Course Profile

Science

Grade 9
Academic

• *for teachers by teachers*

Course Profiles are professional development materials designed to help teachers implement the new Grade 9 secondary school curriculum. These materials were created by writing partnerships of school boards and subject associations. The development of these resources was funded by the Ontario Ministry of Education and Training. This document reflects the views of the developers and not necessarily those of the Ministry. Permission is given to reproduce these materials for any purpose except profit. Teachers are encouraged to amend, revise, edit, cut, paste, and otherwise adapt this material for educational purposes.

Any references in this document to particular commercial resources, learning materials, equipment, or technology reflect only the opinions of the writers of this sample Course Profile, and do not reflect any official endorsement by the Ministry of Education and Training or by the Partnership of school Boards that supported the production of the document.

Acknowledgments

Public District School Board Writing Teams - Science

Course Profile Writing Team
Arthur Prudham, Lead Writer, Waterloo Region District School Board *and*
Science Co-ordinators and Consultants Association of Ontario
Tom Card, Peel District School Board
Nancy Clarke, York Region District School Board
Chuck Hammill, Peel District School Board
Heather Troup, Peel District School Board
Peter Tse, York Region District School Board

Reviewers
Dave Arthur, Ontario Society for Environmental Education (OSEE); Cecil Knight, Kawartha Pine Ridge DSB; Phil Logan, Ed Mahfouz, Patricia Thomas, Ottawa Carleton DSB; Paulette Luft, Philip Marsh, Elaine Sturm, Peel DSB; Dennis Wendland, Waterloo Region DSB *and* OSEE; Fiona White, Kawartha Pine Ridge DSB *and* STAO

Lead Board
Peel District School Board
Allan Smith, Project Manager

Partner Boards
Kawartha Pine Ridge District School Board, Ottawa Carleton District School Board, Waterloo Region District School Board, York Region District School Board

Associations
Ontario Society for Environmental Education (OSEE)
Science Co-ordinators and Consultants Association of Ontario (SCCAO)
Science Teachers Association of Ontario (STAO)

Course Overview
Academic Science Course, Grade 9

Description

This course enables students to understand basic concepts in biology, chemistry, earth and space science, and physics to develop skills in the processes of scientific inquiry and to relate science to technology, society and the environment. Student learning will include scientific theory and investigations related to cell division and reproduction, atomic and molecular structures and properties of elements and compounds, the universe and space exploration, and the principles of electricity.

Unit Titles with Sequence and Timing

This Grade 9 Academic Science course profile has been developed to link units through a progression of skills and in some cases content. Local circumstances may dictate some variation in the sequence suggested below, but it is essential to begin with Unit 1, the skill development unit, since the skills developed are applied in other units. Unit 6, the final assessment task, must be the last unit of the course.

The profile structure is one suggestion. It would also be possible to develop themes which address Expectations from a number of the science strands. For example, an alternate course profile might develop units with titles such as “Nutrition”, which would address Expectations from the Biology and Chemistry strands, or “Science: A Changing Discipline”, which would address Expectations from all four strands.

Observing the skies in the astronomy unit is best done sometime between late November and early February, when nights are long and there is the option to do direct observation in the early evening or morning. It may be necessary for semestered schools to deliver parts of both Units 1 and 5 near the beginning of semester 2 to do this.

The teacher is responsible for creating long-range plans, detailed timing for units and activities, and making decisions about the best order of activities in a given unit. It is important to read through an entire unit prior to making specific plans, since later activities may require introduction early in the unit.

Unit Name and Timing	Unit Title	Skill Development
Unit 1 (14 hours)	Weird Water and Skill Builders	• selected cognitive and manipulative skills for diagnosis of prior learning and skill development
Unit 2 (22 hours)	Reproduction	• inquiry, with a research focus
Unit 3 (22 hours)	Atoms and Elements	• inquiry, with an experimental focus
Unit 4 (22 hours)	Characteristics of Electricity	• inquiry, with a design focus
Unit 5 (22 hours)	Study of the Universe	• developing investigative skills beyond the laboratory
Unit 6 (8 hours)	Making Connections	• final assessment task

Unit Descriptions

Unit 1: Weird Water - Skill Builders
Time: 14 hours

Description

This unit uses some of the unique properties of water as a unifying theme and provides an opportunity for the teacher to assess the current competence of students in science inquiry, their knowledge of the safe and appropriate use of equipment, and their ability to work independently, in small groups and as a whole class during instruction. The second Overall Expectation in each Strand describes the development of cognitive and manipulative science skills. These are the focus of this unit.

Overall Expectations: BYV.01, BYV.02, PHV.01, PHV.02, CHV.01, CHV.02, ESV.01, ESV.02, ESV.03

Specific Expectations: BY1.01, BY2.01, BY2.02, PH1.01, PH2.01, PH2.02, PH2.03, PH2.04, PH2.06, CH1.07, CH1.13, CH2.02, CH2.03, CH2.06, CH2.09, ES1.03, ES2.04, ES2.05, ES2.06, ES3.04

Unit 2: Reproduction
Time: 22 hours

Description

This unit is introduced by examining how developments in reproductive biology have had an impact on society. The focus is on reproductive technology, using current issues to develop student interest in sexual and asexual reproduction. Students will gain a greater appreciation of the Cell Theory, and the importance of mitosis. In addition to proper handling of equipment (such as the light microscope), this unit also provides opportunity for students to improve their inquiry skills through research, analysis, interpretation and evaluation of scientific information, as well as skills for communicating the information.

Overall Expectations: BYV.01, BYV.02, BYV.03
Specific Expectations: BY1.01 to .10, BY2.01 to .09, BY3.01 to .04

Unit 3: Atoms and Elements
Time: 22 hours

Description

In this unit, students will design and conduct investigations into the properties of common elements and compounds with a focus on laboratory and environmental safety. The topics of this unit lend themselves naturally to experimentation and provide opportunities for students to collect, record, organize, analyze and interpret data. The culminating activity of the unit addresses economic and environmental issues and relates to the reactions and properties of common elements and compounds.

Overall Expectations: CHV.01, CHV.02, CHV.03
Specific Expectations: CH1.01 to .15; CH2.01 to .10; CH3.01 to .04

Unit 4: Characteristics of Electricity
Time: 22 hours

Description

In this unit, students will gain an understanding of concepts of static and current electricity. Using a variety of instruments and tools, they will develop skill in gathering qualitative and quantitative data. They will use the relationships among current/electrical resistance /potential difference, and energy/power/time to solve simple problems. Students will apply their knowledge to the design and construction of an electrical circuit which performs a specific function. Safety concerns related to static and current electricity in daily life, and the safe use of tools and electrical equipment, are addressed. Students will evaluate social, economic and environmental costs and benefits associated with electrical energy production and distribution in Canada.

Overall Expectations: PHV.01, PHV.02, PHV.03
Specific Expectations: PH1.01 to .13; PH2.01 to .11; PH3.01 to .03

Unit 5: Study of the Universe
Time: 22 hours

Description

This unit builds on students' curiosity about space and their place in the universe and develops their observational skills in situations other than the laboratory. Students will study the methods scientists use to study space and explore theories on the origin of the universe and the development of technologies used in space studies. Skills of inquiry, problem solving, critical thinking, collaboration and communication are developed. Current space work is emphasized, such as the construction of the new international space station. As a culminating activity, the students develop a proposal for a space mission.

Overall Expectations: ESV.01, ESV.02, ESV.03
Specific Expectations: ES1.01 to .07; ES2.01 to .09; ES3.01 to .04

Unit 6: Making Connections
Time: 8 hours

Description

This unit, which comprises the summative assessment tasks, occurs towards the end of the course. It accounts for 30% of the students' overall course grade, and assesses all three goals of the science course (relating science to technology, society and the environment; inquiry and communication skills; and basic concepts). The course has been designed to allow students to practise skills, and to identify and correct misconceptions in preparation for the final assessment. This assessment also allows the teacher to establish how well students have achieved expectations according to the Achievement Chart for Science (*The Ontario Curriculum, Grades 9 and 10: Science, 1999*, pp. 46-47). The remaining 70% of the course grade will be based on assessments and evaluations conducted throughout the course.

Course Notes

There is a common misconception that science consists solely of a basic set of agreed-upon facts that every student should know. This perception ignores the rapid expansion of knowledge, especially in the areas of science and technology. The established core of science education is not one of facts alone, but of the concepts, skills, attitudes and dispositions which enable learners to interpret and respond to the events, changes and challenges of their world. It is important that all students achieve such scientific literacy, however the path they follow will differ, reflecting local issues and situations, community-based planning and management, and individual student interest.

- The paramount task of science education is to equip all students with *scientific literacy* – that combination of values, knowledge and skills that will enable them to think creatively, reason logically, evaluate information critically and communicate effectively. This is an essential base for making productive and ethical decisions, not only about scientific and technological issues but in all areas of life. At the same time, science education must prepare students who require scientific knowledge and skills for employment or further education in trades, technology and other science related fields.

- To help students achieve this vision, Grade 9 Science is grounded in three goals which parallel those of The Ontario Curriculum, Grades 1-8: Science and Technology, and which are in turn

reflected directly in the three overall expectations for each unit in the course. These goals for students are:

- To relate science to technology, society and the environment;
- To develop skills, strategies and habits of mind required for scientific inquiry; and,
- To understand basic concepts of science

The three goals are of equal importance, and the activities and assessment tasks in this profile reflect that balance.

- An emphasis on science inquiry skills is maintained throughout the course. Through a variety of investigations, students describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. They identify their assumptions, use critical and logical thinking, and consider alternative explanations.

- The expectations are central to all aspects of this course profile. The context in which each unit is delivered, the skills and concepts developed and the assessment tasks used are interconnected, and linked to the Expectations. The assessment data accumulated throughout the course must be sufficient (in kind and number) to permit teachers to evaluate the *consistent level of performance* for each student in each of the categories in the Achievement Chart for Science (policy document, pages 44-47).

- Students should be made fully aware, in advance, of the processes by which they will be assessed and evaluated in each unit of the course and in the summative course evaluation. Use of the Achievement Chart for Science is the basis of assessment of all aspects of the course, and is introduced and discussed in Unit 1.

- This profile describes a science course in which students are taught how, and are actively encouraged, to ask their own questions, and in many cases to find their own answers by inquiry – through experiment, research or the innovation of a device or process. The teacher must make decisions about when and how to intervene to ensure that students are being successful, without usurping their opportunities to find their own way. In this model the teacher is a facilitator of learning, rather than the only source of knowledge - the 'guide on the side', not the 'sage on the stage'. The teacher spends more class time refocusing groups and individual students; less directing whole-class activities.

- Although there is still the need for direct instruction for some skills and concepts, that strategy is only one of a wide range of instructional strategies promoted in this profile. Consequently, there is a much reduced emphasis on traditional laboratory activities in which students are provided step-by-step instructions, and more emphasis on developing students' ability to devise and carry out their own procedures within well-defined limits. Again, the teacher's role is to decide what knowledge and skills students must have for them to proceed safely and successfully in a laboratory setting, without reducing their part in the process to being followers of recipes with entirely predictable results.

- Research across a variety of disciplines indicates that each student interprets new information in terms of what he or she already knows. The student tries to make sense of what is taught by trying to fit it with his or her experience. This implies that teachers must engage students in activities from which the students construct meaning. This does not imply, however, that students must always 'reinvent the wheel'. For example, basic computation and algorithms "were invented precisely so that people would not have to count on their fingers and toes to solve each problem." (Sykes, 1995). Formulas in science serve similar practical purposes. However the formulas and algorithms should be viewed by students as tools for solving problems not as problems to be solved, and should not dominate the curriculum.
- The need for students to interact with others as they expand their experience with new concepts

is so vital that co-operative learning is a primary teaching strategy. Co-operative learning allows individuals to examine their current thinking and to make adaptations in light of input from others. Learners need time to experience, reflect on their experiences in relation to what they already know, and resolve any problems that arise. Accordingly, learners need time to clarify, elaborate, describe, compare, negotiate, and reach consensus on what specific experiences mean to them. Educating students to be effective learners is an important priority in the science program.

- Not all specific expectations are of equal value. Those that are critical to the development of scientific literacy are emphasized in the learning activities, and are often revisited. These are expectations which are taught, assessed, evaluated and where necessary revisited using alternate instructional strategies in a cyclic process that stops only when students have *achieved* the expectations.

- The course begins with a unit which assesses and develops prior knowledge and skills. This pattern is continued by beginning each unit with activities which help students build the necessary background to succeed and which help teachers determine areas for remediation to be addressed during instruction.

- Safety issues should be introduced as appropriate throughout the course. Teachers should consult local and Ministry policy documents, and conform with local Health and Safety practices. Refer also to The Ontario Curriculum, Grades 9 and 10: Science (p. 43).

- As implementation of the Grade 1-8 program proceeds, teachers of Grade 9 Science will find that some of the introductory activities now required to assess and develop student background knowledge and skills will be less time consuming, leaving more time for enhancements and extensions. A chart is provided in the Teacher Support Materials (TSM - Ontario Curriculum, Grades 1 - 8: Science and Technology) which outlines succinctly the areas of the Grade 1-8 program which relate to Expectations in Grade 9 Science.

- There are many opportunities for students to do inquiry by research in this profile. Where activities suggest particular resources and techniques for research, the teacher must decide if the suggestions are feasible, and if not, to adjust them so that the intent of the activity is maintained even if the details are altered to accommodate local circumstances.
  Students should be taught how to use all available tools to access information – from people, print, other media and online sources, both within the school and beyond in the community. They should also be given opportunities to use those skills, and to experience the frustrations that invariably accompany the location and acquisition of quality information.
  However, care must be taken that student time is spent primarily on *processing* information rather than *accessing* information, so that the research does not become an end in itself. It is more time efficient for students to be provided with appropriate resource materials for some activities, rather than having them search them out. For example, a selection of appropriate books, magazines, vertical files and other media on a topic could be located in advance by the teacher and/or teacher librarian and brought to the classroom. Where Internet access if limited, or slow, whole sites can be downloaded to the hard drive of a computer using a commercial software package like WebWhacker (Classroom Connect - ISBN 0932577-39-3 -- web site **http://www.classroom.net**) then used in the classroom. Teachers should also develop collections of articles from various sources that could be maintained in a classroom vertical file for use by students as required, or bundled into packages specific to particular activities.

- The instructional plan for each unit encourages connections to a broad range of community resources. These may include print or electronic sources of information, sites for field trips,

resource people, physical resources, commercial enterprises and post-secondary institutions. These can also be resources for students planning for careers and further education.

- The implementation of Grade 9 Science is a process, not an event. The program will take a number of years to become institutionalized in schools. Beginning in September 1999, it will be necessary that those involved at all levels in the education system make continuous and measurable progress towards the implementation.

- Students who successfully complete Grade 9 Science, whether the Academic or the Applied course, may choose either course option in Grade 10. To ensure that all students have the necessary knowledge and skills to succeed in Grade 10, there is considerable similarity in the learning activities described for both the Academic and Applied courses.

Teaching/Learning Strategies

Most learning activities in this profile focus on the inquiry process, draw on scientific skills and concepts and are set in a context of science as it relates to technology, society and the environment. This approach is a significant, intentional change from past practice which tended to focus first on content, and is critical to the development of scientific literacy for all students. There has been a conscious effort to address the principles of best practice in instruction, as outlined below, in the student activities throughout this profile.

Instructional strategies in Grade 9 Science:
- include whole class, small group and individual instruction
- promote the role of teacher as guide and facilitator in the classroom
- use electronic technology in investigations as appropriate (including computer software, laboratory interface devices, calculators, video and digital cameras)
- address a variety of learning styles in each unit
- can be modified for special needs students
- promote direct involvement in a variety of concrete experiences with the natural world which enable students to construct their own understanding of concepts and principles
- provide challenging experiences appropriate to the needs of a broad spectrum of students
- encourage maximum student engagement in the learning activities
- encourage student choice regarding the processes and products of learning in the science classroom
- provide opportunities for genuine inquiry - to generate questions, apply a variety of investigative approaches in learning, and communicate findings in a variety of ways
- provide options which enable students to demonstrate Achievement Level 4
- use formative assessment to provide opportunities for re-learning
- link assessment tools to the expectations addressed
- allow students to practise during the course tasks like those on which they will be assessed and evaluated
- connect with expectations from other subject areas when appropriate
- support opportunities for transfer – to solve problems and innovate by applying scientific concepts and processes to their lives outside the school and beyond the artificial boundaries which separate school subjects.

Assessment/Evaluation

Assessment is a systematic process of collecting information or evidence about student learning; *evaluation* is the judgment we make about the assessments of student learning based on established criteria.The assessment strategies in this profile support the view that assessment must be embedded within the instructional process throughout each unit rather than being an isolated event at the end. In that view, assessment drives the course and each activity within it. Making the details of the

assessment and evaluation process public to all students is a powerful way to promote student success in the achievement of Expectations. By making assessment central to the learning process, a wide variety of assessment tools can be used in each unit, maximizing the opportunity for each student to succeed.

There has been a conscious effort to address the principles of best practice in assessment and evaluation, as outlined below, throughout this profile.

Quality Assessment and Evaluation

- can be modified to accommodate a variety of learning styles
- can be modified to accommodate special needs students
- include both performance tasks and paper-pencil instruments
- can be diagnostic, formative or summative
- are clearly linked to the Expectations and to the Achievement Levels Chart for Science
- may assess both individual and group performance
- employ a wide variety of assessment and evaluation tools and procedures
- are used to improve learning, both from the perspective of the student and the teacher
- make the student a partner in the assessment process through helping to set criteria and through self and peer assessments
- provide judgments about student achievement in the four categories described in the Achievement Levels Chart for Science
- are criterion referenced, comparing student performance to the Expectations, not to other students

Resource Summary

A. General References on Science Education

Armstrong, Thomas. (1994) Multiple Intelligences in the Classroom. Alexandria, VA: Association for Supervision and Curriculum Development. ISBN 0-87120-230-1

Brown, John L. (1995) Observing Dimensions of Learning in Classrooms and Schools. Alexandria, VA: Association for Supervision and Curriculum Development. ISBN 0-87120-255-7

Burke, Kay. (1993) How to Assess Thoughtful Outcomes. Palatine, Illinois: IRI/Skylight Puhlishing, Inc. ISBN 0-932935-58-3 (1-800-348-4474)

Herman, Aschbacher and Winters. (1992) A Practical Guide to Alternative Assessment. Association for Supervision and Curriculum Development. ISBN 0-87120-197-6

McDonald, Joseph P. et al. (1993) Graduation by Exhibition: Assessing Genuine Achievement. Alexandria, VA: Association for Supervision and Curriculum Development. ISBN 0-87120-204-2

The Minister of Education and Training, Ontario. (1993) Assessment Planning Guide: Junior Science OAIP. Toronto, ON: Queen's Printer. ISBN 0-7778-0716-5

The Waterloo County Board of Education. (1993) Windows on Learning. Kitchener, ON.

The Waterloo County Board of Education. (1993) Assessment for Learning in the Transition Years and the Specialization Years. Kitchener, ON.

Zemelman, Daniels and Hyde. (1993) Best Practice: New Standards for Teaching and Learning in America's Schools. Portsmouth, NH: Heinemann. ISBN 0-435-08788-6

B. A Selection of Science and Education Internet Sites (and sites that lead to them)

American Association for the Advancement of Science
http://www.aaas.org/

Association for Supervision and Curriculum Development -- variety of high quality publications and

videos on a wide variety of topics -- many principals and superintendents have memberships and can purchase materials at reduced rates. Also the home of Educational Leadership magazine.
http://www.ascd.org/

Canadian government and research sites related to science and engineering
http://www.nserc.ca/relate.htm

Education Network of Ontario
http://www.enoreo.on.ca/

Education resources on the web (Canadian site)
http://www.educ.uvic.ca/depts/snsc/pages/weblinks/weblinks.htm

Gateway to Educational Materials
http://www.thegateway.org/

Kathy Schrock's Guide for Educators.
http://discoveryschool.com/schrockguide/

MET Web Index -- to find anything on the Ministry's web site.
http://www.edu.gov.on.ca/eng/webmap.html

Midwest Mathematics and Science Consortium (MSC)
http://www.ncrel.org/msc/msc.htm

National Science Foundation (USA)
http://www.nsf.gov/

National Staff Development Council -- issues of implementation
http://www.nsdc.org/

Online Resources for Assessment
http://www.rmcdenver.com/useguide/assessme/online.htm

Ontario Ministry of Education and Training (MET) -- curriculum documents page
http://www.edu.gov.on.ca/eng/document/curricul/curricul.html

Regional Education Laboratories in the USA -- focus on educational research
http://www.sedl.org/RELs.html

Rubric for scoring a physics laboratory project
http://www.glenbrook.k12.il.us/gbssci/phys/projects/q1/tparub.html

Science Teachers Association of Ontario (STAO) links to science sites
http://www.stao.org/hotlinks.htm

STAR Centre for Academic Renewal (Texas)
http://www.starcenter.org/

USA National Academy of Sciences
http://www.nas.edu/

Course Evaluation

We will know when we are progressing towards the vision described for Grade 9 Science when we observe:

- students who are actively curious, habitually asking questions about the world around them.
- students who can transfer the skills, concepts and habits of mind learned through science to describe, analyze and explain issues elsewhere in the curriculum and beyond the school that relate science, technology, society and the environment.
- students interacting with others in ways that reflect personal and communal values that have been examined, in part, through the study of science.
- students who are able to consider further studies and/or careers in science and technology since we have maximized the choices open to each by providing engaging learning opportunities and inspiring role models.
- teachers functioning as a community of learners, questioning what they do and how they do it, and improving their craft by sharing their experiences.

Coded Expectations: Science, Grade 9, Academic
Biology: Reproduction

Overall Expectatons

BYV.01

– describe cell theory, and apply it to processes of cell division, including mitosis, and the function of sexual (including human) and asexual reproductive systems;

BYV.02

– investigate and analyse cell division and factors affecting cell reproduction;

BYV.03

– evaluate the implications for social decision making of scientific research and technological developments in reproductive biology.

Specific Expectations

Understanding Basic Concepts

BY1.01

– describe the major postulates of the cell theory and how the theory explains cell division (e.g., all living things are made up of one or more cells and the products of those cells; cells are the functional units of life; all cells come from pre-existing cells);

BY1.02

– describe cell division, including mitosis, as part of the cell cycle, including the roles of the nucleus, cell membrane, and organelles (e.g., stages of mitosis – prophase, metaphase, anaphase, and telophase);

BY1.03

– explain how the cell nucleus determines cellular processes and contains genetic material, and why DNA replication is important to organism survival;

BY1.04

– describe various types of asexual reproduction that occur in plant species or animal species, and various methods for the asexual propagation of plants (e.g., fission, budding, production of spores; fission in the amoeba and planaria flatworm, budding in the hydra and sponge; use of bulbs, cuttings, grafting, and modified stems in plants);

BY1.05

– describe and give examples of types of sexual reproduction that occur in plants and in animals, including hermaphrodites (e.g., conjugation, cross-fertilization, internal and external fertilization);

BY1.06

– compare sexual and asexual reproduction (e.g., asexual reproduction produces offspring whose DNA is identical to the parent's DNA, given the same environment; sexual reproduction introduces variation to a species);

BY1.07

– describe the production, structure, and function of a mature egg and sperm in the development and formation of the zygote and embryo;

BY1.08

– describe, in general terms, the roles of hormones in human reproduction where there is no conception, and where conception, development, and parturition occur (e.g., the role that hormones produced in the pituitary gland play in regulating the development of ova or eggs);

BY1.09

– describe, in general terms, human development from conception to the growth of human organs and body proportions, including embryonic human development from early cleavage to the morphological stages;

BY1.10

– distinguish between somatic and reproductive cells and describe factors that may alter genetic material in both types of cells (e.g., uncontrolled exposure to a radioactive source and other mutagens).

Developing Skills of Inquiry and Communication

BY2.01

– formulate scientific questions related to reproduction (e.g., "What factors affect the health of the mother and foetus during the human pregnancy?");

BY2.02

– demonstrate the skills required to plan and conduct an inquiry into reproduction, using instruments and tools safely, accurately, and effectively (e.g., use a microscope at an appropriate level of magnification to locate and view nuclear division on a slide);

BY2.03

– select and integrate information from various sources, including electronic and print resources, community resources, and personally collected data, to answer the questions chosen (e.g., investigate the effects that ultraviolet radiation, carcinogens, water pollution, toxins, or nuclear radiation have on developing organisms);

BY2.04

– analyse qualitative and quantitative data and explain how the evidence gathered supports or refutes an initial hypothesis (e.g., propose an explanation for trends in the optimum reproductive years of women and, following data collection, evaluate the accuracy of that explanation);

BY2.05

– communicate scientific ideas, procedures, results, and conclusions using appropriate language and formats (e.g., describe the steps involved in spore and gamete production in mosses and explain the relationship between them);

BY2.06

– defend orally a given position on an issue or problem, based on their findings;

BY2.07

– use a microscope or microviewer to identify the various stages of mitosis (e.g., use prepared slides of mitosis);

BY2.08

– design and conduct an investigation into the stages of cell division to determine changes taking place in the nucleus and cell membrane (e.g., prepare slides of mitosis and observe them through a microscope);

BY2.09

– use a microscope to make scientific observations of an organism undergoing fission by the process of cell division (e.g., prepare a slide or use a prepared slide to draw an organism undergoing fission);

BY2.10

– predict the number of cell divisions required to produce a certain number of cells.

Relating Science to Technology, Society and the Environment

BY3.01

– demonstrate an understanding of the historical development of reproductive biology and outline the contribution of the microscope to knowledge in the field (e.g., describe the impact of the microscope on the development of scientific understanding of breeding);

BY3.02

– provide examples of how developments in reproductive biology have had an impact on global and local food production, populations, the spread of disease, and the environment (e.g., the impact of scientific developments in such areas as species preservation, genetic engineering of crops, or reproductive technologies);

BY3.03

– describe the importance of Canadian research and technological development in genetics and reproductive biology (e.g., describe and assess how techniques used to bring together nucleii of different plant species such as rye and wheat have improved hardiness and yield by producing the hybrid triticale);

BY3.04

– investigate careers that require an understanding of reproductive biology.

Chemistry: Atoms and Elements

Overall Expectations

CHV.01

– describe various models of the atom, the atomic structure of common elements, and their organization in the periodic table;

CHV.02

– investigate the physical and chemical properties of elements and compounds and use the periodic table to predict the properties of elements;

CHV.03

– describe technologies associated with the refinement, use, and recycling of chemical elements and compounds.

Specific Expectations

Understanding Basic Concepts

CH1.01

– explain the characteristics and utility of a scientific model;

CH1.02

– describe and explain the particle theory of matter;

CH1.03

– describe an element as a pure substance made up of one type of particle or atom with its own distinct properties;

CH1.04

– recognize compounds as pure substances which may be broken down into elements by chemical means;

CH1.05

– demonstrate an understanding of compounds and elements by describing them in terms of molecules and atoms;

CH1.06

– describe the evolution of models of the atom (e.g., from Dalton to Bohr);

CH1.07

– describe the Bohr-Rutherford model of atomic structure and apply it to atoms and their common ions to atomic number 20;

CH1.08
– identify general features of the periodic table (e.g., arrangement of the elements based on atomic structure, groups or families of elements, periods or horizontal rows);

CH1.09
– relate the Bohr-Rutherford atomic model to properties of elements and their positions in the periodic table;

CH1.10
– compare similarities in properties both between and within families of elements to similarities in their atomic structure (e.g., alkali metals, halogens, noble gases);

CH1.11
– use the periodic table to predict the physical and chemical characteristics of an element (e.g., predict that a metal such as sodium will be extremely reactive with a non-metal such as chlorine);

CH1.12
– identify and write the symbols for common elements and the formulae for common compounds (e.g., C, Cl, S, N; H_2O, CO_2, NaCl);

CH1.13
– solve density problems – given any two of mass, volume, and density, determine the third – using the formula *density = mass/volume* and appropriate SI units;

CH1.14
– describe, through observations, the evidence for chemical changes (e.g., changes in colour, production of a gas, formation of a precipitate, production or absorption of heat, production of light);

CH1.15
– identify, through their observations, the characteristic physical and chemical properties of common elements and compounds (e.g., aluminum is a good conductor of heat; magnesium reacts with oxygen to produce magnesium oxide).

Developing Skills of Inquiry and Communication

CH2.01
– demonstrate knowledge of laboratory, safety, and disposal procedures while conducting investigations (e.g., wear safety glasses; practise orderliness and cleanliness; be aware of WHMIS guidelines and emergency procedures; be aware of proper handling and storage procedures);

CH2.02
– formulate scientific questions about physical and chemical properties of elements and compounds;

CH2.03
– demonstrate the skills required to plan and conduct an inquiry into the properties of elements and compounds, using instruments, tools, and apparatus safely, accurately, and effectively (e.g., investigate the reactions of some metals and some non-metals);

CH2.04
– select and integrate information from various sources, including electronic and print resources, community resources, and personally collected data, to answer the questions chosen;

CH2.05
– gather and record qualitative and quantitative data using an appropriate format, and analyse the data to explain how the evidence gathered supports or refutes an initial hypothesis (e.g., conclude from data obtained from the electrolysis of water that the proportion of hydrogen to oxygen in water molecules is 2:1);

CH2.06

– communicate scientific ideas, procedures, results, and conclusions using appropriate SI units, language, and formats, and evaluate the processes used in planning, problem solving, decision making, and completing the task (e.g., use appropriate vocabulary such as *substance, compound, element, atomic number, mass number*);

CH2.07

– formulate definitions of major variables and other aspects of their investigations (e.g., define mass, electrons, protons, neutrons, ions, and isotopes);

CH2.08

– design and conduct experiments to determine the physical and chemical properties of everyday and common laboratory substances such as carbon, copper nitrate, starch, and wax (e.g., physical properties: colour, change of state, solubility; chemical properties: combustibility, reaction with water);

CH2.09

– use molecular models to illustrate the structure of simple molecules (e.g., H_2, O_2, H_2O, NH_3, CH_4, CO_2);

CH2.10

– use proper notation to represent elements, including their atomic number and mass number (e.g., represent the C-12 isotope, which has an atomic number of 6 and a mass number of 12, as $^{12}_{6}C$).

Relating Science to Technology, Society and the Environment

CH3.01

– describe the methods used to extract elements in Canada, and outline associated economic and environmental considerations (e.g., use various sources to explain how gold, nickel, carbon, or uranium is obtained and refined);

CH3.02

– compare the physical and chemical properties of elements to assess their potential uses and associated risks (e.g., hydrogen versus helium in balloons, copper versus aluminum in wiring, copper versus lead in plumbing);

CH3.03

– describe technologies that have depended on understanding atomic and molecular structure (e.g., television, X-rays, nuclear medicine, nuclear power, electron microscopy);

CH3.04

– investigate potential careers associated with an understanding of the physical and chemical properties of elements and compounds.

Earth and Space Science: The Study of the Universe

Overall Expectations

ESV.01

– demonstrate an understanding of how scientific evidence and technological advances support the development of theories about the formation, evolution, structure, and nature of our solar system and the universe;

ESV.02

– investigate and predict the appearance and motion of visible celestial objects;

ESV.03

– evaluate how human endeavours and interest in space have contributed to our understanding of outer space, the Earth, and living things, and describe Canadian contributions to space exploration.

Specific Expectations

Understanding Basic Concepts

ES1.01

– describe and compare the major components of the universe, using appropriate scientific terminology and units (e.g., record the location and movement of planets and satellites, and of stars, galaxies, and clusters of galaxies, using Astronomical Units and light years);

ES1. 02

– describe the generally accepted theory of the origin and evolution of the universe (i.e., the "big bang" theory) and the observational evidence that supports it;

ES1.03

– describe and compare the general properties and motions of the components of the solar system (e.g., the composition and the physical properties – such as size and state, rotation, size and period of orbit – of the Sun, planets, moons, asteroids, comets);

ES1.04

– describe and explain the effects of the space environment on organisms and materials (e.g., the effects of microgravity on organisms in a spacecraft);

ES1.05

– outline the generally accepted theory of the formation of the solar system (i.e., that it was formed from a contracting, spinning disc of dust and gas);

ES1.06

– describe the Sun and its effects on the Earth and its atmosphere (e.g., explain the importance of the Sun as an energy source and the types of radiation emitted; describe the aurora borealis);

ES1.07

– outline models and theories for describing the nature of the Sun and stars and their origin, evolution, and fate.

Developing Skills of Inquiry and Communication

ES2.01

– formulate scientific questions about the motion of visible celestial objects;

ES2.02

– plan ways to model and/or simulate an answer to the questions chosen (e.g., determine, using scale models, and describe, using appropriate astronomical units, how astronomers are able to understand and compare the sizes and distances of objects in the solar system, and in the universe beyond);

ES2.03

– demonstrate the skills required to plan and conduct an inquiry into the motion and characteristics of visible celestial objects, using instruments, tools, and apparatus safely, accurately, and effectively;

ES2.04

– select and integrate information from various sources, including electronic and print resources, community resources, and personally collected data, to answer the questions chosen (e.g., analyse and predict the time required for a spacecraft to travel to the Moon, or to another planet or moon in the solar system, and investigate the factors which limit the feasibility of the voyage – such as fuel, costs, time, comfort, safety, speed of travel, and human requirements);

ES2.05

– gather, organize, and record information using a format that is appropriate to the investigation (e.g., maintain a log of observations of changes in the night sky; prepare a comparative data table on various stars);

ES2.06

– analyse qualitative and quantitative data, and explain how evidence gathered supports or refutes an initial hypothesis (e.g., determine the actual size of a celestial object from its distance and its apparent size);

ES2.07

– communicate scientific ideas, procedures, results, and conclusions using appropriate SI units, language, and formats;

ES2.08

– calculate and compare the sizes of, and the distances to, objects in the solar sytem and in the universe beyond, using appropriate SI units;

ES2.09

– predict the qualitative and quantitative characteristics of visible celestial objects (e.g., determine the temperature of a star by observing its colour; predict the next appearance of a comet from the time of its last appearance and the period of its orbit).

Relating Science to Technology, Society, and the Environment

ES3.01

– describe, evaluate, and communicate the impact of research and other accomplishments in space technology on our understanding of scientific theories and principles and on other fields of endeavour (e.g., advances in fluid physics, crystal growth, and material science, and in technologies associated with robotics, agriculture, and telecommunications);

ES3.02

– investigate the ways in which Canada participates in space research and international space programs (e.g., the International Space Station, telecommunications, satellite technology);

ES3.03

– describe and explain how data provided by ground-based astronomy, satellite-based astronomy, and satellite exploration of the Sun, planets, moons, and other solar-system objects contribute to our knowledge of the solar system;

ES3.04

– explore science and technology careers that are related to the exploration of space, and identify their educational requirements.

Physics: The Characteristics of Electricity

Overall Expectations

PHV.01

– describe and apply models of static and current electricity;

PHV.02

– design and conduct investigations into electrical circuits found in everyday life and into the quantitative relationships among current, potential difference, and resistance;

PHV.03

– evaluate the social, economic, and environmental costs and benefits arising from the methods of electrical energy production used in Canada.

Specific Expectations

Understanding Basic Concepts

PH1.01

– describe the properties of static electric charges, and explain electrostatic attraction and repulsion using scientific models of atomic structure;

PH1.02

– describe charging by contact and by induction;

PH1.03

– compare qualitatively static electricity and electric current (e.g., the charge on a charged electroscope and the charge in an operating circuit);

PH1.04

– describe the concepts of electric current, potential difference, and resistance, with the help of a water analogy;

PH1.05

– explain how electric current, potential difference, and electrical resistance are measured using an ammeter and a voltmeter;

PH1.06

– state the SI units of potential difference, electric current, electrical resistance, electrical energy, and power (e.g., volt, ampere, ohm, joule, watt, and kilowatt);

PH1.07

– describe the relationship among electrical resistance R, potential difference V, and current I;

PH1.08

– solve simple problems involving these quantities ($V=IR$);

PH1.09

– describe the potential difference and current characteristics in a series and a parallel circuit;

PH1.10

– compare the electrical resistance of a series and a parallel connection of identical resistors to that of a single resistor;

PH1.11

– determine quantitatively the percent efficiency of an electrical device that converts electrical energy to other forms of energy, using the relationship *percent efficiency = energy output/energy input x 100*;

PH1.12

– describe the relationship among electrical energy transformed E, power P, and elapsed time t, and solve simple problems involving these physical quantities ($E=P\Delta t$);

PH1.13

– compare methods of producing electrical energy, including their advantages and disadvantages (e.g., voltaic cells; primary and secondary cells; photoelectric cells and thermocouples; hydro-electric and fossil-fuelled power; wind, and tidal power).

Developing Skills of Inquiry and Communication

PH2.01

– demonstrate knowledge of electrical safety procedures when planning and carrying out an inquiry and choosing and using materials, tools, and equipment;

PH2.02

– formulate scientific questions about electricity and restate them in a testable form, identifying the relationships among variables (e.g., “What is the relationship among the number of dry cells connected, in series or in parallel, the potential difference of the source, and the electric current that passes through a resistor?”);

PH2.03

– demonstrate the skills required to plan and conduct an inquiry into electricity, using instruments, tools, and apparatus safely, accurately, and effectively (e.g., use an ammeter and a voltmeter to measure current and potential difference in a circuit);

PH2.04

– select and integrate information from various sources, including electronic and print resources, community resources, and personally collected data, to answer the questions chosen;

PH2.05

– gather and record qualitative and quantitative data using an appropriate format, and analyse the data to explain how the evidence gathered supports or refutes an initial hypothesis (e.g., explain the variations in the monthly costs of electrical energy);

PH2.06

– communicate ideas, procedures, results, and conclusions using appropriate SI units, language, and formats, and evaluate the processes used in planning, problem solving, decision making, and completing the task;

PH2.07

– design, draw, and construct series and parallel circuits for a given purpose, and measure current, potential difference, and resistance at various points in the circuit, using appropriate instruments and SI units (e.g., design and construct a circuit used to enable one of several light bulbs to be switched on and off independently of the others);

PH2.08

– formulate operational definitions for physical quantities involved in electricity (e.g., *potential difference*, *current*, *resistance*, *electrical energy*, and *power*);

PH2.09

– charge an electroscope by contact and by induction;

PH2.10

– predict, verify, and explain the effect of a nearby charged object on a charged electroscope;

PH2.11

– use appropriate instruments and techniques to investigate potential difference against current for an ohmic resistor in a simple series circuit, graph the data, and determine resistance from the slope of the graph.

Relating Science to Technology, Society, and the Environment

PH3.01

– explain practical applications of static and current electricity (e.g., an air cleaner, an electrostatic paint sprayer);

PH3.02

– devise a plan for a self-contained system to generate energy, using renewable energy sources, to meet the energy requirements of a dwelling, farm, or community in Ontario (e.g., design a plan to use any combination of wind, solar, or hydroelectric power);

PH3.03

– identify problems related to electrostatic charge in everyday situations and evaluate solutions (e.g., use of static straps to reduce charge build-up in automobiles; use of electrostatic precipitators to decrease pollution; use of lightning rods to protect buildings).