Earth and Mars are at their closest approach.

The motion of Mars as observed from Earth can be described using a race analogy. Imagine two runners named Tellus (the Earth) and Areos (Mars) who are racing around a track that is almost perfectly circular. Rather than allowing Areos (the outside runner) to start the race further along the track than Tellus (the inside runner), the two runners start side by side. Since Tellus can run faster than Areos (because he is closer to the Sun), Areos quickly begins to fall behind. As Tellus gains on Areos, there will be a short period of time where it will appear as though the outside runner slows down, stops momentarily, and then goes backwards. This is only an illusion, of course, as both runners are always travelling forward around the track.

The graph below shows where Mars appears to slow down, then stops, and reverses direction for a brief period before resuming its normal movement across the sky. We call this *retrograde motion*. In this observational activity, you will be plotting some data in order to examine something that was a very difficult idea for ancient astronomers to explain.

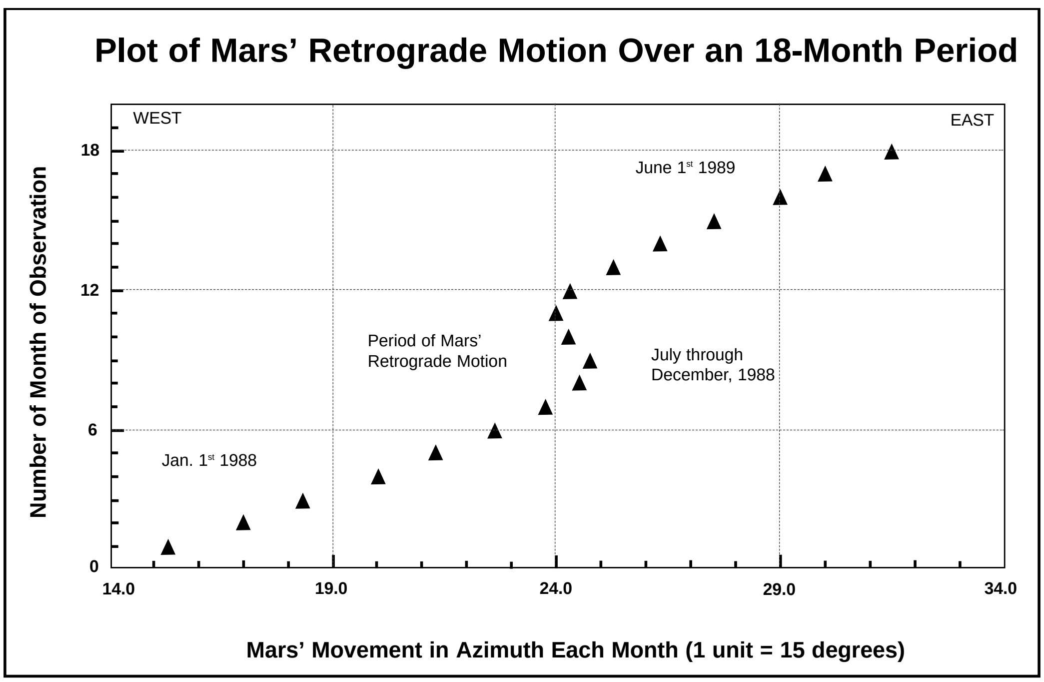


Figure 1: Retrograde Motion of Mars

Does This Planet Have Retrograde Motion?

Purpose:

To monitor and record the motion of Mars over time to better understand retrograde motion.

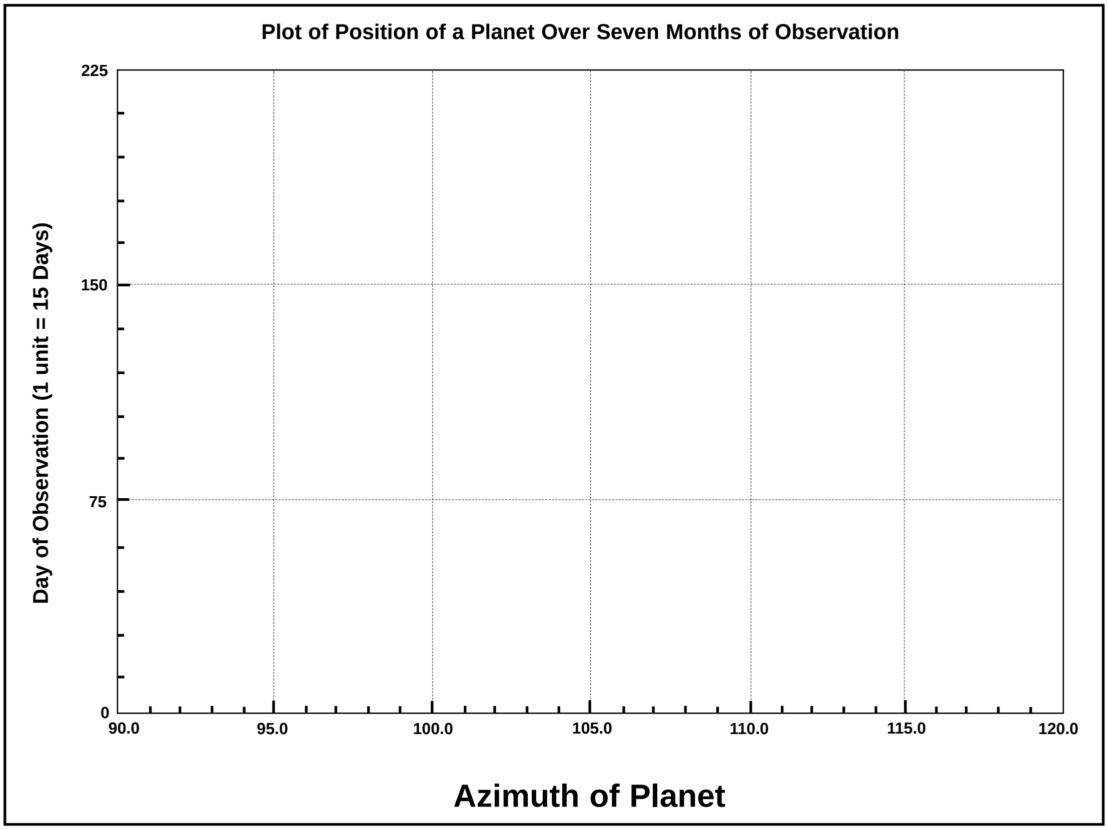
Procedure:

Using the data set that appears below, plot each position carefully on the blank graph on the next page. Label each point you plot with the date of the observation to better simulate actual measurements. Join all of the points with a smooth line.

Data Chart: Planet Positions

Date of Observation	Azimuth of Planet
July 1	112.5°
July 15	105.0°
August 1	98.25°
August 15	94.0°
September 1	93.75°
September 15	94.0°
October 1	97.5°
October 15	102.0°
November 1	108.75°
November 15	109.0°
December 1	101.25°
December 15	95.0°
January 1	90.0°

Position of Planet



Follow-up Questions:

1. How does your plot compare with that of Mars (see Figure 1)? Identify at least two similarities and two differences.

____

____

____

____

2. Does this planet revolve around the Sun in the same direction as the Earth? Justify your answer based on the data you have presented above.

____

____

____

____

3. Write a simple procedure to make planetary observations (of Mars or Jupiter), including recording and graphing the data, and presenting the graph to your classmates.

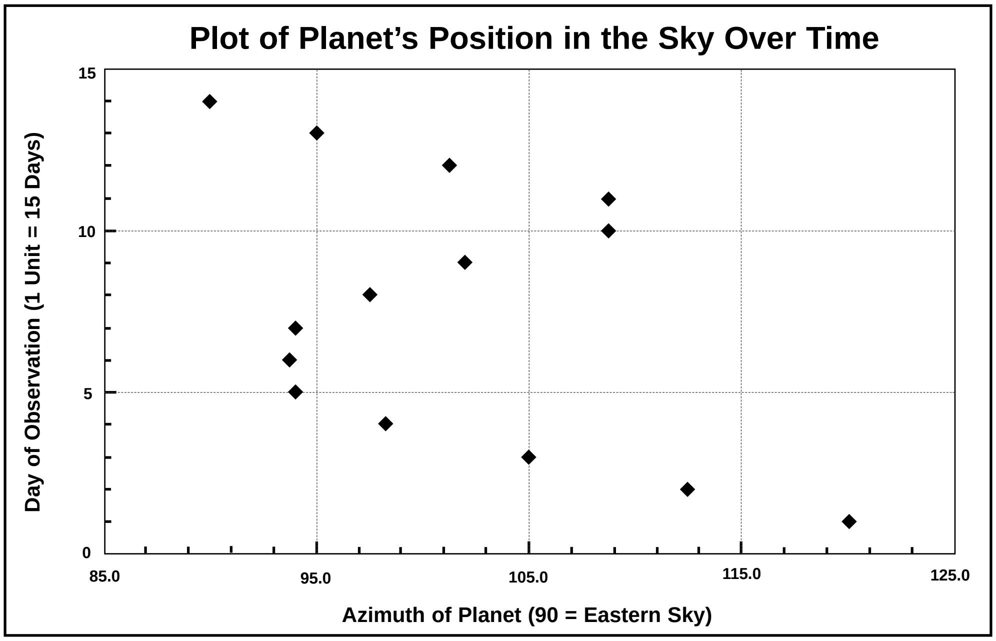
   - ____
   - ____
   - ____
   - ____

4. Imagine that you are one of the ancient Greek astronomers (perhaps Ptolemy) and you are seeking an explanation as to why Mars periodically and mysteriously slows down, stops moving for a couple of weeks, reverses its motion against the background of distant stars, and then resumes its normal eastward movement across the sky. Furthermore, you have noticed by searching your records that this happens most dramatically every 17 years or so.

   Design a model of the cosmos that will satisfy the best minds of your age. Research the topic of *retrograde motion* and see how the early astronomers solved this problem. Report the five (5) most significant ideas from your research in the space below.

   - ____
   - ____
   - ____
   - ____
   - ____

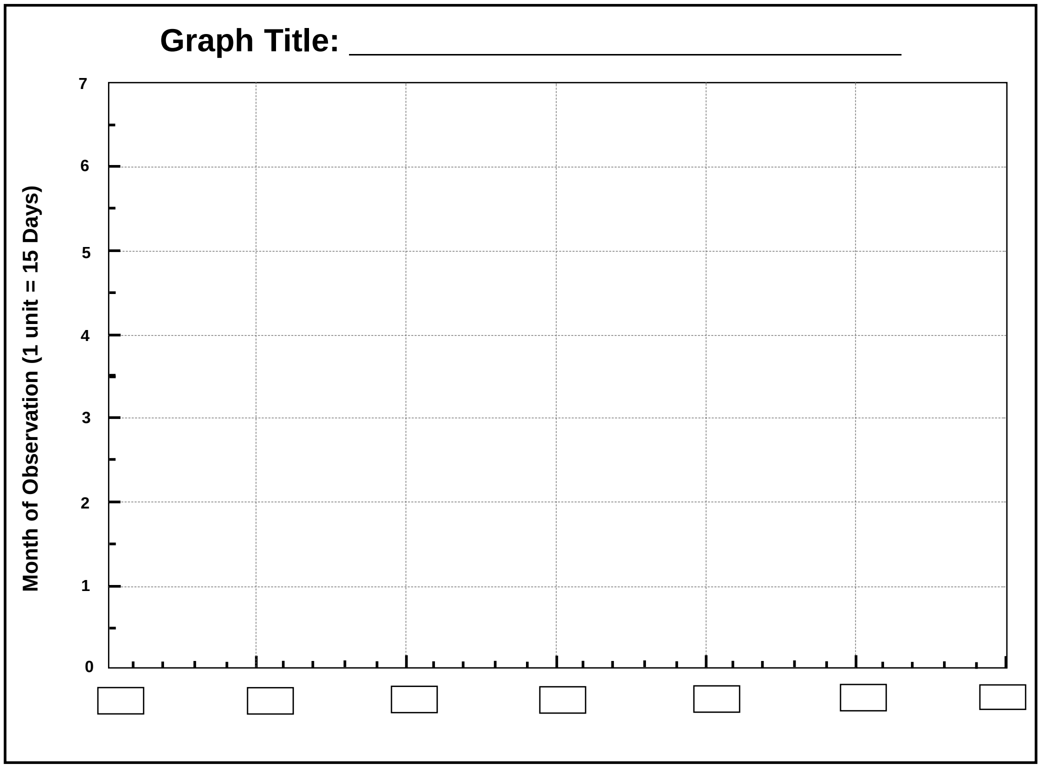
5. Compare your graph to the one that appears below. After examining your own work, comment on how successful your graphing technique was, and make a few notes for the future. Complete the checklist of graphing skills below.



Checklist of Graphing Skills	Name: ______________________			
	NI	**S**	**E**	**Comments**
Standard Elements — selects appropriate type of graph				
— uses appropriate scale for each axis				
— chooses appropriate origin and intervals along each axis				
— labels axes clearly				
— states in the graph's main title the relationship between axes				
— places independent variable on the *x*-axis				
— places dependent variable on the *y*-axis				
— includes key or legend when necessary				
Data — plots data accurately				
— depicts trends (when applicable)				
Presentation				
— uses space on the graph appropriately				
— uses space on the paper appropriately				
— graphs neatly and clearly				
— depicts trends clearly, so they are easy to interpret				

NI — Needs Improvement
S — Satisfactory
E — Excellent

6a. Make any necessary modifications to your plot on the blank graph presented below. Be sure to base your changes on the items mentioned in your "Checklist of Graphing Skills."



6b. Note the changes made to your graph in the space provided below.

- ______________________
- ______________________
- ______________________
- ______________________

SLA
Student Learning Activity

The Search for Extraterrestrial Intelligence — The Drake Equation

Background Information:

The search for extraterrestrial life usually generates a discussion of UFOs and the extent to which we believe in them. Internet sites provide information about the search for life in star systems beyond the solar system. Space probes sent from Earth are carefully sterilized so they do not contaminate any organism that may be contacted in space. Likewise, all incoming space probes are similarly sterilized for the same reason against what is called "back contamination" of the Earth.

The search for extraterrestrial intelligence (SETI) is an excellent example of how serious science can be distorted and corrupted by popularized accounts. The UFO debate is just one such situation. The SETI program is a well-funded attempt at scanning the heavens for transmissions that may originate from past or presently communicating intelligent lifeforms. One of the founding members of the SETI research community, Dr. Frank Drake, developed an interesting probability relationship that has become known as the *Drake Equation*. By entering values for certain symbols in this equation, one can speculate about the number of intelligent, communicating civilizations in our galaxy. An example appears in this learning activity (see the 1961 equation). The Drake Equation was developed as a way to focus on the key factors which determine how many intelligent, communicating civilizations there are in our own Milky Way galaxy.

If you are you interested in participating actively in the SETI program, log on to the Planetary Society website at http://www.planetary.org, and follow the SETI links from there. You will be looking for the seti@home hyperlinks.

The Drake Equation looks like this:

$$\mathbf{N_0 = N^*\ f_p\ n_e\ f_l\ f_i\ f_c\ f_L}$$

Where $\mathbf{N_0}$ = Number of intelligent, communicating civilizations in our Milky Way galaxy.

$\mathbf{N^*}$ = Number of stars in the Milky Way galaxy.

$\mathbf{f_p}$ = Fraction of **N** having planetary systems.

$\mathbf{n_e}$ = Number of planets per star capable of sustaining life.

$\mathbf{f_l}$ = Fraction of $\mathbf{n_e}$ where life evolves.

$\mathbf{f_i}$ = Fraction of $\mathbf{f_l}$ where intelligent life evolves.

$\mathbf{f_c}$ = Fraction of $\mathbf{f_i}$ that develops the means of radio frequency communication.

$\mathbf{f_L}$ = Fraction of a planet's natural history during which a civilization is actively communicating beyond itself into deep space.

The equation could be seen as providing answers to a number of questions.

N* represents the number of stars estimated to be in the Milky Way galaxy.

Question: How many stars are in the Milky Way galaxy?
Answer: Current estimates are 100 billion.

$\mathbf{f_p}$ is the fraction of stars that have planets around them.

Question: What percentage of stars have planetary systems?
Answer: Current estimates range from 20% to 50%.

$\mathbf{n_e}$ is the number of planets per star that are capable of sustaining life.

Question: For each star that does have a planetary system, how many planets are capable of sustaining life?
Answer: Current estimates range from 1 to 5.

$\mathbf{f_l}$ is the fraction of planets in $\mathbf{n_e}$ where life evolves.

Question: On what percentage of the planets that are capable of sustaining life does life actually begin and evolve?
Answer: Current estimates range from 100% (where life can evolve, it will) down to close to 0% (life is a very rare occurrence).

$\mathbf{f_i}$ is the fraction of $\mathbf{f_l}$ where intelligent life evolves.

Question: On the planets where life does evolve, what percentage of these evolve intelligent, self-aware lifeforms?
Answer: Estimates range from 100% (intelligence is such a survival advantage that it will certainly evolve) down to near 0%.

$\mathbf{f_c}$ is the fraction of $\mathbf{f_i}$ that communicate.

Question: What percentage of intelligent species have the means to communicate?
Answer: Estimates are from 10% to 20%.

$\mathbf{f_L}$ is the fraction of the planet's lifespan during which the actively communicating civilizations live.

Question: For each civilization that does develop the ability to communicate into deep space, for how long during the planet's life does the civilization last?
Answer: This is perhaps the toughest of all the questions to answer. If we take Earth as an example, the expected lifetime of our Sun and the Earth is roughly 10 billion years. So far, we have been communicating with radio waves for less than 100 years. How long will our civilization survive? Will we destroy ourselves in a matter of years as some have predicted, or will we overcome our problems and survive for millenia to come? If we were destroyed tomorrow, the answer to this question would be 1/100,000,000th. If we survive for 10,000 years the answer will be 1/1,000,000th.

When all of these variables are multiplied together, we arrive at: $\mathbf{N_0}$, the number of actively communicating civilizations in the galaxy.

The real value of the Drake Equation is not in finding an answer that we can say is correct, but in discussing the questions that are attached to each of the terms in the equation. Here you get a chance to be in charge of the tremendous guesswork involved in filling in the variables. As a technological and scientific society, we will learn more from astronomy, biology, and the other sciences and be able to better estimate the answers to the questions presented above.

Try the Drake Equation for Yourself:

For each of the variables in the equation, a sample number appears to assist you. In the spaces to the right of each number, enter *your own estimates* for that variable. According to the Drake Equation and with the use of a calculator, multiply your numbers and fractions to calculate N: the number of intelligent, communicating civilizations in the Milky Way galaxy.

Note: Numbers that are listed as '**f**' are written as decimal fractions. For example, 50% in the line $\mathbf{f_c}$ is entered as 0.50 into your calculator, and so on. If you arrive at an answer that is less than 1.00 (the current known value for the Drake Equation), change one or more of your estimates.

N* = Number of stars in the Milky Way galaxy.

100 billion			

$\mathbf{f_p}$ = Fraction of **N** having planetary systems.

50% = 0.50			

$\mathbf{n_e}$ = Number of planets per star capable of sustaining life.

1			

$\mathbf{f_l}$ = Fraction of $\mathbf{n_e}$ where life evolves.

30% = 0.30			

$\mathbf{f_i}$ = Fraction of $\mathbf{f_l}$ where intelligent life evolves.

20% = 0.20			

$\mathbf{f_c}$ = Fraction of $\mathbf{f_i}$ that develop the means of radio frequency communication.

10% = 0.10			

$\mathbf{f_L}$ = Fraction of a planet's natural history during which a civilization is actively communicating beyond itself into deep space.

1/1,000,000th (10,000 years)		

Calculate $\mathbf{N_0 = N^* \ f_p \ n_e \ f_l \ f_i \ f_c \ f_L}$

Example: (100,000,000,000) x (.50) x (1.00) x (.30) x (.20) x (.10) x (0.000 001)
= **N**, the number of actively communicating civilizations in the galaxy.

300			

TSM
Teacher Support Material

Sample Plots of Astronomical Data for Teacher Reference, and Databases for Objects

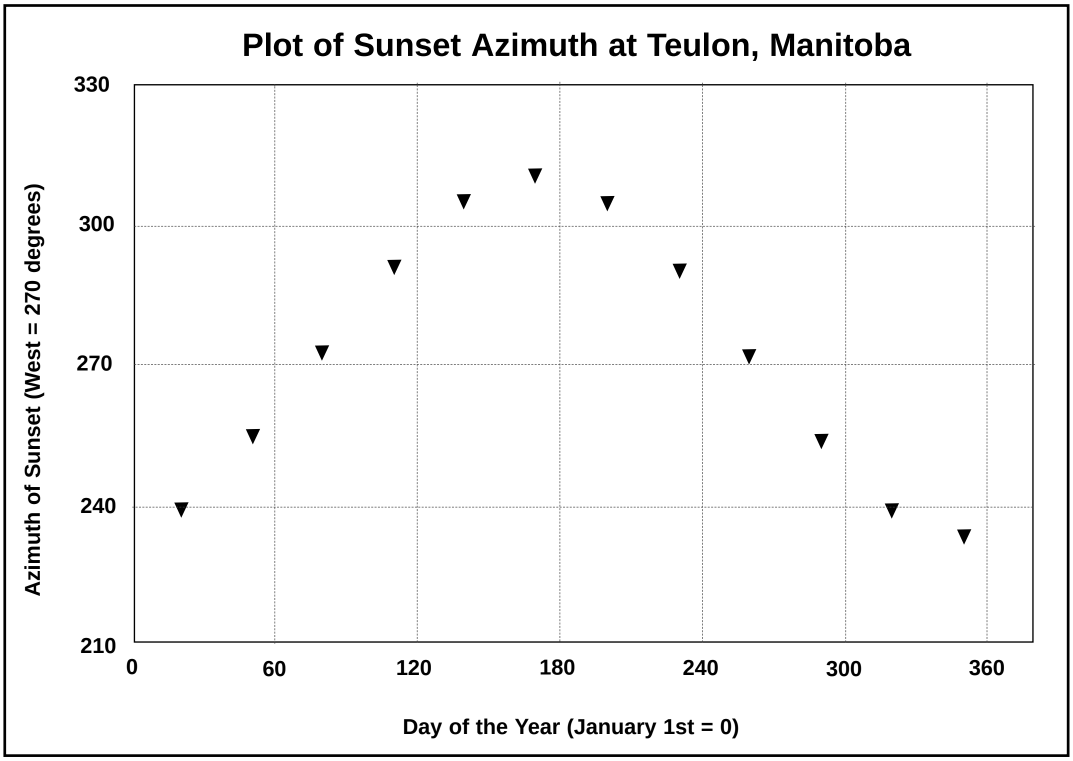
Notes for Instruction:

The following data charts are provided to supplement previously recorded data or in lieu of observational data where direct data collecting is not possible. It is preferred, however, that students acquire positioned data from astronomy software rather than use these data charts and plots. A comprehensive list of websites offering such software can be found at:

http://www.GriffithsObs.org/ or http://www.seds.org/

1. **Data Set and Plot of Sun's Azimuth at Sunset Over Time**

Day	Azimuth of Sunset
21	239.7º
51	255.1º
80	272.7º
110	291.2º
140	305.2º
170	310.7º
200	304.8º
230	290.3º
260	272.1º
290	254.2º
320	239.2º
350	233.5º



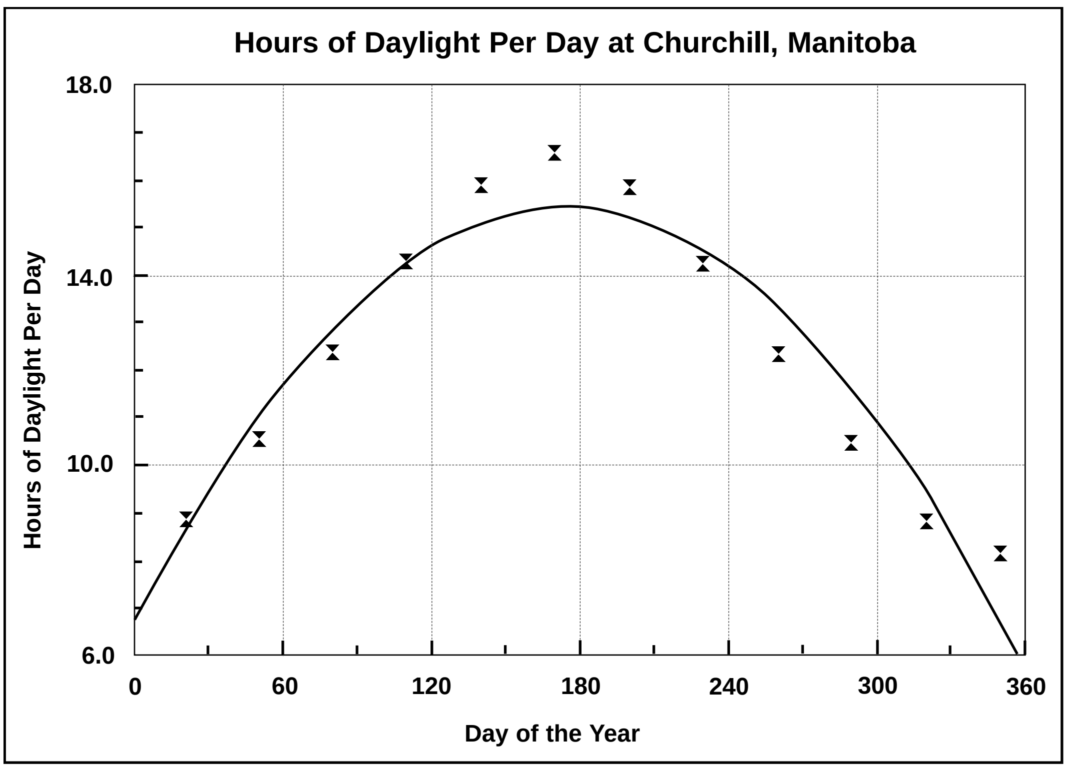
Plot of Sunset Position Over One Year at Teulon, Manitoba

The above plot illustrates that the position of sunset throughout the year follows a predictable pattern. In the winter (days 300 to 60), the Sun sets well to the southwest in the sky, corresponding with the shortest hours of daylight. As the year progresses, the Sun sets increasingly towards the north, with sunset due west (270° azimuth) at the Vernal Equinox (first day of spring). On or near the Summer Solstice of June 21st, the Sun sets at its most northerly position (day 180), going down well to the northwest on the horizon. For the remainder of the year, until the Winter Solstice of December 21st, the sunset location moves progressively southward on the horizon by about one Sun diameter per day (0.5 degree). The Earth's axial tilt of 23.5° is responsible for this apparent motion of the Sun throughout the year.

2. **Data Set and Plot of Hours of Daylight Per Day for One Year at Churchill, Manitoba**

Day	Hours of Daylight
21	8.867
51	10.55
80	12.375
110	14.308
140	15.892
170	16.583
200	15.879
230	14.251
260	12.34
290	10.483
320	8.833
350	8.152

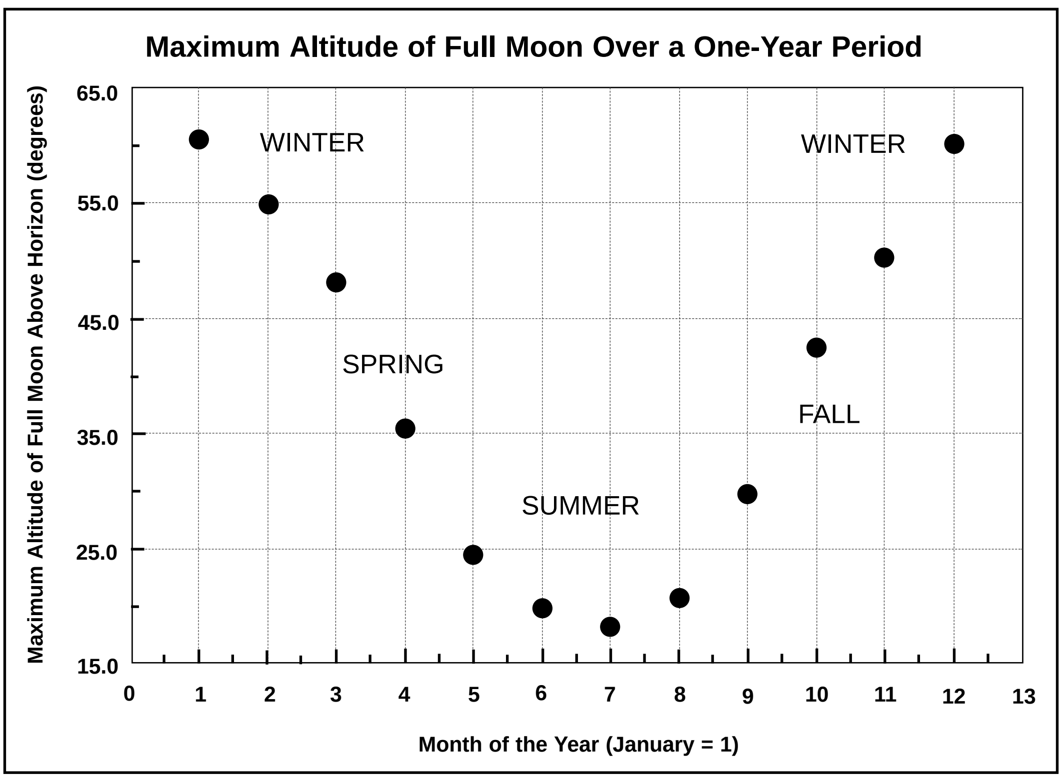
Alhough most students are aware that there are more hours of daylight in the summer than in the Manitoba winters, it is always instructive to see this represented through plotting software in graphical mode. The regularity of the increase and decrease is marked, upon closer examination, by the fact that the lengthening of daylight during the spring and the decrease in daylight in the fall are the two periods where the most rapid day-to-day changes occur (note the steepness of the plot during the intervals of spring and fall). The levelling off of the curve near the beginning of summer and winter paints not only a good numerical picture, but conjures emotions as well!



3. **Data Set and Plot of Full Moon's Maximum Altitude Over a One-Year Period**

Month of Year	Full Moon's Maximum Altitude (degrees above horizon)
Jan.	60.5º
Feb.	54.8º
Mar.	48.1º
Apr.	35.4º
May	24.4º
June	19.9º
July	18.2º
Aug.	20.8º
Sept.	29.8º
Oct.	42.4º
Nov.	50.2º
Dec.	60.1º

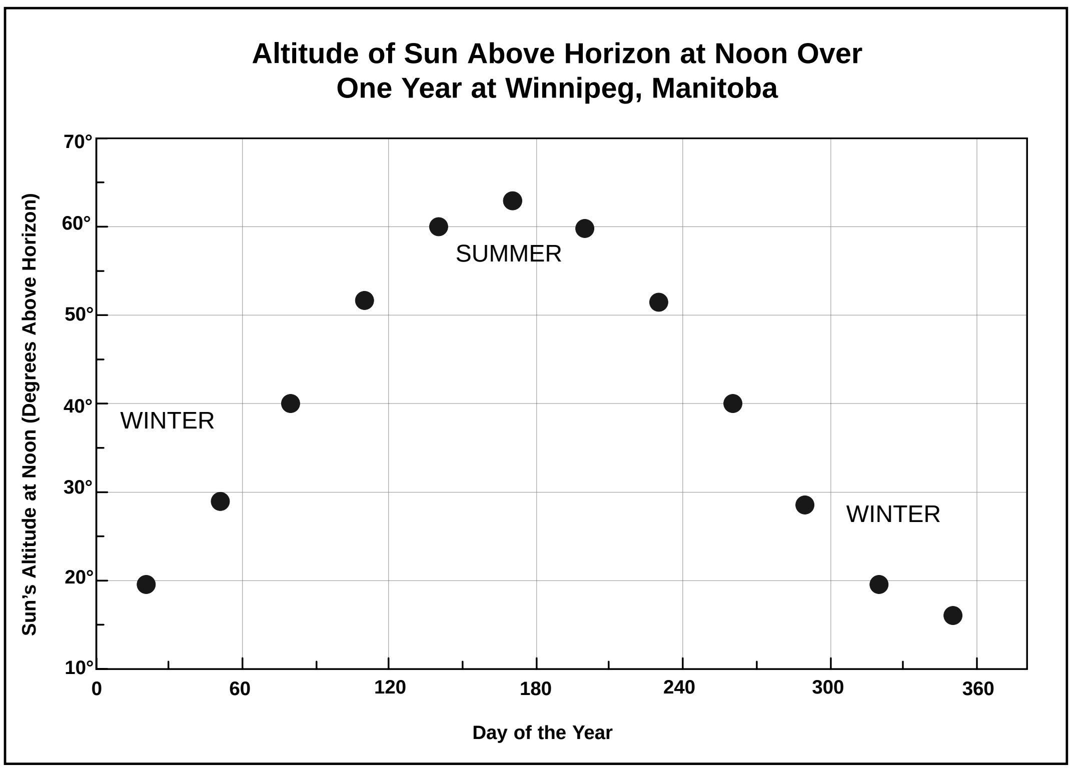
The phenomenon depicted in the graph below is generally poorly understood by the public. In the northern hemisphere, the Moon is higher in the sky during the winter and significantly lower in the sky during the summer. This results from the superposition of two geometries that are opposed to one another — the inclination of the Earth's axis with respect to its orbit around the Sun, and the inclination of the Moon's orbital path around the Earth with respect to the Equator. Historically, and for ancient cultures, it was fortuitous to have the Moon dominating the night sky at a time when the hours of daylight were shortened. One could ask the students: "Could this curious situation have an influence on the ocean tides?" In addition, it may explain why the Swampy Cree of northern Manitoba refer to the moon as "tipiskaw pissim" — or "night Sun" — as opposed to giving it a separate planetary significance.



4. **Data Set and Plot of Sun's Altitude Above the Horizon at Noon, Winnipeg Manitoba.**

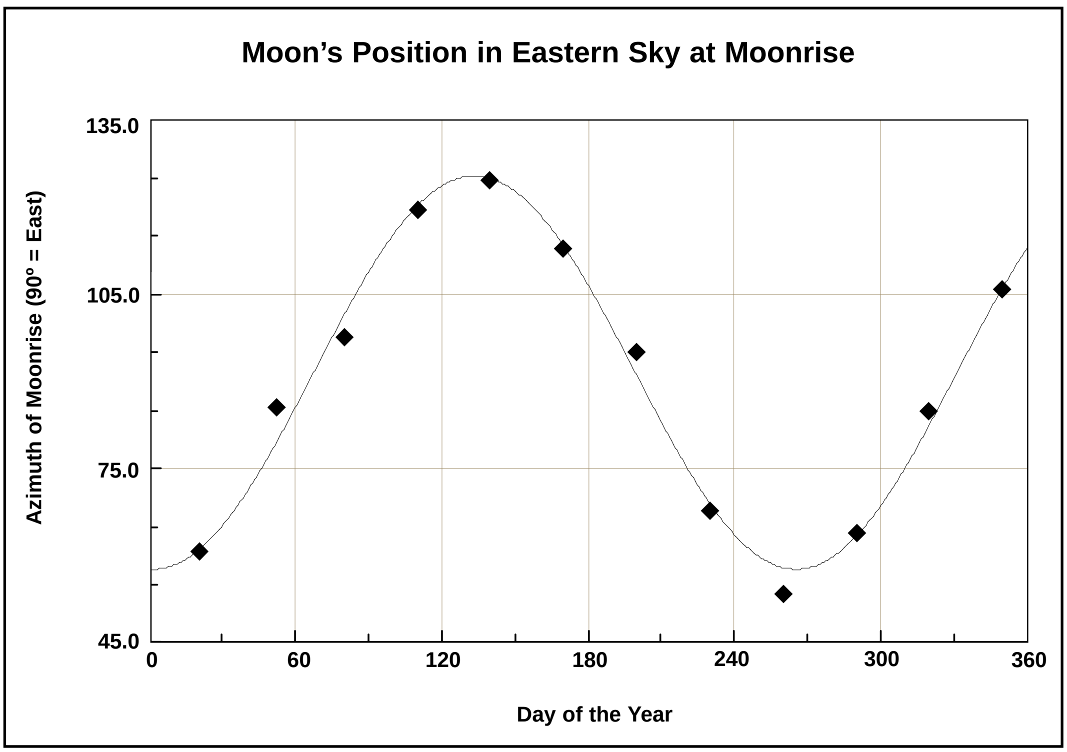
Day of Year	Altitude of Sun at Noon
21	9.7º
51	29º
80	40.2º
110	51.8º
140	60º
170	63.1º
200	60.0º
230	51.5º
260	40º
290	28.6º
320	19.6º
350	16.2º

The data required to produce the plot below could also be generated through student observation using their constructed astrolabe (as discussed previously). Determining the amplitude of the "wave" in this plot (exactly 23.5 degrees) shows that it matches the current axial tilt of the Earth.



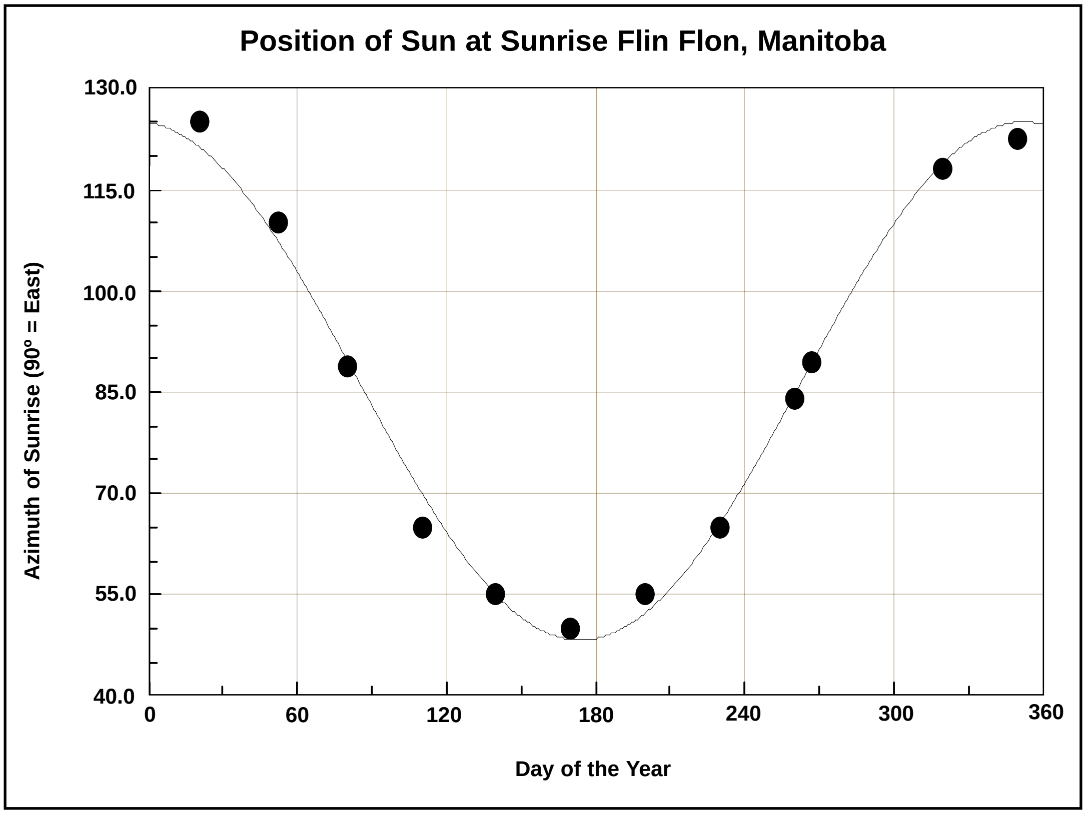
5. **Data Set and Plot of Moon's Position in the Eastern Sky at Moonrise**

Day of Year	Azimuth of Moon
21	60.7º
51	85.5º
80	97.5º
110	119.5º
140	124.7º
170	112.8º
200	95.0º
230	67.6º
260	53.5º
290	63.9º
320	84.8º
350	106.0º



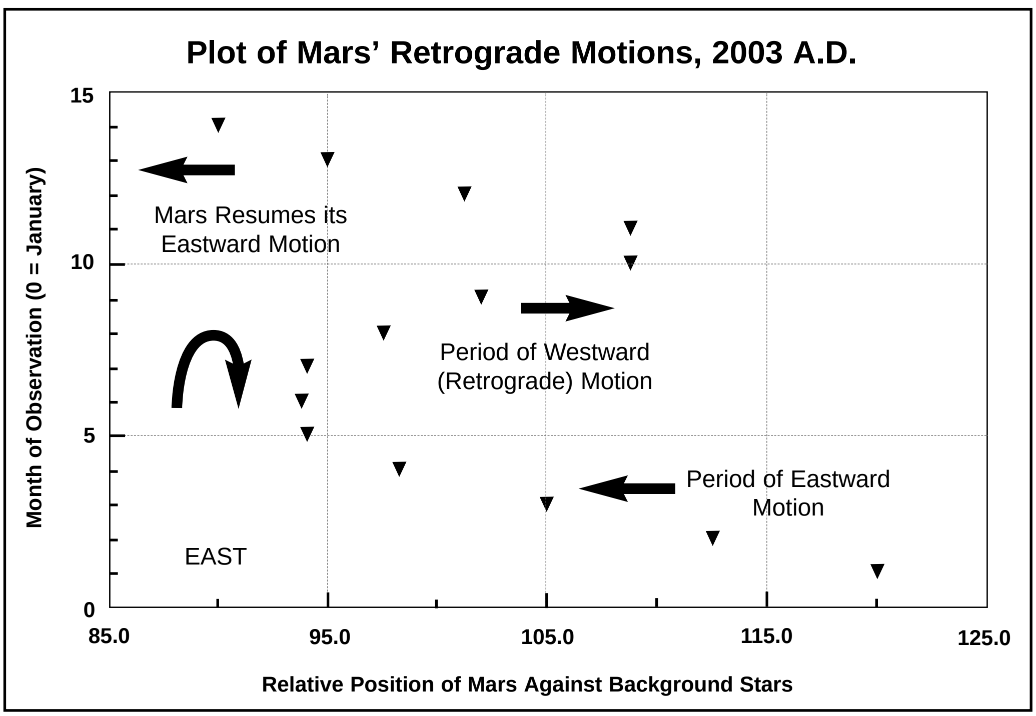
6. **Data Set and Plot of Sun's Position at Sunrise, Flin Flon, Manitoba.**

Day of Year	Azimuth of Sunrise
1	124.6º
8	125.9º
13	126.5º
20	126.5º
79	88.7º
166	49.5º
258	84.0º
267	89.5º



7. **Data Set and Plot of Mars' Retrograde Motions, 2003 A.D.**

Mars' Position	Month
120º	1 (Jan. 2003)
112.5º	2 (Feb.)
105.0º	3 (Mar.)
98.25º	4 (Apr.)
94.0º	5 (May)
93.75º	6 (June)
94.0º	7 (July)
97.5º	8 (Aug.)
102.0º	9 (Sept.)
108.75º	10 (Oct.)
108.75º	11 (Nov.)
101.25º	12 (Dec.)
95.0º	13 (Jan. 2004)
90.0º	14 (Feb. 2004)



The Great Astronomical Word Explosion

SLA Student Learning Activity

Instructions:

Complete each statement using the words and phrases below. This should be a useful review of many of the terms you have encountered in your introduction to astronomy. Some of the words can be used more than once. The numbers are used only once.

Halley	cultures and religions	minerals	white dwarf
apparent	the Earth	star	galaxies
hydrogen	Pluto	1000	Jupiter
the Sun	expansion	solar	verification
comet	nuclear fusion	instabilities	one million
suns	moons	gravity	galaxy
contraction	Alpha Centauri	light	heliocentric
Big Bang	the Milky Way	spiral	thermonuclear
supernovas	black hole	ellipse	planet
nine	150 million	one year	63,000
Hubble	aurora borealis	dispersed	light spectrum
mass	geocentric	four to five	blue
Sirius	Neptune	ray of light	asteroids
pressure	cloud of gas and dust	red	Uranus
years	10 to 15 billion years ago	neutrons	helium
radio waves	100 to 400 billion	ring	astronomical
light-year	galaxies	yellow-orange	

1. A ____________________ is a celestial body that pursues an orbit around a central ________________________. Our solar system has ______________________ of them, and some astronomers speculate that the belt of _______________________ between the orbits of Mars and Jupiter was once a tenth planet that has been destroyed.

2. It is the force of ___________________________ that holds the planets in orbit around the __________________________, and also causes the entire solar system to orbit around the ________________________________.

3. ___________________________ are natural satellites of planets. The large number of small bodies between Mars and Jupiter are called the _____________________________, which means “star-like.” Certain planets also have a _____________________________ system that encircles them, comprised of thousands of small, rocky, and icy pieces of material left over from the disintegration of a once-large satellite.

4. Certain asteroids, called the Trojans, cross the orbit of Mars and make close approaches to the Earth. Their maximum size is about ___________________________ kilometres across. Due to the fact that asteroids and moons are composed of rocky material, some people would like to exploit them as sources of _________________________________ .

5. The largest planet in the solar system is ____________________________, and the smallest is ______________________. The 'third rocky one from the Sun' is ___________________.

6. The four giant gas planets, listed in order of increasing distance from the Sun are _______________________, ________________________, ______________________, and _______________________ . They all have large families of _________________________ orbiting them.

7. An _____________________________________ unit (AU) is the average distance between ____________________________ and the ____________________. It is equivalent to about _____________________ kilometres. A ____________________________ is a much larger distance unit used by astronomers, and is the distance that a __________________________ traverses in ___________________________. A light-year is equivalent to about _____________________________ AU's.

8. A _________________________ is a solar system object that can can have a gas and dust tail exceeding millions of kilometres in length. These celestial wonders of ice, rock, and organic compounds travel around the Sun in elongated orbits called an ___________________________. In 1997, Hale-Bopp was one of the most brilliant to recently enter the inner solar system, and was visible to the unaided eye for months. However, it is __________________________ that is the most celebrated __________________________, returning to put on a show with a period of about 76 years.

9. The Sun is a ______________________________, an enormous sphere of gas that emits its energy through the process of ____________________________. The temperatures in the extreme outer layer of the Sun’s atmosphere, “the solar corona,” can reach ____________________ degrees Celsius. Every 10 years or so, ______________________ flares erupt from the Sun’s surface layers, eventually disturbing communication systems on Earth. The beautiful ______________________________ near the North Pole is caused by streams of charged particles which are emitted by the Sun and interact with the magnetic field of the Earth high in the atmosphere.

10. The nearest star to the Earth is the ___________________________. The next nearest star system to ours is _________________________, which is a triple-star system approximately ____________________________ light-years from Earth. The colour of its three stars, indicating that they are Sun-like, is ___________________________. The hottest stars are ______________________ in colour, and the coolest stars are _____________________.

11. The ________________________ magnitude (brightness as seen from the Earth) of a star differs from its absolute magnitude (a truer measure of a star’s brightness) because of the great distance between the star and the Earth. This affects the quantity of ________________ that is observed in the night sky. The brightest star in the sky from our point of view is ___________________________ in the constellation *Canis Major* (the Great Dog), but it is actually much less luminous than the nearby red giant star, Betelgeuse, in the constellation Orion. Very often, stars appear bright simply because they are close to us.

12. A _________________________ is the remains of a supermassive star that is apparently invisible due to the fact that tremendous _____________________ forces do not permit its visible _____________________________ to escape and be seen.

13. Neither the ________________________ model of the universe (with the Earth at the centre) nor the _______________________ model (with the Sun at the centre) represent the actual conceptions of the cosmos accepted by astronomers today. The solar system is just one small fraction of the galaxy called _____________________________. The universe is comprised of perhaps hundreds of billions of ______________________________ like the nearest great spiral galaxy to ours, the Andromeda Galaxy.

14. A ______________________________ is actually an enormous collection of stars, dust, and various gases, all bound together by gravitational attraction. The Milky Way contains somewhere in the neighbourhood of ___________________________ stars. Some galaxies have a pinwheel-like appearance, and are called _______________________ galaxies (like the Milky Way). Still others are irregular in form (like the Large Magellanic Cloud, for instance). Quasars (which is a loose acronym for "quasi-stellar objects") are strange sources of _________________________, and can emit as much energy as an entire galaxy of stars.

15. A large cloud of gas and dust called a ______________________________ is often called the "birthplace of stars." These clouds of gases, mostly _______________________________ and ________________________, contract under the influence of __________________________. A star is born when its ______________________________ furnace inside ignites as temperatures rise to millions of degrees Celsius.

16. Depending on the initial _____________________ of the material from the nebula that coalesces to form a star, the resulting star can end its life span as a small ___________________________, or as a spectacular ______________________ explosion that leaves behind a super-dense remnant called a ______________________ star. The most massive stars, those about 25 times heavier than our Sun, have the potential to become a ____________________________, from which time and space cannot escape. All of the chemical elements that make up other stars, planets, and matter (including living beings like you) are synthesized from the exploding stars.

17. By analyzing the rainbow-like colours of a _____________________ from a celestial body (for example, a star beyond our Sun), it is possible to detect planets around it by looking for small _____________________ in the motions of the central star. The ____________________ Space Telescope has already confirmed the existence of a number of planetary systems around stars other than our Sun.

18. According to cosmologists (scientists studying the ultimate fate of the cosmos), it is thought that after the universe's initial period of _________________________, a period of ___________________________ will result in what has been called "the Big Crunch." After that, another ______________________________ could give rise to a whole new universe.

19. The ______________________________ Theory also proposes that all of the material that now comprises the universe was originally concentrated in an exceedingly small volume of space — infinitely small. This mass was under great _______________________, and upon exploding rapidly outward, _______________________ the enormous mass of material that ultimately gave rise to stars, galaxies, and a host of other celestial objects.

20. A diversity of peoples, __________________________________ have proposed their own particular explanation for the origins of the universe, but these perspectives have not utilized the methods and habits of mind traditionally used in the scientific _______________________ of ideas.

TSM
Teacher Support Material

The Great Astronomical Word Explosion (Teacher Version with Answers)

Instructions:

Complete each statement using the words and phrases below. This should be a useful review of many of the terms you have encountered in your introduction to astronomy. Some of the words can be used more than once. The numbers are used only once.

Halley	cultures and religions	minerals	white dwarf
apparent	the Earth	star	galaxies
hydrogen	Pluto	1000	Jupiter
the Sun	expansion	solar	verification
comet	nuclear fusion	instabilities	one million
suns	moons	gravity	galaxy
contraction	Alpha Centauri	light	heliocentric
Big Bang	the Milky Way	spiral	thermonuclear
supernovas	black hole	ellipse	planet
nine	150 million	one year	63,000
Hubble	aurora borealis	dispersed	light spectrum
mass	geocentric	four to five	blue
Sirius	Neptune	ray of light	asteroids
pressure	cloud of gas and dust	red	Uranus
years	10 to 15 billion years ago	neutrons	helium
radio waves	100 to 400 billion	ring	astronomical
light-year	galaxies	yellow-orange	

1. A _____ *planet* _____ is a celestial body that pursues an orbit around a central _____ *star* _____. Our solar system has _____ *nine* _____ of them, and some astronomers speculate that the belt of _____ *asteroids* _____ between the orbits of Mars and Jupiter was once a tenth planet that has been destroyed.

2. It is the force of _____ *gravity* _____ that holds the planets in orbit around the _____ *Sun* _____, and also causes the entire solar system to orbit around the _____ *Milky Way* _____.

3. _____ *Moons* _____ are natural satellites of planets. The large number of small bodies between Mars and Jupiter are called the _____ *asteroids* _____, which means "star-like." Certain planets also have a _____ *ring* _____ system that encircles them, comprised of thousands of small, rocky, and icy pieces of material left

over from the disintegration of a once-large satellite.

4. Certain asteroids, called the Trojans, cross the orbit of Mars and make close approaches to the Earth. Their maximum size is about ___*1,000*___ kilometres across. Due to the fact that asteroids and moons are composed of rocky material, some people would like to exploit them as sources of ___*minerals*___.

5. The largest planet in the solar system is ___*Jupiter*___, and the smallest is ___*Pluto*___. The 'third rocky one from the Sun' is ___*Earth*___.

6. The four giant gas planets, listed in order of increasing distance from the Sun are ___*Jupiter*___, ___*Saturn*___, ___*Uranus*___, and ___*Neptune*___. They all have large families of ___*moons*___ orbiting them.

7. An ___*astronomical*___ unit (AU) is the average distance between ___*Earth*___ and the ___*Sun*___. It is equivalent to about ___*150 million*___ kilometres. A ___*light-year*___ is a much larger distance unit used by astronomers, and is the distance that a ___*ray of light*___ traverses in ___*one year*___. A light-year is equivalent to about ___*63,000*___ AU's.

8. A ___*comet*___ is a solar system object that can can have a gas and dust tail exceeding millions of kilometres in length. These celestial wonders of ice, rock, and organic compounds travel around the Sun in elongated orbits called an ___*ellipse*___. In 1997, Hale-Bopp was one of the most brilliant to recently enter the inner solar system, and was visible to the unaided eye for months. However, it is ___*Halley*___ that is the most celebrated ___*comet*___, returning to put on a show with a period of about 76 years.

9. The Sun is a ____*star*____, an enormous sphere of gas that emits its energy through the process of ____*nuclear fusion*____. The temperatures in the extreme outer layer of the Sun's atmosphere, "the solar corona," can reach ____*one million*____ degrees Celsius. Every 10 years or so, ____*solar*____ flares erupt from the Sun's surface layers, eventually disturbing communication systems on Earth. The beautiful ____*aurora borealis*____ near the North Pole is caused by streams of charged particles which are emitted by the Sun and interact with the magnetic field of the Earth high in the atmosphere.

10. The nearest star to the Earth is the ____*Sun*____. The next nearest star system to ours is ____*Alpha Centauri*____, which is a triple-star system approximately ____*four to five*____ light-years from Earth. The colour of its three stars, indicating that they are Sun-like, is ____*yellow-orange*____. The hottest stars are ____*blue*____ in colour, and the coolest stars are ____*red*____.

11. The ____*apparent*____ magnitude (brightness as seen from the Earth) of a star differs from its absolute magnitude (a truer measure of a star's brightness) because of the great distance between the star and the Earth. This affects the quantity of ____*light*____ that is observed in the night sky. The brightest star in the sky from our point of view is ____*Sirius ("serious")*____ in the constellation *Canis Major* (the Great Dog), but it is actually much less luminous than the nearby red giant star, Betelgeuse, in the constellation Orion. Very often, stars appear bright simply because they are close to us.

12. A ____*black hole*____ is the remains of a supermassive star that is apparently invisible due to the fact that tremendous ____*gravitational*____ forces do not permit its visible ____*light*____ to escape and be seen.

13. Neither the ____*geocentric*____ model of the universe (with the Earth at the centre) nor the ____*heliocentric*____ model (with the Sun at the centre) represent the actual conceptions of the cosmos accepted by astronomers today. The solar system is just one small fraction of the galaxy called ____*the Milky Way*____. The universe is comprised of perhaps hundreds of billions of ____*galaxies*____ like the nearest great spiral galaxy to ours, the Andromeda Galaxy.

14. A ___*galaxy*___ is actually an enormous collection of stars, dust, and various gases, all bound together by gravitational attraction. The Milky Way contains somewhere in the neighbourhood of ___*100 to 400 billion*___ stars. Some galaxies have a pinwheel-like appearance, and are called ___*spiral*___ galaxies (like the Milky Way). Still others are irregular in form (like the Large Magellanic Cloud, for instance). Quasars (which is a loose acronym for "quasi-stellar objects") are strange sources of ___*radio waves*___, and can emit as much energy as an entire galaxy of stars.

15. A large cloud of gas and dust called a ___*nebula*___ is often called the "birthplace of stars." These clouds of gases, mostly ___*hydrogen*___ and ___*helium*___, contract under the influence of ___*gravity*___. A star is born when its ___*thermonuclear*___ furnace inside ignites as temperatures rise to millions of degrees Celsius.

16. Depending on the initial ___*mass*___ of the material from the nebula that coalesces to form a star, the resulting star can end its life span as a small ___*white dwarf*___, or as a spectacular ___*supernova*___ explosion that leaves behind a super-dense remnant called a ___*neutron*___ star. The most massive stars, those about 25 times heavier than our Sun, have the potential to become a ___*black hole*___, from which time and space cannot escape. All of the chemical elements that make up other stars, planets, and matter (including living beings like you) are synthesized from the exploding stars.

17. By analyzing the rainbow-like colours of a ___*light spectrum*___ from a celestial body (for example, a star beyond our Sun), it is possible to detect planets around it by looking for small ___*instabilities*___ in the motions of the central star. The ___*Hubble*___ Space Telescope has already confirmed the existence of a number of planetary systems around stars other than our Sun.

18. According to cosmologists (scientists studying the ultimate fate of the cosmos), it is thought that after the universe's initial period of ___*expansion*___, a period of ___*contraction*___ will result in what has been called "the Big Crunch." After that, another ___*expansion*___ could give rise to a whole new universe.

19. The ___________*Big Bang*___________ Theory also proposes that all of the material that now comprises the universe was originally concentrated in an exceedingly small volume of space — infinitely small. This mass was under great _________*pressure*_________, and upon exploding rapidly outward, _________*dispersed*_________ the enormous mass of material that ultimately gave rise to stars, galaxies, and a host of other celestial objects.

20. A diversity of peoples, ______*cultures and religions*________ have proposed their own particular explanation for the origins of the universe, but these perspectives have not utilized the methods and habits of mind traditionally used in the scientific ______*verification*______ of ideas.

SLA
Student Learning Activity

Weighing the Benefits and Risks of Space Exploration

Indicate if you agree or disagree with each statement. If your opinion is mixed, explain why. You will be asked to discuss each of these points with the class when finished.

Statement	I Agree	I Disagree	Mixed Opinion
It is absolutely necessary to do all we can to contact extraterrestrial intelligences in order to secure the benefits of their advanced technologies.			
The discovery and exploitation of mineral resources on asteroids is more important in the long term than our health care system is in the short term.			
It is wise to use nuclear-powered engines for space travel since these permit us to travel much farther at a reduced price.			
If we do not survey the heavens with more complex instruments, we will not be in a position to defend the Earth against dangerous events like asteroid impacts.			
Space belongs to those countries and commercial interests that colonize and exploit it economically.			
Attempts at the colonization of space should respect the current ethnic proportions and balance of women and men that exist here on Earth.			
Remote sensing observation will be an essential tool in determining “who we take,” “what we take,” and “where we go” when we colonize the solar system.			
If we were to “terraform” Mars, another planet, or a moon in the solar system, it would be necessary to understand all of the impacts that human colonization would have on the “new home.”			
The Canadian government should reduce its expenditures on non-essential space research and concentrate its efforts in improving agricultural productivity on Earth.			
The primary role of space agencies is to ensure that one's nation is capable of defending against a military attack from space-based weapons.			
It is not a problem that space tourism will only be affordable by the rich. This should be encouraged until access is available for all potential tourists.			
It is impossible to pollute space, therefore, it would be a good place to send our wastes and our undesirable or dangerous organisms.			

Canadian Projects in the Space Sciences

SLA Student Learning Activity

Research three scientific projects or new technologies that affect Canadian efforts in space exploration. Identify and summarize the key results in the chart below. Be prepared to discuss your research with the class.

Key Result Areas	Project 1	Project 2	Project 3
Name of Canadian project or new technology			
Brief description of the project or new technology			
Does the project or new technology involve international cooperation? If yes, with which nation(s)?			
What are the positive results of Canada's participation in this project or development of this new technology? When will these results occur?			
What are some of the concerns or worries that surround this project or new technology?			
Identify one or two of your information sources related to the advantages of the project or new technology.			

Senior 1

Appendices:
General Learning Outcomes
and Rubrics

General Learning Outcomes

The purpose of Manitoba science curricula is to help students gain a measure of scientific literacy that will assist them in becoming informed, productive, and fulfilled members of society. As a result of their Early, Middle, and Senior Years science education Manitoba students will be able to:

Nature of Science and Technology

A1. recognize both the power and limitations of science as a way of answering questions about the world and explaining natural phenomena

A2. recognize that scientific knowledge is based on evidence, models, and explanations, and evolves as new evidence appears and new conceptualizations develop

A3. distinguish critically between science and technology in terms of their respective contexts, goals, methods, products, and values

A4. identify and appreciate contributions made by women and men from many societies and cultural backgrounds towards increasing our understanding of the world and in bringing about technological innovations

A5. recognize that science and technology interact with and advance one another

Science, Technology, Society, and the Environment (STSE)

B1. describe scientific and technological developments, past and present, and appreciate their impact on individuals, societies, and the environment, both locally and globally

B2. recognize that scientific and technological endeavours have been and continue to be influenced by human needs and the societal context of the time

B3. identify the factors that affect health, and explain the relationships among personal habits, lifestyle choices, and human health, both individual and social

B4. demonstrate a knowledge of and personal consideration for a range of possible science- and technology-related interests, hobbies, and careers

B5. identify and demonstrate actions that promote a sustainable environment, society, and economy, both locally and globally

Scientific and Technological Skills and Attitudes

C1. recognize safety symbols and practices related to scientific and technological activities and to their daily lives, and apply this knowledge in appropriate situations

C2. demonstrate appropriate scientific inquiry skills when seeking answers to questions

C3. demonstrate appropriate problem-solving skills while seeking solutions to technological challenges

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C4. demonstrate appropriate critical thinking and decision-making skills when choosing a course of action based on scientific and technological information

C5. demonstrate curiosity, skepticism, creativity, open-mindedness, accuracy, precision, honesty, and persistence, and appreciate their importance as scientific and technological habits of mind

C6. employ effective communication skills and utilize information technology to gather and share scientific and technological ideas and data

C7. work cooperatively and value the ideas and contributions of others while carrying out scientific and technological activities

C8. evaluate, from a scientific perspective, information and ideas encountered during investigations and in daily life

Essential Science Knowledge

D1. understand essential life structures and processes pertaining to a wide variety of organisms, including humans

D2. understand various biotic and abiotic components of ecosystems, as well as their interaction and interdependence within ecosystems and within the biosphere as a whole

D3. understand the properties and structures of matter, as well as various common manifestations and applications of the actions and interactions of matter

D4. understand how stability, motion, forces, and energy transfers and transformations play a role in a wide range of natural and constructed contexts

D5. understand the composition of the Earth’s atmosphere, hydrosphere, and lithosphere, as well as the processes involved within and among them

D6. understand the composition of the universe, the interactions within it, and the impacts of humankind’s continued attempts to understand and explore it

Unifying Concepts

E1. describe and appreciate the similarity and diversity of forms, functions, and patterns within the natural and constructed world

E2. describe and appreciate how the natural and constructed world is made up of systems and how interactions take place within and among these systems

E3. recognize that characteristics of materials and systems can remain constant or change over time, and describe the conditions and processes involved

E4. recognize that energy, whether transmitted or transformed, is the driving force of both movement and change, and is inherent within materials and in the interactions among them

Rubric for the Assessment of Class Presentations

Student Name(s) ______________________________

Topic/Title ______________________________

Criteria	Performance Levels			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Content	❐ Student(s) do not understand the topic.	❐ Student(s) have a basic understanding of the topic. ❐ Student(s) did not relate the material presented to their own experiences.	❐ Good understanding of the topic. ❐ Knowledge is thorough and detailed. ❐ Student(s) has attempted to relate the material presented to their own experiences.	❐ Excellent depth of understanding is evident. ❐ Student(s) has presented material that goes further that what was required. Excellent research. ❐ Student(s) has shown how the material presented relates to their own experiences.
Interest and Enthusiasm	❐ Student(s) presenting displayed little interest and enthusiasm for their topic.	❐ Some interest and enthusiasm was evident in the presentation. ❐ The class was not very interested or enthusiastic.	❐ The presenters were clearly interested in their topic and their enthusiasm was quite evident. ❐ The class was noticeably attentive during the presentation.	❐ The interest of the presenters was exceptional as was their enthusiasm. ❐ The class was keenly attentive during the presentation.
Clarity and Organization of Material	❐ The information presented was confusing.	❐ The information was somewhat vague. ❐ There was some organization.	❐ The information was clearly presented. ❐ The presentation was well organized.	❐ All information was relevant and clearly presented. ❐ The presentation was extremely well organized. ❐ Main points were emphasized and reinforced with appropriate examples.
Use of Visual Aids	❐ Visual aids were not used.	❐ Visual aids were used. ❐ They were not well done. ❐ The aids used were somewhat relevant to the presentation.	❐ Visual aids were used. ❐ They were quite well done. ❐ They were relevant to the presentation.	❐ Strong visual aids were used. ❐ They were extremely well done with colour, clarity and care. ❐ They were designed to emphasize and strengthen the presentation and were successful.

**Teachers are reminded that this rubric would vary with the assignment and format of the presentation.*

Rubric for the Assessment of a Research Project

Student Name(s) ______________________________

Topic/Title ______________________________

Criteria	Performance Levels: Level 1	Level 2	Level 3	Level 4
Source of Information	☐ Student(s) used only one source of information.	☐ Student(s) used two sources of information.	☐ Student(s) used a variety of sources.	☐ Student(s) used a wide variety of sources including the Internet.
Information Collected	☐ The information collected was not relevant.	☐ The information collected was relevant to the topic but was not blended into a cohesive piece.	☐ The information collected was relevant to the topic and was somewhat organized into a cohesive piece.	☐ The information collected was relevant to the topic and was carefully organized into a cohesive piece of research.
Organization of Material	☐ The information collected was not organized.	☐ The information was somewhat organized.	☐ The information was organized and contained recognizable sections.	☐ The information was organized and contained recognizable sections that included an introduction, a main body with supporting evidence, and a conclusion that summarized the report.
Presentation of Material	☐ The report was handwritten, contrary to established guidelines.	☐ The report was neatly handwritten. ☐ The report contained a bibliography that was not correctly formatted.	☐ The report was typed. ☐ The report contained graphics. ☐ The report contained a bibliography that was not correctly formatted.	☐ The report was neatly typed with appropriate format. ☐ The report contained a title page. ☐ The report contained relevant graphics. ☐ The report contained a complete correctly formatted bibliography.

**Teachers are reminded that this rubric would vary with the assignment and format of the presentation.*

Rubric for the Assessment of a Decision-Making Process Activity

Student Name(s) ______________________________

Topic/Title ______________________________

Criteria	Performance Levels			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Identification of STSE Issue	❐ Student cannot identify an STSE issue without assistance	❐ Student has a basic understanding that an issue could have implications STSE, not necessarily differentiating among the four areas	❐ Good understanding of a connection between an issue and its STSE applications ❐ Some evidence of awareness of an individual response	❐ Excellent depth and sensitivity in connecting an issue with its STSE implications ❐ Demonstrates a level of social responsibility
Evaluates Current Research on Issue	❐ Student is able to access a small amount of current research, with no evaluation of that research evident	❐ Demonstrates some ability to recognize the positions taken in the research data, with no clear evaluative statements	❐ Has secured an array of research, narrow in its scope, but clearly identifies the positions taken ❐ Can offer personal opinions on issue, not necessarily evaluation	❐ All acquired research is current, relevant, and from a variety of perspectives ❐ Demonstrates insight into the stated positions, and can frame an evaluation
Formulates Possible Options	❐ Unable to clearly identify the possible options ❐ Can form options that are not clearly connected to the problem to be solved	❐ Can offer at least one feasible option that is connected to the problem ❐ Other options may be more or less related directly to the problem	❐ Develops at least two feasible options that are internally consistent, and directly address the problem ❐ Recognizes that some options will fail	❐ Level of sophistication of feasible options is beyond expectations ❐ All options demonstrate a reasonable chance of succeeding in being chosen
Identifies Projected Impacts	❐ Student is not able to foresee the possible con-sequences of the options selected ❐ There appears to be a naïve awareness of consequences	❐ In a vague or insubstantial way, student identifies potential impacts of decisions taken ❐ Most of the feasible options are viewed as having projected impacts	❐ In an organized way, student identifies potential impacts of decisions taken ❐ All of the feasible options are viewed as having projected impacts, some beneficial, some not	❐ Student is capable of offering a cost/benefits/risks analysis of each feasible solution ❐ Constructs an organized report that clearly outlines the impacts of each

continued

Rubric for the Assessment of a Decision-Making Process Activity (continued)

Student Name(s) ______________________________

Topic/Title ______________________________

Criteria	Performance Levels			
	Level 1	**Level 2**	**Level 3**	**Level 4**
Selects an Option and Makes a Decision	❒ Unable to come to a decision that clearly connects with the problem to be solved ❒ Requires direction from the outside to make a choice	❒ Can identify a feasible option, but is faced with the inability to clearly decide on a plan ❒ Still requiring outside influences to stand by a decision to proceed	❒ Clearly selects an option, decides on a course of action, but others can identify that a better course of action remains untried ❒ Recognizes potential safety concerns	❒ A thorough analysis of all options was done collaboratively ❒ Decision was firm, justified by the research base, and recognizes most of the safety concerns
Implements the Decision	❒ Unable to fully implement the decision, but there remains opportunity to modify it ❒ Decision lacks the clarity to proceed	❒ Implements the decision with a recognition that not all details are laid out in advance ❒ Some lack of clarity in having a plan for implementation	❒ Implements with some visible clarity of purpose ❒ Confidence is demonstrated that the plan will be one that can be of a scientific inquiry approach	❒ Implements a plan with visible clarity of purpose, backed by the research base ❒ It is clearly demonstrated that the plan will be one that can be carried to completion as inquiry
Identifies and Evaluates Actual Impacts of Decision	❒ Unable to clearly recognize more than one possible actual impact ❒ Cannot effectively evaluate the effects of the decision(s) taken	❒ Can clearly recognize more than one possible actual impact for the decision taken ❒ Cannot effectively evaluate the effects of the decision(s) taken in most instances	❒ Able to recognize and comment upon the actual impacts observed ❒ Some ability in evaluating the impacts of the decision	❒ Able to recognize and comment deeply upon the actual impacts observed, noting unforeseen or unique outcomes ❒ Facility in evaluating the impacts of the decision
Reflects on the Decision-Making and Implementation of a Plan	❒ Begins to demonstrate an awareness of the need to review the plan ❒ A reluctance to consider a re-evaluation of the plan	❒ Reflects and intends to communicate the results of the implementation plan ❒ Has some difficulty in how to proceed with a re-evaluation of the problem-solving plan	❒ Reflects upon and does communicate the results of the implementation plan ❒ Recognizes how to proceed with a re-evaluation of the problem-solving plan	❒ A higher order synthesis is visible in the reflection process ❒ Evidence of a sophisticated environmental awareness that informs this post-implementation period

** Teachers are reminded that the above criteria are suggestions only, and will be adapted according to the needs of the assignment. It is preferable if this rubric is modified in consultation with the students, leading to clarity of purpose.*

Lab Report Assessment

Project Title ______________________ Date ______________

Team Members ______________________________________

Area of Interest	Possible Points	Self	Teacher
Formulates Testable Questions: Question is testable and focussed with cause and effect relationship identified.			
Formulates a Prediction/Hypothesis: Independent and dependent variables are identified and the prediction/hypothesis clearly identifies a cause and effect relationship between these two variables.			
Creates a Plan: All steps are included and clearly described in a logical sequence. All required materials/equipment are identified. Safety considerations are addressed; major intervening variables are controlled.			
Conducts a Fair Test and Records Observations: There is evidence of repeated trials and the inclusion of all data. Detailed data is recorded, and appropriate units are used; data is recorded in a clear/well-structured/ appropriate format for later reference.			
Interprets and Evaluates Results: Patterns/trends/discrepancies are identified. Strengths and weaknesses of approach and potential sources of error are identified. Changes to the original plan are identified and justified.			
Draws a Conclusion: Conclusion explains cause and effect relationship between dependent and independent variables; alternative explanations are identified; hypothesis is supported or rejected.			
Makes Connections: Potential applications are identified and/or links to area of study are made.			
Total Points			

Observation Checklist — Scientific Inquiry
Conducting a Fair Test

Project Title ________________________________ Date ____________________

	Names	Safe Work Habits (workspace, handling equipment, goggles, disposal)	Ensuring Accuracy/ Reliability (repeating measurements/ experiments)	Observing and Recording (carried out during experiment)	Follows a Plan	Evidence of Perseverance and/or Confidence	Comments
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							

Note: A group of students can be selected as a focus for observation on a given day, and/or one or more of the observational areas can be selected as a focus. The emphasis should be on gathering cummulative information over a period of time.

Observation Checklist — Scientific Inquiry
Conducting a Fair Test (continued)

Project Title ________________________________ Date ________________

	Names	Safe Work Habits (workspace, handling equipment, goggles, disposal)	Ensuring Accuracy/ Reliability (repeating measurements/ experiments)	Observing and Recording (carried out during experiment)	Follows a Plan	Evidence of Perseverance and/or Confidence	Comments
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
32							
33							

NOTES

Senior 1

References

REFERENCES

Alberta Education. *Program of Studies—Elementary Schools: Science.* Edmonton, AB: Alberta Education, 1995.

Alberta Learning. *Grade 7 Science Program Outcomes: Resource Development Draft.* Edmonton, AB: Alberta Learning, April 1999.

_ _ _ . *Grade 8 Science Program Outcomes: Resource Development Draft.* Edmonton, AB: Alberta Learning, April 1999.

_ _ _ . *Grade 9 Science Program Outcomes: Resource Development Draft.* Edmonton, AB: Alberta Learning, November 1999.

American Association for the Advancement of Science. *Benchmarks for Science Literacy: Project 2061.* New York, NY: Oxford University Press, 1993.

_ _ _ . *Science for All Americans.* Washington, DC: American Association for the Advancement of Science Publications, 1990.

Arons, Arnold. *A Guide to Introductory Physics Teaching.* Toronto, ON: John Wiley and Sons, 1990.

Bybee, Rodger W. *Science and Technology Education for the Elementary Years: Frameworks for Curriculum and Instruction.* Rowley, MA: The National Center for Improving Science Education (The Network), 1989.

Council of Ministers of Education, Canada. *Common Framework of Science Learning Outcomes K to 12: Pan-Canadian Protocol for Collaboration on School Curriculum.* Toronto, ON: Council of Ministers of Education, Canada, 1997.

_ _ _ . *Science Assessment: Framework and Criteria, School Achievement Indicators Program SAIP.* Toronto, ON: Council of Ministers of Education, Canada, 1996.

Conseil supérieur de l’éducation. *Améliorer l’éducation scientifique sans compromettre l’orientation des élèves: les sciences de la nature et la mathématique au deuxième cycle du secondaire.* Montreal, QC: Conseil supérieur de l’éducation, 1990.

_ _ _ . *L'initiation des élèves aux sciences de la nature chez les enfants au primaire.* Montreal, QC: Conseil supérieur de l'éducation, 1989.

Evans, James. "Teaching Electricity with Batteries and Bulbs." *The Physics Teacher.* (January 1978): 15.

Larochelle, M. et J. Désautels. *Autour de l'idée de science: itinéraires cognitifs d'étudiants et d'étudiantes.* Laval, QC: Presse de l'université Laval, 1992.

Manitoba Education and Training. *A Foundation for Excellence.* Renewing Education: New Directions series. Winnipeg, MB: Manitoba Education and Training, 1995.

_ _ _ . *Education for a Sustainable Future: A Resource for Curriculum Developers, Teachers, and Administrators.* Winnipeg, MB: Manitoba Education and Training, 2000.

_ _ _ . *Grades 5–8 Science: Manitoba Curriculum Framework of Outcomes.* Winnipeg, MB. Manitoba Education and Training, 2000.

_ _ _ . *Kindergarten to Grade 4 Science: A Foundation for Implementation.* Winnipeg, MB: Manitoba Education and Training, 1999.

_ _ _ . *Kindergarten to Grade 4 Science: Manitoba Curriculum Framework of Outcomes.* Winnipeg, MB: Manitoba Education and Training, 1999.

_ _ _ . *Reporting on Student Progress and Achievement: A Policy Handbook for Teachers, Administrators, and Parents.* Renewing Education: New Directions series. Winnipeg, MB: Manitoba Education and Training, 1997.

_ _ _ . *Resource-Based Learning: An Educational Model.* Manitoba School Library Media Program Curriculum Committee. Winnipeg, MB: Manitoba Education and Training, 1994.

_ _ _ . *Senior 1 English Language Arts: Manitoba Curriculum Framework of Outcomes and Senior 1 Standards.* Renewing Education: New Directions series. Winnipeg, MB: Manitoba Education and Training, 1996.

_ _ _ . *Senior 1 Science: Manitoba Curriculum Framework of Outcomes.* Winnipeg, MB: Manitoba Education and Training, 2000.

_ _ _ . *Science Safety: A Kindergarten to Senior 4 Resource Manual for Teachers, Schools, and School Divisions.* Renewing Education: New Directions series. Winnipeg, MB: Manitoba Education and Training, 1997.

_ _ _ . *Senior Years Science Teachers' Handbook: A Teaching Resource.* Renewing Education: New Directions series. Winnipeg, MB: Manitoba Education and Training, 1997.

_ _ _ . *Success for All Learners: A Handbook on Differentiating Instruction: A Resource for Kindergarten to Senior 4 Schools.* Renewing Education: New Directions series. Winnipeg, MB: Manitoba Education and Training, 1996.

_ _ _ . *Technology As a Foundation Skill Area: A Journey Toward Information Technology Literacy.* Renewing Education: New Directions series. Winnipeg, MB: Manitoba Education and Training, 1998.

McDermott, L. and P. Schaffer. "Research as a Guide for Curriculum Development. Part I: An Example from Introductory Electricity." *American Journal of Physics* 60(11) (1992): 994–1003.

Morse, Robert. *Teaching Electrostatics.* College Park, MD: American Association of Physics Teachers, 1999.

National Research Council. *National Science Education Standards.* Washington, DC: National Academy Press, 1996.

National Science Teachers Association. *Scope, Sequence, and Coordination of Secondary School Science.* Arlington, VA: National Science Teachers Association, 1992.

_ _ _ . *The Content Core: A Guide for Curriculum Designers.* Arlington, VA: National Science Teachers Association, 1993.

Ontario Ministry of Education and Training. *The Ontario Curriculum Grades 1–8: Science and Technology.* Toronto, ON: Ministry of Education and Training, 1998.

_ _ _ . *The Ontario Curriculum Grades 9 and 10: Science, 1999.* Toronto, ON: Ministry of Education and Training, 1999.

Newfoundland and Labrador Department of Education, Primary, Elementary and Secondary Education Branch. *Foundation for the Atlantic Canada Science Curriculum.* St. John's, NF: Newfoundland and Labrador Department of Education, 1998.

Orpwood, G., and J.P. Souque. *Science Education in Canadian Schools, Background Study 52*. Ottawa, ON: Ministry of Supply and Services, 1984.

Plumb, Donald, Bob Ritter, Edward James, and Alan J. Hirsch. *Science 9*. Scarborough, ON: Nelson, a division of Thomson Learning, 1999.

Prince Edward Island Department of Education, English Programs and Services Division. *Atlantic Canada Science Curriculum: Grade 7–9*. (Draft October, 1999) Charlottetown, PE: Prince Edward Island Department of Education, 1999.

Science Council of Canada. *Science for Every Student, Report 36*. Ottawa, ON: Ministry of Supply and Services, 1984.

Sustainability Manitoba. *Sustainable Development Strategy for Manitoba*. Winnipeg, MB: Sustainability Manitoba, 1994.

United Nations Educational, Scientific and Cultural Organization (UNESCO). "Le développement durable grâce à l'éducation relative à l'environnement." *Connexion 13.2*. New York, NY: June, 1988.

Wolfe, E., C. Clancy, G. Jasper, D. Lindenberg, D. Lynn, F. Mustoe, and R. Smythe. *Sciencepower 9: Science, Technology, Society, Environment*. Toronto, ON: McGraw-Hill Ryerson Limited, 1999.

World Commission on Environment and Development. *Our Common Future*. New York, NY: Oxford University Press, 1987.

Printed in Canada
Imprimé au Canada