Course Profile

Science

Grade 9
Applied

• *for teachers by teachers*

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Unit 1: Weird Water - Skill Builders
Time: 865 minutes

Unit Description

This unit uses some of the unique properties of water as a unifying theme and provides opportunities for the teacher to assess the current status of students with respect to their skills 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 of the Ministry Strands describes the development of cognitive and manipulative science skills, and it is these Expectations that are the focus of this unit.

Strand(s) & Expectations

Strands: Biology, Chemistry, Earth and Space Science, Physics

Expectations:

Knowledge / Understanding
postulates of Cell Theory, process of cell division, BY1.01
properties of static electric charges, PH1.01
properties, motion and components of solar system, ES1.03
models - atomic, subatomic CH1.04
Skills - inquiry, communication
initiating and planning
• plan and conduct investigation, using tools, BY2.03
• plan and conduct investigation, using tools, CH2.04
• formulate questions PH2.03
• formulate questions CH2.03
performing and recording
• manipulation of lab equipment calculator, PH2.01
• manipulation of lab equipment microscope, BY2.02
• manipulation of lab equipment glassware, CH2.04
• gather, organize and record information ES2.05
analyzing and interpreting
• research, evaluate and integrate ES2.04
• research, evaluate and integrate PH2.05
• using model CH2.10
communicating
• scientific ideas BY2.07
• scientific ideas PH2.07
• scientific ideas CH2.06
Applications
how data from different sources contribute to knowledge ES3.03

Activity Titles (Time and Sequence)

Activity	*Title*	*Time (minutes)*
1	Working with Water	80-100
2	Pond Water	150
3	Properties of Water	225
4	Water and Space	120-150
5	Models of Atoms and Molecules	120
6	Culminating Task	120

Prior Learning Required

Teachers should examine the Teacher Support Material (TSM - Ontario Curriculum, Grades 1 - 8: Science and Technology) to gain an understanding of content and skills with which students arrive. This is a diagnostic unit, providing opportunities to assess the knowledge and skills of students as they begin this course.

Unit Planning Notes

Student notebooks should be divided into two parts: *Science Notes* where students copy or create their notes and a *Science Journal* where students record their questions and reflect on their learning.

The 'Wonder Wall', or a bulletin board where students post Thought Provoking Questions (TPQ.) needs to be organized before the first class. Its use is explained in Activity 1. (See TSM - Glossary: *Wonder Wall*)

Specific planning for each activity is described in the subsequent pages. However, the following should be noted in advance:

- pond water is required for Activity 2

- access to the Resource Centre / Library materials is required for Activities 4 and 6

Learning/Teaching Strategies or Activities

Activity	*Strategy*	*Description*
1	Mind Map	Diagnostic in nature, where students record what they know about water related to the four strands. The students will work in a whole-class setting and individually.
2	Using equipment	The activity reviews microscope use and the completion of scientific diagrams. The students will work individually or in pairs depending on the availability of microscopes.
3	Inquiry / Experimental	This is a hands-on activity on measurement, collecting and organizing data. The students will work in small group settings including a jigsaw activity.
4	Inquiry / Research	This is a research activity conducted in the Resource Centre. The students will work individually.
5	Using models	This is a teacher-directed activity on the role and importance of models. The students will work in small groups.
6	Culminating Task	Students will work individually.

Assessment / Evaluation

Activity	*Assessing and Evaluating*	*Method or Instrument*
1	Prior Knowledge	Mind Map
2	Microscope Usage	Peer check-list
	Scientific Diagrams	Teacher evaluated
3	Communication and Group skills	Rubrics
	Recording data	Rubrics
	Interpreting and analyzing data	Rubrics
4	Communication skills	Rubrics
	Research skills	Rubrics
5	Prior Knowledge	Science Journal and checklist
	Understanding concepts	Science Journal and Quiz
6	Inquiry Skills	Culminating Task Rubric
	Understanding concepts	Mind Map revision and Quiz

Resources

Scales of Scientific Inquiry and Technological Design, Peel District School Board, 1998.

Activity 1: Working with Water (Introduction to Course Expectations)

Time: 80 - 100 minutes

Description

The first activity serves to introduce the course content, the assessment and evaluation practices employed, the notebook organization, and to begin some diagnostic tasks. There are four parts to this activity and they should be presented in the order suggested here. Other course-beginning procedures, as determined by individual schools, can be integrated into this first activity.

Strand(s) & Expectations

Strands: Biology, Chemistry, Earth and Space Science, Physics

Expectations: BY2.02, BY2.07, PH2.03, PH2.07, CH2.03, CH2.06

These expectations relate to formulating questions and communicating ideas -- two aspects of the inquiry process which are stressed in this activity. These will be assessed on many occasions throughout the course.

Planning Notes

Equipment required:

ebonite rod	wool or fur
rubbing alcohol	paraffin wax
dry cell	copper wire (depending on the demonstrations planned)

Handouts:

mind map template	Achievement Chart for Science
outline of the Culminating Task	rubric used to evaluate the Culminating Task

Any demonstration should be practised ahead of time. As well, it is necessary to be conversant with the Achievement Chart for Science and the rubrics for inquiry and the final assessment task.

Prior Learning Required

None is specifically required but many students will arrive being familiar with some aspects of inquiry. For a summary of students' previous learning refer to TSM - Ontario Curriculum, Grades 1 - 8: Science and Technology.

Teaching/Learning Strategies

1.1 **Student Activity**: Students will observe a number of discrepant event demonstrations related to water. Students will work on developing their questioning skills. Questions, observations and inferences should be recorded in the Science Journal. Students will also post their questions on a bulletin board (the Wonder Wall - see TSM - Glossary).

Teacher Facilitation: The teacher will perform a number of discrepant event demonstrations that are related to water. These could include:

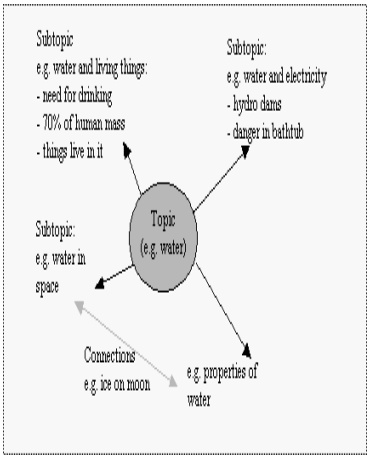
- bending of water: charge an ebonite rod by rubbing it with a piece of wool or fur and hold the charged rod close to a narrow stream of water

- paraffin in water and in alcohol: set up two beakers, one containing alcohol and the other containing water, and place a piece of paraffin wax in each. [Take appropriate safety precautions using flammable alcohol; some individuals have skin sensitivities or allergies to alcohols.]

- mini-electrolysis: attach each terminal of a dry cell to two separate pieces of copper wire and immerse the ends of the wires in a beaker of acidified water.

The intent of these activities is to develop the questioning skills of the students. (Refer to Teacher Support Material, TSM - Questions.) At no time should you explain the events. Discuss observations and inferences with students. Prompt students to modify their questions until they are in a form that could be subjected to investigation – a question on an issue which could be researched, or one which identifies variables which could be subjected to experimental investigation. (Refer to Teacher Support Material, TSM - Questions.) A bulletin board should be set aside for students to post questions. This could be called "The Wonder Wall" or "TPQ" (thought provoking questions) (TSM - Glossary: *Wonder Wall*). Throughout the course, as questions are answered, solutions are posted, and as new questions evolve they are added. Questions from the Wonder Wall and Science Journal may provide a starting point for the end-of-course Final Assessment (Unit 6: Making Connections).

1.2 **Student Activity**: Students working in groups will complete the mind map template to the best of their abilities. At the end of the unit, students will revise their original mind map.**Teacher Facilitation**: The teacher will hand out the mind map sheets (see example that follows and TSM - Visual Tools) to the class. These will not be evaluated but will be used to assess some of the students' prior knowledge and to be used as a starting point to assess and evaluate learning during this unit.



1.3 **Student Activity**: Students will learn that the Achievement Chart for Science is the key tool that the teacher will use to evaluate their performance in Grade 9 Science. **Teacher Facilitation**: The teacher will introduce and explain the Achievement Chart for Science.

This should be explained to the students so that they are aware of the levels from the beginning. This should be shared with parents and guardians as well. (Some schools may have a special grade 9 parents' night.) A way of explaining this to students is that the various assessments are *observations* made by you, the teacher, in order to produce an *inference*, their evaluation in the course.

1.4 **Student Activity**: Students will be introduced to the Culminating Task for the first Unit:

In this task, students will be required to formulate a specific question based on concepts and/or skills developed during the first unit. They are to conduct an investigation using the inquiry process (either experimental or research) to answer their question and produce a written report.

Students review with the teacher the rubric for evaluating this Culminating Task.**Teacher Facilitation**: The teacher will inform students that the culminating task for this unit mirrors the end-of-course assessment where they will also investigate a question of their own choice. This activity allows students to practise skills needed for the final assessment while helping to diagnose areas of relative weakness and strength.

The rubrics for the inquiry process (both experimental and research) are found in the Teacher Support Materials (TSM - Rubrics). They may be used as presented or modified to meet individual teacher needs. The teacher will remind students to record questions in their Science Journal and to post questions on the "Wonder Wall" throughout the unit. Students may be directed to these places to find their question for the Culminating Task.

If students are having difficulty coming up with their own questions, several possibilities are provided below. These should only be given to students if all other means of developing their own questions have been exhausted.

- What is the cost per year of a water drip from a leaky tap?
- Where do you find the most microscopic organisms in pond water, at the bottom of the pond or near the upper surface?
- How does temperature affect the density of a material?
- Do liquids, other than water, behave in the same manner when charged objects are brought near to a stream of the liquid? Why is this so?
- In what ways is water a very special liquid?
- What causes different patterns of water droplets to form on various surfaces, like glass?
- Is the density of a salt solution (15 g of salt per 100 g of water) the same as a sugar solution (15 g of sugar per 100 g of water)?

Assessment/Evaluation Techniques

The mind map will be used to estimate the class's familiarity with the topic. It will not form any part of a student's evaluation. Their questioning skills should not be evaluated during this activity. This will come later as they have more opportunity to practise.

Accommodations

This activity will give you an opportunity to gauge the need for accommodations for students with special needs in future activities.

Refer to TSM - Accommodations for Students with Special Needs

References

Scales of Scientific Inquiry and Technological Design , Peel District School Board, 1998.

Achievement Chart for Science, The Ontario Curriculum Grades 9 and 10, Science pp.44-47

Various source books for demonstrations

Activity 2: Observing Life in Pond Water
Time: 150 minutes

Description

This activity allows for a review of the skills related to the use of the microscope, as well as concepts related to The Cell Theory and simple cellular structure. Students will have the opportunity to apply this knowledge and skill to the study of pond water.

Strand(s) & Expectations

Strand: Biology
Expectations: BY1.01, BY2.02

Planning Notes

Equipment and Materials needed:

- microscope
- cover slips
- slides - flat & depression
- iodine stain
- copper penny
- pond water
- onion skin

Prior Learning Required

Refer to Teacher Support Materials (TSM - Ontario Curriculum, Grades 1 - 8: Science and Technology).

Teaching/Learning Strategies

The following sequence is suggested to develop skills and concepts for this unit.

2.1 **Student Activity**: The students will view a variety of materials using a compound or dissecting microscope. They will then view a penny (Cdn - for leaf structure - is it maple or sycamore?- and identification, US - for Lincoln between the pillars) using either microscope. They will draw a detailed scientific diagram of the penny to practise recording what is seen, not inferred.

Teacher Facilitation: The teacher will discuss appropriate uses of the compound and dissecting microscopes. (Note - sufficient light reflects off the penny to allow use of the compound microscope.) The teacher will observe student use of the microscope, initiate peer assessment of microscope use, and outline the expectations for scientific diagrams (i.e., stippling, labeling…..).

2.2 **Student Activity**: The students will practise making a wet-mount using newsprint (e.g., the letter "e" lab and a coloured picture).

Teacher Facilitation: The teacher will review proper technique to avoid creating air bubbles.

2.3 **Student Activity**: The students will use a Graffiti or Think-Pair-Share process to verbalize their understanding of animal and plant cells and the Cell Theory.

Teacher Facilitation: Refer to the Glossary (TSM - Glossary) for a brief description of the Graffiti process. Think-Pair-Share is a simple example of a Cooperative Small Group Learning (CSML) strategy in which students first consider (silently) what they recall about a topic, then after a minute or two of silent reflection share their thoughts with one partner. The pair then consolidate their thinking and, under the teacher's direction, participate in a sharing session with pairs in the class.

2.4 **Student Activity**: The students will stain and mount an onion skin for viewing of a typical plant cell, then view a prepared slide of an animal cell. Students will compare animal and plant cells and state the components of the cell theory using any format/structure of their choice e.g., notes, tables, diagrams, visual presentation etc.

Teacher Facilitation: The teacher will review handling of stains, cellular structures which are stained, and the main observable differences between plant and animal cells. Safety: Students should avoid skin contact with biological stains, and should be advised of proper chemical disposal procedures.

2.5 **Student Activity**: The students will observe a sample of pond water and draw a protist.

Teacher Facilitation: The teacher will discuss the use of depression vs. flat slides, importance of scanning the slide and possible protists found in pond water.

Safety: The teacher will remind students that pond water may contain harmful organisms and/or pollutants and should be handled with appropriate caution (wash hands after handling; no contact of pond water with cuts or face, etc.).

Assessment / Evaluation Techniques

- Use a peer check-list (see Attachment A) to assess the use of the microscope.
- Use a teacher marking scheme to assess the diagrams drawn.

Accommodations (Special Needs)

Some students may benefit from working with a peer helper during the microscope exercise, or may need written instructions.

Refer to TSM - Accommodations for Students with Special Needs

Resources

Videos on Cell Theory - e.g. Pomasanoff, A. Director. The Invisible World. Videorecording. The National Geographic Society. Vestron Video, 1979.

Images from various types of microscopes

Appendices

TSM - Ontario Curriculum, Grades 1 - 8: Science and Technology

Attachment

Peer Assessment of Microscope Use

Does your partner.....		Yes / No
1.	carry the microscope with two hands.	
2.	start with the stage down.	
3.	locate and focus the specimen successfully starting with the lowest power.	
4.	use the coarse adjustment to move stage up.	
5.	view the microscope from the side as the stage is raised.	
6.	focus on the slide by turning the coarse adjustment knob away from them.	
7.	view the nosepiece from the side while slowly rotating the objective lenses.	
8.	use only the fine adjustment knob to focus clearly on the slide.	
9.	move the nosepiece to the lowest objective before removing the slide.	
10.	return the stage to its initial position before carrying the microscope back to the cart.	

Note: One should never touch either the eyepiece or the objective lenses directly. Use only the appropriate tissue on the lenses for the removal of dirt and fingerprints.

Activity 3: Properties of Water - Density

Time: 225 minutes

Description

In this activity, students will be expected to determine the relative densities of different types of material and justify their claim with numerical data. They will work collaboratively in small-group and large-group settings to complete a task and practise appropriate measurement skills. The *focus* of this activity is scientific inquiry and the nature of experimentation (collect, analyze and interpret data, make predictions and justify the claim) using the concepts of density, mass, and volume as the *vehicle* for developing and assessing those skills.

Strands(s) & Expectations

Strand: Chemistry
Expectations: CH2.04

Planning Notes

Equipment needed:

- balances or scales
- narrow glass tubes / clear plastic straws
- graduated cylinders
- computer with spreadsheet (optional)
- rulers
- test tubes
- over flow cans

items to measure: wood, rubber stoppers, styrofoam balls, aluminum blocks, lead fishing sinkers.

Materials:
5 different intensely coloured salt or sugar solutions with densities suggested below (Activity 3.2):

100 g solute in 1 L water with orange food colouring
50 g of solute in 1 L water with blue food colouring
25 g of solute in 1 L water with red food colouring
12.5 g of solute in 1 L of water with green food colouring
6.25 g of solute in 1 L of water with yellow food colouring

Prior Learning Required

Students should have some knowledge of the concept of density and of variables, and the ability to use balances, overflow cans and, graduated cylinders. They should also have some experience at collecting data, reading a meniscus and graphing.

Teaching / Learning Strategies

3.1 **Student Activity**: Students view the discrepant events described below and generate questions for potential use during the Culminating Task.

> **Teacher Facilitation**: The teacher will demonstrate the sinking and floating of different cans of soft drinks (various brands, regular and diet) in a tank of water. This is a quick assessment of prior learning - concept of density. The questions generated should not be answered but should be posted on the Wonder Wall or in the students' Science Journal.

3.2 **Student Activity**: In Collaborative Small-Group Learning (C.S.G.L.). Students will determine the relative densities of three coloured solutions given three test tubes, a waste container, a clear straw / glass tubing and three of the five solutions.

Students will obtain any three prepared solutions from the front desk in three separate test tubes. They will determine the relative densities of two solutions by 'drawing' about 1 cm of each of the solutions into the clear plastic straw. This is done by first inserting the straw 1 cm into a solution, then putting a finger over the top of the straw, and moving the straw into 2 cm of a second solution without removing the finger (thus keeping solution one in the straw). The finger is then removed to allow the second solution to come into the straw. If the two solutions mix, then solution one is greater in density than solution two. If two distinct layers are seen, then solution one is lower in density than solution two. Students can repeat this process to determine the relative densities of their three solutions. When this is done, each group will record their findings on a class data chart. Students then use the collective results to determine the relative densities of all five solutions.

Students will write a brief explanation in their Science Journals on how they deduced the relative densities of the solutions.

> **Teacher Facilitation**: The teacher will ensure that different groups have a different combination of three liquids to test and that no mixing and contamination of the stock solutions. Create a class recording chart for the groups.

Sample Class Data Chart for Unit 1 Activity 3 (with one group's data entered as an example)						
Solution Colour	***Group 1***	***Group 2***	***Group 3***	***Group 4***	***Group 5***	***Group 6***
Red						
Green	M					
Orange						
Yellow	L					
Blue	H					

Legend: H = highest density of the three solutions tested
M = middle density of the three solutions tested
L = lowest density of the three solutions tested

3.3 **Student Activity**: Students will calculate densities in collaborative small groups (C.S.G.L.) using a home group / expert group structure. Each of the five expert groups will learn one of the following:

- measuring the mass of solid objects on available balances
- measuring the mass of liquids on available balances
- measuring the volume of irregular objects directly by displacement
- measuring the volume of irregular objects using water displacement into overflow cans
- measuring the volume of regular objects - measurements, mathematical formulae, calculations

Experts will then return to their home groups. The task of each home group is to measure the volume and mass of at least five samples of a solid (regular or irregular shape) and five samples of a liquid (one of the colored solutions from Activity 3.2). For example, group 1 will measure different sizes of rubber stoppers and five different volumes of the orange solution; group 2 will measure different sizes of wood and five different volumes of the green solution; etc. When this is completed, students will have at least ten sets of data. A tabular data chart may be given to students beforehand for recording purposes, or students may be asked to design their own way of recording the data.

Teacher Facilitation: For classes using electronic balances, the teacher will combine the two mass measurement together to create four expert groups.

3.4 **Student Activity**: Home groups will report their collected data to the instructor, who will then have a comprehensive set of results. Students will then be given all sets of results and their task is to use the data (graph and calculation) to support their claim made in Activity 3.2 in which they deduced the relative densities of the five solutions. Students will plot one graph of mass vs. volume data showing lines for all five solutions.

Teacher Facilitation: To compile the class data efficiently, it may be easier if groups input their data into a spreadsheet directly. The teacher will review graphing techniques, line of best fit and qualitative determination of the slope of the line (i.e., more dense = steeper slope) using one set of results.

Pass results to the Math department for in-depth analysis of data by students.

3.5 **Student Activity**: Students will determine from the class data the 'best' density value for each of the solids. Students will sketch one graph (showing relative positions of lines with no numeric values) for all solid substances. Students will observe the teacher demonstration on sinking and floating of objects and based on the result, estimate the density of water and sketch the line (for water) on their graphs.

Teacher Facilitation: The teacher will place one of each type of the solids (from the home group activity above) in a tank of water to observe which substances float and sink.

Assessment /Evaluation Techniques

A variety of assessment and evaluation instruments is possible. The teacher should not use all, but select some appropriate ones. Use rubrics developed from the Achievement Chart for Science and from the samples in TSM - Rubrics.

- calculation of density through performance task - students are to determine the density of an unknown solution given appropriate equipment
- communication and group skills using rubrics
- data recording - tabular recording chart or student design to record data
- data interpretation - group presentation, written explanation, graphing
- data analysis - graphing, written explanation
- quiz

Accommodation

Some students will need peer or teacher assistance to interpret class data on liquid densities and to draw graphs and interpret them. Written instructions and/or visual examples may also be required for students with language difficulties to help them generate useful charts and graphs.

Refer to TSM - Accommodations for Students with Special Needs

Resources

Lincoln County Board of Education; Lem, V., ed. Growing Collaboratively. Prentice Hall Canada Inc., Scarborough, Ont.; 1993.

Activity 4: Using the Resource Centre to Inquire about Water and Space

Time: 120- 150 minutes

Description

In this activity students will formulate a question that pinpoints a topic for investigation. They will then conduct a research inquiry using a wide variety of print and electronic resources. Documents, books, articles and other resources will be accessed and judged critically with attention to usefulness, accuracy, bias, validity, and authenticity of information. Chosen information from many sources will be recorded, organized, analyzed and integrated to allow the student to communicate their answer to the original question. A one-page written report provides an opportunity for teachers to check writing skills using a diagnostic assessment. A bibliography will be produced by the student and will be assessed for both form and content.

Strand and Expectations

Strand: Earth and Space Science
Expectations: ES1.03, ES2.04, ES2.05, ES2.06

Planning Notes

Introduce Activity 4 several class periods before the actual research time in the resource centre. Students will need time to formulate their question, and should be encouraged to consult family members, other students, and friends for ideas.

Co-ordination with the teacher-librarian is necessary to ensure the success of this activity. Many resource centres have orientation programs to help students use the library. Librarians can also help students critique on-line sources of information to decide if the material is reliable and valid. Critical analysis handouts may be available in the resource centre. Documentation of sources of information and organization of a bibliography are also processes that can be directed by the teacher in concert with the teacher-librarian.

The teacher will focus on small group interaction, and one-to-one learning opportunities. Students may require encouragement to stay on track, find and integrate their information. Monitoring and checking off each stage of work encourages students to complete manageable portions of the research, and ensures that their time is used effectively and efficiently. This may be accomplished using a monitoring sheet developed by the teacher (and the teacher-librarian).

Refer to the Course Notes for some ideas which may be used as alternatives if a school resource centre is unavailable.

Prior Learning Required

Students have practised framing questions, and have also had opportunities to access, organize, and present information in grades seven and eight. They may not be familiar with all of the different research strategies available, and should be helped to expand their skills in this area.

Teaching/Learning Strategies

4.1 **Student Activity**: Students will examine the bibliography assessment checklist and the writing scale rubric for the one page report (TSM - Rubrics)

> **Teacher Facilitation**: The teacher will lead a discussion to clearly establish the purpose of the research activity and preview assessment expectations.

4.2 **Student Activity**: Students will frame questions that are open-ended, and directed towards understanding the universe, and our solar system using the underlying theme of water. Out-of-class time over a few days may be needed for students to develop a satisfactory question. Students may ask parents, relatives, and friends for ideas.

> **Teacher Facilitation**: The teacher will ask questions to help students get started. Starter questions should be on a different, but related, topic. For example: "Where in the solar system would you be able to mine iron? Copper?", or "What is the greatest range of temperature found on the surface on a planet in the solar system?"

4.3 **Student Activity**: Students will use as many resources as possible (print, electronic, community experts) to help answer their question. Information is evaluated for relevance, accuracy, bias, completeness, and authenticity.

> **Teacher Facilitation**: The teacher will help students access information by providing checklists to guide their search. Introduce students to the concepts of relevance, accuracy, bias, completeness and authenticity of information sources. Provide critical evaluation sheets to help students determine the value of information from a variety of resources.

4.4 **Student Activity**: Students will choose their five best resources that will help answer their question. At least one source must be electronic, one source from a journal or periodical, and one source from a book or encyclopedia.

> **Teacher Facilitation**: The teacher will encourage peer-sharing of resources to enable students to work co-operatively.

4.5 **Student Activity**: Students will record and organize information. All information required for properly citing references is recorded.

> **Teacher Facilitation**: The teacher will show students samples of bibliographies. Include examples of on-line citations.

4.6 **Student Activity**: Students will write a one-page report that answers their question and includes an bibliography for their best 5 resources.

> **Teacher Facilitation**: The teacher will remind students to refer to the writing scale rubric and the bibliography checklist that will be used as the assessment tools.

4.7 **Student Activity**: Students will reflect on the research assignment in their Science Journals, and comment on why they chose their final resources, the difficulties they encountered, and

their successes. Also, additional questions that may be investigated for the end of unit Culminating Task should be recorded.

Assessment/Evaluation Techniques

The expectations that will be assessed include developing skills of Inquiry and Communication.

As the activity is taking place early in the course, the assessment will be diagnostic in nature, and will allow the teacher to note and guide the students' achievement of inquiry and writing skills. Areas that require remediation should be taken into account and a plan for upgrading skills developed.

The assessment tools to be utilized include a checklist for the bibliography, and a writing scale rubric for the one page report.

No sample checklist has been included in the profile; the teacher should use the school's style guide to create one, or acquire one from the resource centre or another department within the school. Students in the science classroom should be encouraged to use the same bibliographic style as is used elsewhere in the curriculum.

Accommodations

It is important to note that some students may find the writing challenging, but it is necessary to assess their skills early and provide appropriate support where required. Future activities will encourage students to use other formats (visual, and oral) to communicate their ideas.

Refer to TSM - Accommodations for Students with Special Needs

Activity 5: Models of Atoms and Molecules
Time: 120 minutes

Description:

In this activity, students will review and extend their knowledge of models in science. They will then use a model to explain some observations about water.

Strand(s) & Expectations

Strands: Biology, Chemistry, Physics
Expectations: CH1.04, BY1.01, PH1.01, CH2.03, CH2.06, CH2.10

Planning Notes:

Materials required for the activities include:

- variety of models and real items
- tape or modeling clay
- material for electrostatics (e.g. ebonite, plexiglass, plastic rods, fur, wool silk)
- watch glasses
- molecular modeling kit

Prior Learning Required

Although no specific prior knowledge of the topics is prerequisite, the teacher will be able to determine the general background knowledge of the class during the discussion and brainstorming activities.

Teaching/Learning Strategies

5.1 **Student Activity**: Students will be presented with a mixture of models (e.g., model of ear, skeleton, cell, atom, car, doll, diagram of the Krebs cycle, a mathematical formula, doll house, symbolic model such as H_2O...etc.) and items that are not models, one at a time, and watch as the teacher places them into one of two piles. When they feel they know the "rule" for putting them into piles (i.e., models vs. non-models), students will be invited to select an item and place it appropriately. This will continue until the students discover the rule or until it is appropriate to tell them.

> **Teacher Facilitation**: The teacher will present the items to the students as a game show host might, with lots of enthusiasm and establishing false patterns at the beginning (e.g., put several items that are obviously science items, but non-models, into one pile; then place a non science item model in the other pile; and then hold up a science-based model and have students guess as to which pile it belongs). This will force students to examine their reasoning several times during the activity. Follow the initial activity by discussing with students: characteristics of models (i.e., they are alternate representations of reality); reasons for using models (object is too small, too large, too expensive, too dangerous, inaccessible); and types of models (physical, graphic, conceptual, mathematical).

5.2 **Student Activity**: In small groups students will report on chart paper what they think they "know" about atoms. After each group shares with the class, the groups will then draw a model of the atom which they feel captures the necessary points presented by all groups. Groups will then present their model and their reasoning to the class. A teacher-led discussion will follow, then students will make an entry into their Science Notebook as seatwork or homework.

> **Teacher Facilitation**: As groups discuss and later draw, the teacher will move about the class encouraging and questioning groups as appropriate. Following the presentation of drawings, review or present information regarding: the components of the atom (i.e., protons, neutrons, electrons); a simplified Bohr-Rutherford model (nucleus of protons and neutrons, electrons orbiting the nucleus); and the method by which atoms gain a charge (i.e., gain of electrons results in a negative charge, loss of electrons results in a positive charge). Once student questions are discussed, have them make a note in their Science Notebook about a) models and b) the atomic model.

5.3 **Student Activity**: Students, in pairs or small groups, will set up materials according to teacher instructions. Materials will include a neutral rod (e.g., uncharged ebonite rod) resting on a watch glass and held in place by tape or modeling clay. The watch glass is free to rotate. Have students bring charged rods (positive and negative, one at a time) close to the neutral one and record what happens. Have them repeat this, but this time using a charged rod on the watch glass as well. Students then use the model of the atom discussed previously to infer the movement of electrons and propose a possible explanation for their observations.

Explanations are shared. Students will then extend their reasoning to offer an explanation of the teacher demonstration which follows.

Teacher Facilitation: As the students work, the teacher will travel about the class making observations and brief anecdotal notes about student work methods and participation. Following discussion of student observations and explanations, repeat the discrepant event from the beginning of the unit whereby a stream of water is bent using first a positively-charged rod, then a negatively-charged rod. Question them as to whether water is positively charged, negatively charged or neutral. Briefly review the atomic structure of elements and compounds. Then discuss how localized charges can occur within a neutral molecule (i.e., if electrons tend towards one part of a molecule, that portion will effectively become negative, while the area with relatively fewer electrons will take on a positive charge).

5.4 **Student Activity**: Students will be presented with two models of water, one linear, the other bent. They are told that the hydrogen atoms have a slightly positive charge and the oxygen a slightly negative charge. In a think-pair-share (C.S.G.L.) format, students will use their knowledge of charges and electrons to defend the model that better explains their observations of the discrepant events.

Teacher Facilitation: As an alternative to the above activity, teacher may present the correct model of a water molecule (bent). Students would then relate their observations about the behaviour of water to the model. Using effective questioning techniques, the teacher will challenge students to verbalize their thinking and reasoning at each step. They will likely require reminders of past learning. Remind them of the Culminating Task and encourage them to jot down questions as they work.
Summarize the activity by discussing advantages and disadvantages of models and reasons for their evolution.

Assessment/Evaluation Techniques

- anecdotal comments from class observations
- completion and accuracy of entries in Science Notebook
- quiz

Accommodations

Activity 5.4 as written may be used as an enrichment activity.
Refer to: TSM - Accommodations for Students with Special Needs

Activity 6: Culminating Task
Time: 120 minutes

Description

Students are required to formulate a specific question based on concepts and/or skills developed during this first unit. They will conduct an investigation using the inquiry process (either experimental or research) to answer their question and produce a written report.
As well, students will complete a second mind map using the same format as the one done in Activity 1.

Planning Notes

This activity was introduced during Activity 1. Time must be provided towards the end of the unit so that students can work on this activity.

Prior Learning Required

Students will use several of the skills they practised during this unit in order to successfully complete the Culminating Task.

Assessment/Evaluation Techniques

A rubric for evaluating inquiry, both experimental and research, and a rubric for evaluating writing are found in the Teacher Support Materials (TSM - Rubrics).
The mind map should be compared to the one produced in Activity 1 to assess student learning during this unit.
Quiz to assess understanding of concepts.

Accommodations

Refer to TSM - Accommodations for Students with Special Needs for a number of specific suggestions for accommodating both academically challenged and ESL/ESD students. Although some degree of uniformity is desirable in the way in which students'' achievement is assessed, the teacher should still provide alternatives which will maximize each student''s chance to be successful when they demonstrate their learning.

Unit 2: Applied Biology - Reproduction - Processes and Applications
Time: 22 hours or 1320 minutes

Unit Description

The reproduction unit is introduced by examining a wide variety of careers associated with Reproductive Biology and related biotechnologies. The primary focus will involve learning and using the inquiry skills necessary to investigate and understand an issue. Students will be able to propose and evaluate ideas, think critically, and make decisions based on information from a wide variety of sources including electronic and print resources. The end-of-unit task will involve students researching and reporting on a specific occupation related to Biotechnology.

Strand(s) and Expectations

Strand: Biology
Overall Expectations: BYV.01, BYV.02, BYV.03
Specific Expectations: BY1.01 to .07; BY2.01 to .09; BY3.01 to .05

Activity Titles (Time and Sequence)

Activity	*Title*	*Time (Minutes)*
1	Careers In Biotechnology	200
2	Cell Division and Mitosis	300
3	Asexual and Sexual Reproduction	250
4	Investigation into Asexual Reproduction	200
5	Issues in Human Reproduction	200
6	End-of-Unit Task	170

Prior Learning Required

Students should have some background knowledge of the general structure and some organelles of the cell, such as the cell membrane and cytoplasm; the nucleus is of particular importance, so students can further understand the process of sexual and asexual reproduction in plant and animal cells. The ability to safely handle equipment such as microscopes, balances, glassware, etc. is essential. Also, the skills related to the inquiry process are required.

Unit Planning Notes

Specific planning for each activity is described in the subsequent pages. However, the following should be noted:

- a list of possible careers related to reproductive biology is needed for Activity 1, the Guidance/Career Centre may facilitate making the list and finding suitable resources

- access to the Resources/Centre/Library is required for Activity 5, coordinate with the teacher-librarian beforehand

Learning / Teaching Strategies or Activities

Activity	*Strategy*	*Description*
1	Reflection, Inquiry - Experimental and Critical Reading	Diagnostic in nature, this activity allows students and teachers to think about careers in Biotechnology. Working in groups, students investigate the production of yogurt. Individually, students examine an issue related to Reproductive Biology and biotechnology.
2	Equipment Use and Communication	This is a hands-on activity on observing slides of plant and animal cells in mitosis, drawing diagrams and making relevant calculations. Working in groups, students interpret information and present the ideas in a skit/drama.
3	Teacher-directed note taking and Carousel activity	There will be discussions on sexual and asexual reproduction followed by an activity where students are introduced to a wide variety of examples of the concepts discussed.
4	Inquiry - Experimental	Working in groups, students will complete an inquiry activity on the growth of yeast.
5	Case studies	Student will research an issue in human reproduction and use the information to generate a hypothetical case study.
6	End-of-Task Activity	Students will participate in a model Reproductive Biology and Biotechnology Career Conference.

Assessment / Evaluation

Activity	Assessing and Evaluating	Instrument
1	Skills in inquiry - experimental and critical reading	rubrics
2	Recording data and communicating ideas.	checklist for scientific diagrams science Journal quiz
3	Recording data (notes) and in comparing concepts	science Journal comparison chart/ graphic organizer
4	Skills in inquiry - experimental	rubrics quiz
5	Communication	Achievement Level Chart for Science
6	Understanding of connections to S.T.S.E.	writing rubric for newspaper report checklist for project display board peer assessment for role playing (student-designed checklist or rubric)

Resources

Galbraith, D. et. al Analyzing Issues, Science, Technology and Society. Trifolium Books, Toronto, Ontario, 1997. ISBN 1-895579-33-3

Grace, E.S. Biotechnology Unzipped; Promises & Realities. Trifolium Books, Inc. 1997.

Harkness, J., & Helgren, D., consultants. Impacts of Technology: Teacher's Resource Manual. Globe Book Company, New Jersey, 1993. ISBN 835-90459-8.

Ontario Agri-Food Education. From Both Sides: An Investigation of an Environmental Issue Using Creative Controversy, 1997.

Peel District School Board. Scales of Scientific Inquiry and Technological Design. 1998.

Activity 1: Careers In Reproductive Biology and Biotechnology
Time: 250 minutes

Description:

The first activity introduces the focus for this unit - careers which apply a knowledge of reproductive biology. Many occupations which presently exist (and many that will exist in the future) are found in a wide range of biotechnology industries. Students are introduced to possible careers, one of which they will focus on during their end-of-unit task (Activity 6).

Strands and Expectations

Strand: Biology
Expectations: BY3.01, BY3.02, BY3.04, BY3.05

Planning Notes

When planning this unit, work closely with the counseling, career education and/or co-operative education departments in your school. This is an excellent opportunity for guest speakers (perhaps parents of students in the class), field trips or even job shadowing for part of a day. Later activities involve library research. These times should be planned with the teacher-librarian early in the unit.

Prior Learning Required

No specific knowledge of reproductive biology is required. Students will have had some exposure to applications through various media sources.

Teaching/Learning Strategies

1.1 **Student Activity**: Students will listen to or read a short passage, or watch a video describing work in reproductive technology. This could be fictional, describing work in reproductive technology. Students will write a short reflective piece in their Science Journals, and share their reflections with the class. For homework, students will collect three newspaper articles which describe or discuss reproductive technology issues. These are needed for Activity 1.5.

Teacher Facilitation: The teacher will read the passage or show a video sequence dealing with reproductive technology (e.g., cloning of dinosaurs from fossil insect blood in a clip from *Jurassic Park*) to the class. The teacher needs to provide a focus for student reflection (e.g., understanding basic concepts, implications for future, ethics) and then ensure that all students have an opportunity to share their thoughts with the class.

The teacher should have several articles in case students have difficulty coming up with appropriate articles for homework. Topics may include the cloning of Dolly, human cloning, gene therapy or genetically altered food. Throughout the unit, students will add questions to the Wonder Wall. Students must be encouraged to begin their newspaper article search early, since articles on this topic are not daily news and the collection will take some time.

1.2 **Student Activity**: Students will have to determine the identity of the reproduction technology related job title that has been taped or pinned to their backs by asking questions of the other students in the class. [Refer to alternative activity designs in the Accommodations below.] Once students have successfully completed this activity, they will attempt to write a job description in their Science Journals and suggest methods of discovering more information about the career. This could be finished as a homework assignment.

Teacher Facilitation: The teacher will develop a large list of reproductive technology related occupations, record each one on a separate file card, and also display the complete list on the blackboard, overhead or bulletin board. The teacher will lead a reporting session in which students share their ideas about the occupation, some possible ways of coming up with more information and the knowledge or concepts required in order to more fully understand what biotechnology is all about. This will allow the teacher to assess prior knowledge. Occupation titles may include: genetic engineer, doctor, nurse, veterinarian, plant breeder, animal breeder, pharmacist, florist, ultrasound technologist, amniocentesis technologist, medical laboratory technologist, DNA fingerprinting technologist, bacteriologist, zoo employee, apple grower, vineyard owner, wheat farmer, dairy farmer, beef farmer, environmental worker, forestry worker, dog breeder, genetic counselor, artificial insemination technician, nursery owners and technician for seed companies, technician for agricultural chemical companies, embryologist. The list might reflect local industries and community resources.

1.3 **Student Activity**: Students will be introduced to the end-of-unit task in which each person is to select a particular occupation related to biotechnology and research it fully. Each student is to complete a display board as well as participate in a Reproductive Biology and Biotechnology Career Conference where they will be in role, representing their profession. A two to three page newspaper article is to be produced by each student, describing the conference and including one in-depth interview. This may also take the form of a video or audio report. Students will select their topic by the end of activity 1.5.

Teacher Facilitation: The teacher will explain to students how the concepts learned in this unit as well as the skills practised will help them successfully complete the end-of-unit task. Teachers will encourage students to go beyond print and electronic resources to contact people working in the biotechnology field.

1.4 **Student Activity**: Students are introduced to biotechnology through a lab activity where they make yogurt. Students work in small groups to produce the initial sample of yogurt and then redesign the procedure to test one of the variables. Students should examine their yogurt samples the following day and compare the yogurt to the original milk (e.g., colour, odour, texture, general appearance). Students will write a report that indicates the planning that went into the design of the fair test, displays data in an organized, easy to follow way and analyzes the data to come up with an appropriate conclusion.

> **Teacher Facilitation**: The basic recipe for yogurt involves heating 15 ml of milk in a hot water bath to a temperature of 85ºC and allowing it to cool to 40ºC before adding approximately 1 ml of yogurt containing live culture (seed). The tubes should be covered with foil and incubated overnight at 35ºC. All glassware and thermometers should be free of contamination. Teachers should remind students that the yogurt should not be eaten. Possible variables which could be examined by the students include incubation temperature, type of milk, type of seed yogurt, quantity of yogurt and of milk. The teacher should describe the use of bacteria in the production of other dairy food products.

1.5 **Student Activity**: Students will critically read one of their articles from homework Activity 1.1, examining the evidence that supports the argument presented and the biases of the author. Students will also examine the writing style of these articles since they are required to write one article as part of their end-of-unit task.

> **Teacher Facilitation**: The teacher will have to ensure that each student has one article that is suitable for this exercise. This can be accomplished by checking the three articles from each student on the day before the class when they are to be used. Students should not be penalized for selecting articles that can't be analyzed. The teacher could develop a worksheet which directs the students' analysis. (TSM.- Bias Assessment.)

Assessment/Evaluation Techniques

Activities 1.1, 1.2 and 1.3 are diagnostic in nature or designed to set the stage for further studies and no formal assessment is necessary. The report on the yogurt experiment can be evaluated using the rubric for experimental inquiry. The worksheet from Activity 1.5 can be evaluated using a part of the research rubric (TSM - Rubrics).

Accommodations

Alternatives for activity 1.2 could include using head-bands, cards on strings worn backwards, or matching job titles with job descriptions.

Refer to TSM - Accommodations for Students with Special Needs

References

Czerneda, J.E. No Limits: Developing Scientific Literacy Using Science Fiction. Trifolium Books Inc., Toronto, Canada, 1999.

CareerWare. “Choices”. Ottawa.

Activity 2: Cell Division and Mitosis
Time: 300 minutes

Description

This activity introduces students to the importance of cell division, both as it relates to asexual reproduction and to growth and repair processes which occur in all multi-cellular organisms. Skill with the use of the microscope and the production of scientific diagrams is further developed.

Strand(s) and Expectations

Strand: Biology
Expectations: BY1.01, BY1.02, BY1.03, BY2.09

Planning Notes

The intent of this activity is for students to recognize that mitosis is a complex process and that it is essential to the survival of living things. The process of cell division occurs perfectly almost all of the time but the consequences of error can be serious. To facilitate the students' understanding of the phases of mitosis, terminology will be minimized and students will focus on the changes in appearance of DNA in the process. Microscopes and prepared slides of mitosis (either plant or animal cells) are required. If available, teachers should utilize micro viewers and a video-camera microscope attachment to optimize student recognition of representative cells.

A number of manipulatives and handouts must be prepared, (e.g. sets of large laminated cut-outs - one set per group - of the stages of mitosis; sheets with unlabeled diagrams showing the stages of mitosis in random order for individual students to cut and paste on their recording sheet).

Prior Learning Required

Students should recognize the nucleus as the control centre of the cell and DNA as a chemical involved in genetic traits. It should not be necessary to re-teach the cell theory. Students should know how to use microscopes properly and be able to complete scientific diagrams from Unit 1.

Teaching/Learning Strategies

2.1 **Student Activity**: Working in groups, students will be given a set of laminated cut-outs of diagrams showing the individual stages of mitosis. The cut-outs are unlabelled. Students will

be asked to put them order from first to last, state their reasons for placing them in that order and what they believe the process represents. Smaller cut-outs should then be attached on a recording sheet in a circle to show that the process is a cycle.

> **Teacher Facilitation**: The teacher will provide students with no additional information other than the cut-outs. Restrict the terminology to key terms based on student questions as they complete the activity. [This activity has been tried with success with students in elementary school.]

2.2 **Student Activity**: Students will discuss and make notes on DNA, the importance of accuracy in copying the DNA during cell division and the final outcome of two genetically identical daughter cells.

> **Teacher Facilitation**: The teacher will direct the brief discussion and note making activity.

2.3 **Student Activity**: Students will use manipulatives such as yarn or pipe cleaners to demonstrate the changes to DNA while cells undergo mitosis. They will complete their recording sheet from Activity 2.1 to outline the major changes to the DNA during mitosis. The appearance and disappearance of the relevant structures inside the cell during this process should also be noted.

> **Teacher Facilitation**: The teacher will monitor the completion of the recording sheet and help students use yarn to demonstrate the extended DNA in interphase and the condensed DNA in prophase.

2.4 **Student Activity**: Students will complete a hands-on but directed activity in which they learn and practise microscope calculations including total magnification, field of view, specimen size and diagram magnification.

> **Teacher Facilitation**: The teacher will design an appropriate activity. Emphasis should be placed on calculating specimen size and diagram magnification. It may be necessary to provide the size of the field of view for the magnifications where students cannot use a ruler.

2.5 **Student Activity**: Students will locate representative cells undergoing mitosis, and draw detailed, labeled scientific diagrams with calculations of specimen size and diagram magnification.

> **Teacher Facilitation**: The teacher will help students locate dividing cells and monitor student progress. A review of drawing scientific diagrams may be necessary.

2.6 **Student Activity**: In groups of 6, students will dramatize the process of mitosis using any of the equipment provided to enhance their skit. Following the skits, students will view a moving sequence of mitosis using websites, CD-ROM or videos. In their Science Journal, students will then complete a self- or peer- assessment of the activity to assess how well their skit mirrors the events of mitosis shown in the video.

Teacher Facilitation: The teacher could arrange to borrow equipment from the Physical Education department such as plastic hoops, orange pylons, balls and skipping ropes.

Assessment / Evaluation Techniques

- Teacher evaluation of the recording sheet (Activity 2.3)
- Peer evaluation of scientific diagrams using a checklist followed by teacher evaluatio (Activity 2.5)
- Teacher evaluation of self or peer assessment from Science Journal (Activity 2.6)
- Short test which includes both recall and higher order questions.

Accommodations

Refer to: TSM - Accommodations for Students with Special Needs

References

CD ROM, websites, videos for viewing mitosis

Videodiscovery, Inc. BioScience II Videodisk. Wm. C. Brown Publishers.

Activity 3: Asexual and Sexual Reproduction
Time: 250 minutes

Description

Students will examine various forms of asexual and sexual reproduction found throughout many different kingdoms (plant, animal and protista) and make comparisons between the two types, focusing on advantages and disadvantages.

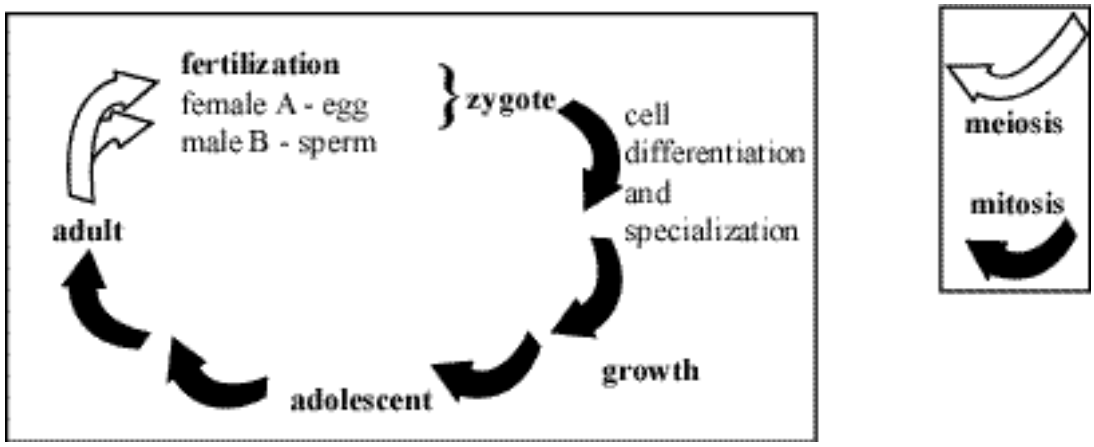
Strand(s) and Expectations

Strand: Biology
Expectations: BY1.04, BY1.05, BY1.06, BY3.05

Planning Notes

The teacher should prepare appropriate examples of mitosis and asexual reproduction (e.g., budding, production of spores, fission in amoeba and planaria, plant bulbs, strawberry runners, grafting, cuttings, pictures of damaged tissues, pictures of babies and teenagers, pictures showing tadpole to frog, maple keys to maple tree, crayfish limb regeneration) and appropriate examples of sexual reproduction (e.g., hermaphrodites such as earthworms, puppy and seed comparison, external and internal fertilization, comparison of plant pollination and animal fertilization, microscopic slides of pollen, chicken egg, lily flower, pine cones with seeds, cob of corn, split beans showing embryonic plant). These will be

arranged in the carousel activities where students will be answering questions and recording notes. The diagram below shows the different types of cell division in a representative life cycle.



Prior Learning Required

Students require a knowledge of mitosis.

Teaching/Learning Strategies

3.1 **Student Activity**: Students will make notes based on a class discussion of the importance of mitosis.

Teacher Facilitation: The teacher will lead a discussion to link the concepts of cell division to growth and repair, differentiation, regeneration and asexual reproduction. The teacher should also explain that offspring resulting from asexual reproduction are genetically identical to the parent.

3.2 **Student Activity**: Students will observe representative examples of mitosis and asexual reproduction in a carousel format and record information in their Science Notebooks.

Teacher Facilitation: The teacher should prepare questions for each example and explain the set up of the room. This activity is intended to expand student understanding of the role and importance of mitosis to organisms, rather than learning the specific details.

Station	Examples	Description	Questions
1	budding	slide or picture of yeast	What would happen to the buds?
2		• slide or picture of hydra showing small hydra budding from it • visual of poplar tree with caption describing the budding process	How did budding from these organisms differ from those in station 1?
3	asexual reproduction	picture of frog metamorphosis, flip chart	What is metamorphosis? What other organisms undergo this process? How would cells need to change (differentiate) for metamorphosis to occur?
4	growth and differentiation	picture of baby and teenager	Is this an example of metamorphosis? What had to happen for the baby to change to the teenager? Growth? Divide? Or differentiate? Explain.
5	fission	picture of amoeba or paramecium	How are the cells different from the original? How are the cells similar to the original? How do they compare to each other?
6	regeneration	preserved specimen or picture of crayfish regeneration (one large pincer and one small pincer)	Why are the two claws different in size? What other examples of regeneration can you come up with?
7	repair	• picture of open wound /injury • picture of closed wound	How did the wound close?
8	cutting	geranium stem in water	Do you think this will work with leaves? How can you test your hypothesis?
Some of the above questions are designed to be open-ended to prompt students for further research, to record on the Wonder Wall, or to come up with a topic for the final assessment task for the course (Unit 6 - Making Connections).			

3.3 **Student Activity**: Students will make notes based on class discussion regarding the necessity for sex cells in plants and animals to have half the number of chromosomes of body cells.

Teacher Facilitation: The teacher should stress the fact that mitosis is not the only process which generates new cells, but sexual reproduction requires sperm and egg cells to have half the chromosomes of other body cells. The details of this process i.e., meiosis will be explained in grade 11 Biology and it is not necessary to elaborate on them at this time. The teacher should explain that fertilization is the union of male and female sex cells and that this results in variation in the offspring.

3.4 **Student Activity**: Using a carousel format, students will observe representative examples of sexual reproduction and record information in their Science Notebooks.

Teacher Facilitation: The teacher should prepare questions for each example and explain the set up of the room. This activity is intended to expand student understanding of the role and importance of sexual reproduction to organisms, rather than learning the specific details.

Station	Examples	Description of Station	Questions
1	hermaphrodites	• preserved worms or live worms and text describing earthworm reproduction	What is a hermaphrodite? Can hermaphrodites fertilize themselves? What advantages do hermaphrodites have over organisms that have only one sex?
2	external and internal fertilization	pictures of fish and cow	Which organism releases more eggs? Why is it necessary for this to happen?
3	sexual reproduction	model of a flower	What are the male parts and female parts of the flower? What is a perfect flower?
4	pollination	assorted flowers	How do these flowers attract pollinators? What do fruit growers rent bees in the summer?
5	plant and animal fertilization	• picture of the flower showing pollen tube formation • picture of the reproductive system in a female mammal	Compare pollen travel and fertilization in the plant to sperm travel and fertilization in the mammal.
6	babies	• picture of the puppy • seed of a plant	What are these similar?
7	embryonic plant	• container of soaked lima beans • diagram showing embryonic plant in the bean	Instructions to students: Remove the seed coat from one bean, split the seed and make a labeled sketch of the embryonic plant.
8	pollination	- diagram showing cross and self pollination	How might each occur? What are the advantages of each type of pollination? How might flower growers use these processes?
Some of the above questions are designed to be open-ended to prompt students for further research, to record on the Wonder Wall, or to come up with a topic for the final assessment task for the course (Unit 6 - Making Connections). It might be necessary to summarize concepts, correct misconceptions and take up questions.			

3.5 **Student Activity**: Students will compare asexual and sexual reproduction using a format of their choice. Possibilities include comparison tables, Venn diagrams, mind or concept maps.

Teacher Facilitation: The teacher should review explanations and any questions arising from the carousel activities. The teacher should provide, or work with the

class to determine, the headings for comparing asexual and sexual reproduction. The teacher should also suggest different possible formats and encourage students to choose one that is suitable for them. This can be completed for homework.

Assessment/Evaluation Techniques

- teacher evaluation of Science Journal (Activity 3.2 and 3.4)
- teacher evaluation of asexual and sexual reproduction comparison (Activity 3.5)

Accommodations

Refer to: TSM - Accommodations for Students with Special Needs

References

Morholt, E., Brandwein, P., & Joseph, A.. A Sourcebook for the Biological Sciences, 2nd Edition. New York: Harcourt Brace & World, Inc.

Activity 4: Investigation Into Asexual Reproduction
Time: 150 minutes

Description

Working in small groups, students will complete an experimental inquiry activity into yeast growth where they will formulate a question, propose an hypothesis, develop a fair test, perform their experiment, record observations, graph, interpret and analyze their observations and communicate their findings.

Strand(s) and Expectations

Strand: Biology
Expectations: BY2.02, BY2.03, BY2.04, BY2.05, BY2.06, BY2.07

Planning Notes

Students should be introduced to the concepts of interpolation and extrapolation, and dependent and independent variable through a worksheet where their graphing skills are reviewed. Choose a topic for this exercise which is related to this unit (e.g., growth rate of bean seedlings, growth rate of yeast). A large number of clean test tubes are required for this activity as well as sugar, yeast, distilled water, beakers and hot plates.

Prior Learning Required

Students should have prior experience completing an experimental inquiry activity in which they identify variables on their own and design a fair test to discover the effect of altering one of the variables. Students should also know how to display data using a line graph. (See Unit 1, Activity 3.4)

Teaching/Learning Strategies

4.1 **Student Activity**: Students will complete a graphing exercise to introduce the concepts of dependent and independent variables and interpolation and extrapolation.

> **Teacher Facilitation**: The teacher will prepare the worksheet. It may be necessary to provide students with a variety of examples for practice.

4.2 **Student Activity**: Each group of students will decide on a variable to be tested and design a fair test. The report produced at the end of this activity should include an hypothesis, a description of the fair test, all relevant observations (qualitative and quantitative), a graph, analysis of the data, a discussion of error, a conclusion and some industrial uses of yeast

> **Teacher Facilitation**: The procedure for growing yeast requires 1.0 g of yeast and 0.2 g of sucrose mixed thoroughly in 5.0 ml of distilled water in a small test tube. The test tubes are placed in a warm water bath (40ºC) for 10 minutes. The height of the foam is measured as an indication of how much yeast growth has occurred. The appearance of the foam should also be described (e.g. thickness or density of bubbles). Students should determine the variables that could be tested. These include temperature of incubation, quantity of yeast, quantity of sugar, length of incubation, or the addition of different amounts of contaminant (e.g., salt, acid, base, detergent, food colouring). Other variables are possible.

Assessment/Evaluation Techniques

The rubric for experimental inquiry (TSM - Rubrics) can be used to evaluate the report. A quiz can be used to evaluate students' grasp of the concepts of interpolation and extrapolation, dependent and independent variable.

Accommodations

Refer to TSM - Accommodations for Students with Special Needs

Activity 5: Issues In Human Reproduction
Time: 200 minutes

Description

Students will generate hypothetical case studies concerning human reproduction. The subjects could be such topics as fetal alcohol syndrome, effect of X-rays on fetal development, effect of cigarette smoking on fetal development, effect of prescription or non-prescription drugs on the fetus, nutrition during pregnancy, role of parents' lifestyle on health of sperm and eggs, chemicals released from some plastic utensils when microwaved, the incidence of Down's syndrome related to maternal age, temperature and sperm production, use of steroids, use of fertility drugs. Each topic will require research by the students followed by a short oral report presented to the class.

Strand(s) and Expectations

Strand: Biology

Expectations: BY1.07, BY2.07, BY2.08, BY3.03

Planning Notes

Some discussion and description of human development is required prior to beginning the case studies. This is best accomplished through a video and follow-up worksheet. Students should work in pairs or small groups to complete the case study. The teacher will develop a set of questions to guide students through the process. Some time in the library will be required for the completion of this activity. Much of this information is available on the Internet. Refer to the Course Notes for alternative strategies in the event that the school resource centre or Internet access is difficult. Resources in the Course Overview include sites to search for topics in science.

Prior Learning Required

Students need to know how to access information in the library. Individual experience and background knowledge may influence the selection of the topic for a case study.

Teaching/Learning Strategies

5.1 **Student Activity**: Students will view a video related to human reproduction and development and complete a worksheet.

Teacher Facilitation: The teacher will prepare the worksheet.

5.2 **Student Activity**: Students will research background information to their case studies, prepare an oral or written presentation. The case study involves a history and a look into the future of fictional characters experiencing a dilemma, consequence or problem. Although the characters are fictional, they are presented in a realistic setting. Characters may include an affected child, parents, siblings, experts, etc. The information that is presented must be accurate.

Teacher Facilitation: The teacher will generate the set of questions to guide the development of the case studies. Some questions might be:

- What are the names and roles of the characters?
- What are their ages? (If important)
- What is the problem, dilemma or consequence?
- What are the causes of the problem, dilemma or consequence?
- What will happen to the individual(s) in the future?
- What are some solutions?
- What are some strategies that would have prevented the problem in the first place?

Assessment/Evaluation Techniques

Teacher evaluation of report using the communication section of the Achievement Level Chart for Science.

Accommodations

Refer to TSM - Accommodations for Students with Special Needs

References

Fetal Alcohol Syndrome - www.arbi.org
In the Womb (videorecording). (1994) Series: Body Atlas - Episode 1. Ambrose Video Publishing Inc., Video Education Centre.
Reproductive Systems (videorecording). (1994) Series: Your Body. National Geographic Society.

Activity 6: End-of-unit task
Time: 170 minutes

Description

The end-of-unit task completes the focus for this unit -- careers which apply a knowledge of reproductive biology. Each student in the class was assigned or chose an occupation to investigate during the first activity. The end-of-unit task involves the students producing a display board and then, in their various roles, discussing their work, careers, and thoughts about reproductive technology at a Biotechnology Career Conference. Afterwards, each student will produce a newspaper report describing the conference and focusing on an interview with one participant. This could also be an audio or video report.

Strand(s) and Expectations

Strand: Biology
Expectations: BY2.01, BY2.02, BY2.04, BY2.05, BY2.07, BY2.08, BY3.01, BY3.02, BY3.04, BY3.05

Planning Notes

Reporters should be assigned to specific presenters so that each student is interviewed on the day of the conference. The room should be arranged to enhance the feeling of a conference. It might be possible to use another area of the school for the conference.

Prior Learning Required

Students will have practised the necessary research and communication skills throughout the unit.

Teaching/Learning Strategies

6.1 **Student Activity**: Students will set up their display boards and participate in the Biotechnology Career Conference. At the end of the conference, each student will produce a newspaper report. While the students are interviewing each other for the report, they are also completing a peer evaluation of the role playing.

Teacher Facilitation: The teacher should organize the setting of the conference and produce checklists for evaluating the display boards and role playing. Students should participate in the creation of the checklists or rubrics for assessing the activity. Help may be available on the role playing component from the school drama teacher/department.

Assessment/Evaluation Techniques

- teacher evaluation of newspaper report using rubric for writing (TSM - Rubrics)
- teacher evaluation of display board using a checklist.
- peer assessment of role playing using checklist.

Accommodations

Refer to: TSM - Accommodations for Students with Special Needs

Unit 6: Making Connections

Time: 8 hours

Unit Description

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

Strands and Expectations

This unit will focus on the four strands and the three goals of the course.

Planning Notes

The final assessment is comprised of two sections – a common portion (teacher-directed) and an inquiry portion (student-directed, arising from questions recorded and developed throughout the course). The three goals -- relating science to technology, society and the environment, application of skills and understanding of basic concepts -- should be weighted equally, although one section may provide greater emphasis on a specific goal than the other section.

To allow students sufficient time to successfully complete the assessment, the inquiry process needs to be introduced prior to the end of the course. During a prior unit, students should formulate several possible questions and begin initial research to determine feasibility of the question. Some in-class time may be allowed for this.

The common portion could be completed in a formal setting such as an exam or test. The common portion may take up to 3 hours but should not be done in a single sitting. For example, teachers may employ a lab practical (1hour) and a standard exam (1.5 hours).

Assessment in Applied Courses: The following statement, taken from *The Ontario Curriculum, Grades 9 and 10: Program Planning and Assessment*, provides guidance for planning assessment activities in this unit.

"***Applied courses*** focus on the essential concepts of a subject, and develop students' knowledge and skills through practical applications and concrete examples. (p. 4)

Elsewhere, the same document states:

"In all of their courses, students must be provided with numerous and varied opportunities to demonstrate the *full extent* of their achievement of the curriculum expectations, *across all four categories of knowledge and skills*." (p.11)

Therefore, the assessment activities in this unit must provide opportunities for students to *make practical applications* of the "essential concepts" while providing opportunities for students to *demonstrate all the expected knowledge and skills.*

1.1 **Student Activity**: Students will be introduced to the **Student Plan for Inquiry: Research/ Experiment/ Innovation** and will formalize their inquiry question and begin planning.

Teacher Facilitation: The teacher will produce for each student an inquiry plan as suggested below and establish due dates and timelines with students.

Student Plan for Inquiry: Research/Experiment/Innovation

1. Focusing Question (Identify a question that guides the inquiry)

2. Format for Inquiry: (choose one) Research ___ Experiment ___ Innovation ___

3. Brief description (abstract) of the inquiry: What are you going to "do"?

4. What are the likely outcomes of the inquiry? How will you assess whether you have answered your question?

5. Product Description: How will you communicate the results of your work? (see examples below)

6. Inquiry Time-Line: Make a weekly time-line of what you expect to do (materials to find, books and articles to read, skills to practise, experiments to plan and conduct)

7. Teacher support: What help will you need from your teacher? (e.g., equipment, materials, library time, computer access)

8. Safety: Identify safety procedures and considerations for experimental investigations.

Due date for Student Inquiry Plan: _____

Due Date for completed Inquiry Project: _____

Products may be written, visual, oral or a combination thereof. The following is a partial list:

Web page, PowerPoint presentation, journal/diary/log, report, game/simulation, documents, brochure, booklet, magazine, short story, interest kit, model, panorama, invention, poster, bulletin board, video, photo essay, role-playing situation, slide presentation, oral report, lesson, drama, documentary, television show, workshop, seminar, demonstration, mini-experiment.

1.2 **Student Activity**: Students proceed with the inquiry task.

Teacher Facilitation: The teacher will arrange for student access to resource centre, computers, and laboratory space, as needed. After students have submitted their inquiry plan, the teacher can make and keep a copy for recording individual progress. As the inquiry gets underway, the teacher will be able to use the plan as a checklist, and set further detailed requirements for each student (e.g. a method for an experiment, or a partial bibliography for a research investigation). Teachers will review with students the Final Assessment Inquiry Rubric (TSM - Final Assessment Inquiry Rubric) and the rubrics for assessing writing skills and inquiry skills, (both experiment and research) (see TSM - Rubrics) for students to understand the criteria by which their work is being assessed and evaluated.

1.3 **Student Activity**: Students will present the results of their investigation.

Teacher Facilitation: The teacher will arrange times as necessary for student presentations and modify existing assessment tools to meet the needs of the student performance/project.

1.4 **Student Activity**: Students will complete the common portion of the summative assessment.

Teacher Facilitation: The common portion may be composed of (but not restricted to) the following:

- a laboratory practical involving equipment and data manipulation from each of the units
- a critical reading of a current article for which students demonstrate an understanding of the concepts. Students could also evaluate the article for bias, conclusions and evidence. As an extension, students could propose further questions related to the article, and suggest a method for pursuing the research.
- a presentation to students of experimental information (video of a lab, outline of methodology, collected data from a lab, etc.). The task could involve analysis and evaluation of data, effective organization of data, outlining steps of an experiment, describing the purpose of an experiment, or a critique of a student report.
- revisiting of a piece of reflective writing from their Science Journal to show how their understanding of an issue has changed
- a formal test or examination composed using a planning matrix to ensure appropriate weighting of units, concepts, and types of questions. (TSM - Recommendations for the Structure and Format of a Summative Examination)

Teacher Support Materials

1. Accommodations for Students with Special Needs

TSM-Accommodations for Students with Special Needs

Exceptional Students

Students with learning disabilities will need additional supports to succeed in Grade 9 Science. Examples of modifications and aids which may be helpful include the following:

- ensure that peer helpers are available when students are working in small groups
- provide handout sheets with sample calculations and specific skill instructions, when required
- help students create data charts into which they will be recording information
- advise Special Education staff in advance when students will be working on major assignments
- record key words on the board when students are expected to make their own notes
- allow students to report verbally to a scribe (teacher or student) who can help in note making
- permit students a wide range of options for recording and reporting their work to accommodate students with weak writing skills (e.g. drawings, diagrams, flow charts, concept maps)
- timelines may need to be extended to give students more time to process language and put their thoughts into words
- where an activity requires reading, give it in advance to these students

Resources

Education for Exceptional Students, in The Ontario Curriculum, Grades 9 and 10: Program Planning and Assessment. Ministry of Education and Training. Queens Park, Toronto. (1999).

Education for Exceptional Students, in The Ontario Curriculum, Grades 9 and 10: Science. Ministry of Education and Training. Queens Park, Toronto. (1999).

English as a Second Language/English Literacy Development

Intermediate or Advanced speakers will require a few modifications to deal with Grade 9 Science. Some examples include:

- have students keep a science dictionary of terms, using pictures and first language words
- where an activity requires reading, give it in advance to these students
- permit the use of a translation dictionary on assessments
- provide additional time on assessments for dictionary use and processing language
- have the Teacher Librarian identify resources with appropriate reading level when research is required
- advise ESL / ESD staff in advance when significant written work will be required
- separate students with the same first language to encourage English language development

Additional advice and assistance should be sought from school and board resource persons with knowledge of ESL / ELD modifications.

Beginning ESL students will likely need more radical adjustments to the course as described. The following additional suggestions may be helpful.

- Unit 1 should be lengthened.

- Research Inquiry activities should be de-emphasized in earlier units, until language skills have improved.
- The Reproduction unit, with its greater use of new language, should be presented later in the course. Electricity, with a focus on design of circuits, might be a better starting point.
- Hands-on activities help ESL students to develop conceptual understanding, and with it, language.

Resources

ESL / ELD, in The Ontario Curriculum, Grades 9 and 10: Science. Ministry of Education and Training. Queens Park, Toronto. (1999).

2. Instructional Practices

TSM-Bias Assessment of an Article

Bias is an opinion about an issue that favours one side. Bias can also be described as prejudice. Articles about issues may not appear to be biased at first reading, but you may be able to detect bias if you think carefully about the story. Use the following questions to determine if your article is biased.

Article Title: _____

Author: _____ Source of Article: _____ Date of Article: _____

- In what part of the magazine or newspaper is the story located? (Is it a special science, environment, technology section?)

- Is the author an expert in a particular field? Are experts quoted? How do you know they are experts?

- Is the author connected to an organization that might be a "stakeholder" in the issue? Is the author a "stakeholder"? Explain.

- Are there pictures that seem to favour one side of the issue more than the other? Are there words that seem to favour one side of the issue more than the other? Explain.

- Is more than one viewpoint presented in the story? If yes, are all points of view given equal treatment? Explain, using examples.

- What is your conclusion about bias in this article?

TSM-Questions

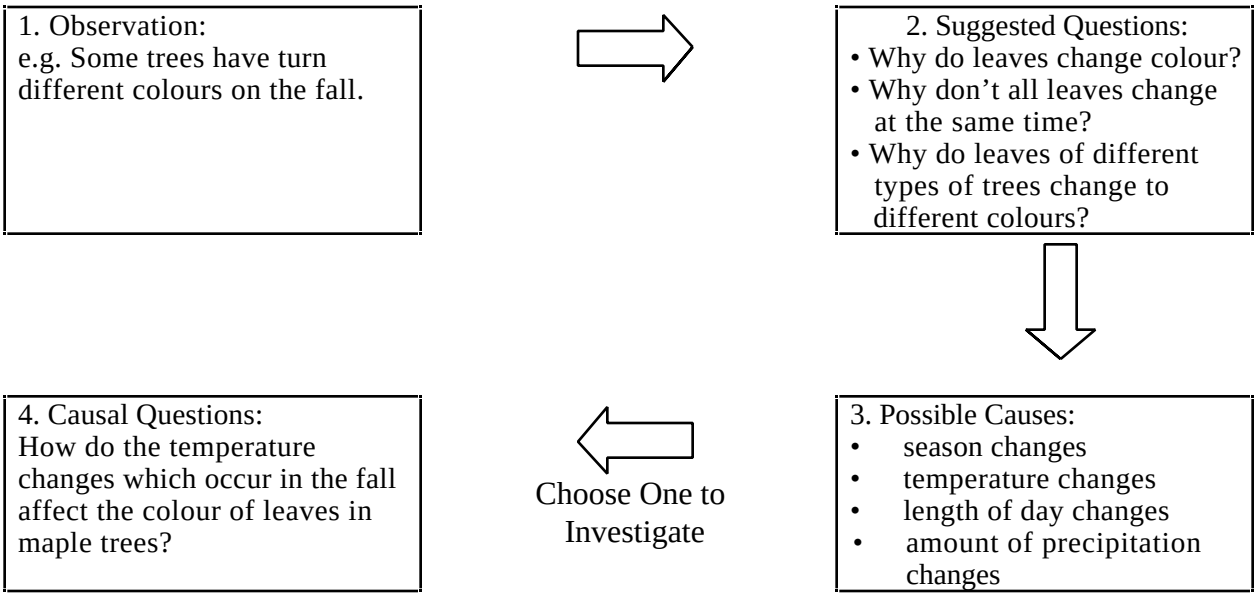
Developing the skills of scientific inquiry in students is a major focus of Grade 9 Science. Central to the inquiry process, and therefore to Grade 9 Science, is the process of asking questions, in particular questions which can be answered through research and experimentation. Below are samples of questions that may help you to broaden the scope of questions that students ask in the classroom.

Sample Questions	**Reasoning Process Implied by the Questions**
How are these the same? How do they differ?	Comparison or contrast
How can I group these? What characteristics are being used to group them?	Classification
What conclusions can be drawn from these data, and how do I justify the conclusions? What is the likelihood of this happening, and how do I support my prediction?	Induction
What must be true, given this principle? What is my proof that it is true?	Deduction
What's wrong with this? What errors have led to this being wrong? How can it be fixed?	Error analysis
What pattern is suggested by this information? How can I represent this information in another format, like a graph or mathematical equation or expression?	Analysis
What do you think about this issue? On what do you base your opinion? What is another way of looking at this issue?	Analysis
Which of these is the best option? Which process should be used?	Decision making
How can I test this question? How can I explain this phenomenon?	Inquiry
How can this device be improved? What new instrument is needed to accomplish this task?	Invention or innovation
How can I take all this information and pull it together to make a generalization? What hypothesis can I generate using these results?	Synthesis
How well did this procedure work? Why was it successful? What could be done to make it better?	Evaluation

Developing Causal Questions

Causal questions are those which suggest that a cause and effect relationship exists which might be worth investigating in order to answer a question. Students can generate causal questions from observations that they have made using the device below, and use the question generated to design an investigation.

For example:



(Developed by Grade 9 Teaching Team, R.H. King Academy, TDSB)

TSM-Visual Tools

The brain works by making patterns which can be visualized through the medium of visual tools. The value of such tools is evident if we think of trying to understand geographical information (for example, how to drive from Belleville to Kenora) using only written text, without the aid of geographical maps.

Visual tools enhance the ability of students to organize information in a useable form, even if their verbal and writing skills are limited. One very common visual tool in the science classroom is the diagram.

The term 'graphic organizer' is insufficient to describe the range of uses for various visual tools. Although some of the tools are organizers, others help students collect ideas in brainstorming sessions before any organization is evident, and yet others can be used for metacognitive purposes - to help students look for new connections among concepts, to facilitate discussions, to generate theories and to do self-assessment.

Visual tools may be classified into three general types:

- brainstorming webs - to foster creativity in individuals and groups
- task-specific organizers - for organizing information in a visual way
- thinking-process maps - to promote cognitive development and critical thinking

i. Brainstorming Webs

Students should be encouraged to invent their own webs and refine them as they generate and gather information, process that information to find conceptual relationships, and then apply or evaluate the knowledge and generalizations formed.

Uses of Brainstorming Webs

- recording ideas beginning with a central idea and working outwards

- note making (as distinct from note taking) - instead of scripting notes, key points are components in a web, showing ideas which are related bundled together within the web

- recording device for small group work

- individuals who have first created a web of their own on a topic are often able to contribute to class or small group discussions more effectively by using that web as a memory aid and device for making connections

Brainstorming webs tend to be individual in structure and open-ended, and as such are not suitable for summative assessments of student learning. If a student verbalizes the thinking that went into a web as part of a formative assessment, however, errors in logic and conceptual errors may become apparent, and can be corrected.

ii. Task-Specific Organizers

These tools are often created by the teacher for use by students, and are focused on isolated tasks. For students to use them successfully, their use must be modelled during instruction. Because they are usually used to outline teacher-directed processes and content driven expectations, they can be very useful in assessing student comprehension of information and concepts.

Uses of Graphic Organizers

- traditional tables and charts used for data display are task-specific organizers

- a set of flow chart symbols denoting starting materials, actions taken, substances added or removed, and products formed can be used to create visual procedures for investigations in the laboratory

- semantic maps can be used do classifications, beginning with a central idea, then breaking it into categories and subcategories. These are visual equivalents of more traditional outlining (such as is used in the summary!) which uses numbering, lettering, a combination, or bullets and dashes to break down a central theme.

iii. Thinking Process Maps

Various designs of thinking-process maps reflect a variety of patterns of thinking. Because they apply across disciplines, they are particularly useful in promoting the use of thinking skills across the curriculum. They help students to represent visually thinking processes such as sequencing, identifying attributes, classifying information, using cause-effect reasoning, decision making, predicting, making use of analogies and seeing part-whole relationships.

Uses of Thinking Process Maps

The structure of these tools is essentially the same as for graphic organizers. They take the form of tree diagrams, flow charts, bubble trees and other semantic maps. The difference, however, is in their use. Very specific thinking skills, such as those listed in the above paragraph, can be taught using particular forms of visual tools. The process by which this is accomplished is beyond the scope of this outline, and is described in the references.

References

Hyerle, David. Visual Tools for constructing knowledge. Association for Supervision and Curriculum Development (ASCD). 1996. ISBN 0-87120-266-2

The Concept Mapping Home Page: **http://www.to.utwente.nl/user/ism/lanzing/cm_home.htm**

Mind Mapping FAQ site: **http://world.std.com/~emagic/mindmap.html**

The World Wide BrainClub: **http://www.silkwood.co.uk/**

3. Assessment Practices

TSM-Taxonomy of Cognitive Skills for Test Questions

The degree of complexity of the thought process involved in answering test questions is outlined below using a simplified taxonomy based on that of Dr. Benjamin Bloom. These terms are used in the Examination Preparation Matrices. It is important to recognize that an individual question may fall into a variety of levels depending on the depth to which a topic was studied.

Questions which reach the Higher Skills level are particularly difficult to create in selected response formats like multiple choice. Once seen by a student, these questions often devolve to the level of Knowledge, even if the details are quite different from the original question. For this reason, some degree of confidentiality may be necessary to accumulate a bank of selected response questions which are able to assess achievement at the higher cognitive levels.

Knowledge

At this level, questions require only direct recall of material included in instruction or in general reading in the subject, and would include recall of specifics, universals, processes, patterns, and structure.

Comprehension

Test questions at this level must not be identical to questions studied, but must be similar in language, context and complexity. They may involve translation, interpolation, extrapolation or generalization of material studied. Problems involving direct application of an algorithm learned in instruction are common at this level, and may include complex problems if the format was previously studied.

Application
The ability to apply principles and generalization to new problems and situations is tested at this level. There must be a degree of unfamiliarity to the problem to prevent direct use of any "type problem" solution. To solve the problem, the student must select the principles or concepts to be used, often after removing extraneous information or rewording the question to conform to a more familiar problem type.

Higher Skills
In Benjamin Bloom's taxonomy, this level would include analysis, synthesis and evaluation. These questions may involve interpretation of experimental data to develop an hypothesis based on the data and the method used to test the hypothesis. Questions which go beyond the level of Application in terms of complexity of presentation, or which span a wide range of content areas and require considerable organizational ability before a solution can be found also belong in this category.

TSM-Recommendations for the Structure and Format of a Summative Examination

Instructions
A cover page for each examination should include general instructions to students regarding such things as:
- mark allocation and suggested time allotment for each section of the exam;
- where answers are to be recorded for each section of the exam;
- any necessary equations or physical constants which may be used during the examination; and,
- the use of calculators, periodic tables, "crib" sheets, notebooks or other aids permitted.

Instructions for each section within the examination should clearly explain how and where the questions should be answered.

General Format
- The examination should consist of a variety of question formats, such as: multiple choice, short answer, extended response, laboratory and problem-solving questions. Students must be given opportunities to experience each format in a variety of situations throughout the course.
- Mark allotments should reflect the amount of time devoted to the material during the course.
- Care should be taken in the layout of the examination to ensure that students do not miss sections or pages.

Marking Schemes
- Marks allotted to each question should reflect the time that a student is expected to spend answering that question.
- Detailed mark values for parts of questions should be clearly indicated.

Examination Preparation Matrices
Use of a matrix with content similar to the model below is highly recommended for all examinations and tests. The matrix is intended to:
- ensure that a wide variety of question formats is used;
- match assessment to program design and emphasis;
- provide students with different learning styles opportunities to demonstrate their learning;
- promote the use of questions which challenge the cognitive skills of students; and,
- broaden assessment to include science process skills as well as facts and concepts.

Examination Preparation Matrix - Question Formats

Each item in the examination is coded into a cell in the matrix.

Question Format	Unit 1 mark %	Unit 2 mark %	Unit 3 mark %	Unit 4 mark %	Unit 5 mark %
Extended Response (value > 5 marks each)					
Short Answer (up to 5 marks each, written responses)					
Multiple Choice (single mark items)					
Data Handling (tables, graphs, numeric problems, creating diagrams)					
Other (matching, completion, true-false, labeling diagrams, etc.)					
Total marks:					

Examination Preparation Matrix - Cognitive Skills and Applications

Each item in the examination is coded into a cell in the matrix.

Cognitive Level	Unit 1 mark %	Unit 2 mark %	Unit 3 mark %	Unit 4 mark %	Unit 5 mark %	Total mark s:
Knowledge/ Recall						
Comprehension						
Application						
Higher Cognitive Skills						
Science, Technology, Society, Environment						
Laboratory based						
Across the Curriculum						

TSM-Rubrics

Complex performance tasks involve the use of knowledge and the application of skills in a context, and must be judged/evaluated using well defined criteria. The vehicle for guiding that judgement is the *rubric*. It consists of a set of criteria in one dimension, and a fixed scale in the other dimension. For The Ontario Curriculum, the most convenient scale is a four-point scale, which parallels the four levels in the Achievement Levels Chart. In the body of the rubric there is a list of characteristics describing performance for each criterion under each of the points on the scale.

Many generic samples of rubrics have been developed which can be modified to apply to different situations. The first overall expectation in each unit of Grade 9 Science refers to student understanding of key concepts. A generalized rubric to evaluate content, concepts and generalizations on a four point scale is below. To be useful, it must be changed to reflect what the content, concepts and/or generalizations are to be achieved by students in the performance task they are to undertake.

Most importantly, students should be given the information in the rubric prior to undertaking the task, so that it is entirely clear to them what a good performance must embody.

Generic Rubric for Declarative Knowledge

[links to Achievement Chart for Science: Knowledge/Understanding]

Criteria	Level 4 Performance	Level 3 Performance	Level 2 Performance	Level 1 Performance
Declarative Knowledge	thoroughly understands all content, concepts and/or generalizations in the task, and demonstrates insightful extensions to some aspects of the information	shows a largely complete and accurate understanding of the content, concepts and/or generalizations in the task	has some misconceptions, and lacks a complete understanding of the content, concepts and/or generalizations in the task	shows a lack of understanding, and significant misconceptions about the content, concepts and/or generalizations in the task

Below is a generalized rubric for evaluating those skills that are described in the second Overall Expectation in each unit of Grade 9 Science. Again, it is necessary to revise this rubric to make it apply to the specific skills that are involved in the performance task, whether they are manipulative skills or thinking and reasoning skills.

Generic Rubric for Procedural Knowledge

[links to Achievement Chart for Science: Knowledge/Understanding and Inquiry, depending on the task]

Criteria	Level 4 Performance	Level 3 Performance	Level 2 Performance	Level 1 Performance
Procedural Knowledge	selects and applies appropriate strategies and/or skills specific to the task without conscious effort and without error, and applies some in innovative ways	selects and applies the appropriate strategies and/or skills specific to the task without significant errors	selects with some assistance, and applies the skills and/or strategies required by the task, but makes a number of non-critical errors in doing so	only selects appropriate skills and/or strategies required by the task with much assistance and makes critical errors in applying them

Rubric for Collaborative Group Work
[links to Learning Skills on Provincial Report Card]

Criteria	Level 4 Performance	Level 3 Performance	Level 2 Performance	Level 1 Performance
Interpersonal Skills in Group Work	interacts positively with all group members, encourages such interaction in others, and is always sensitive to the abilities and feelings of others in contributions	interacts with all group members spontaneously and contributes in a way that is sensitive to the abilities and feelings of others	interacts with other group members if prompted, but sometimes expresses opinions which are insensitive to the abilities and feelings of others	is unable to interact positively within a group, even with prompting, and shows lack of sensitivity to others' feelings and abilities in opinions expressed
Participation to Achieve Group Goals	actively helps to identify group goals and works effectively to meet them in all roles assumed	demonstrates commitment to group goals and carries out assigned roles effectively	demonstrates commitment to group goals, but has difficulty performing assigned roles	shows little commitment to group goals and fails to perform assigned roles
Contribution to Group Maintenance	actively works to identify and carry out changes in group processes necessary to maximize group effectiveness	identifies and helps to make adjustments needed in group processes to maximize group effectiveness	identifies changes needed to improve group processes if prompted, and is minimally involved making those changes	cannot identify changes needed in group processes, and is unwilling to participate in making those changes identified by others
Roles Performed in the Group	volunteers to perform any group role, and does so effectively and creatively	is willing and able to perform most group roles effectively	willing and able to perform some group roles effectively	is limited in inclination or ability to perform roles in the group

Partial Rubric for Inquiry - Experimenting
[Links to Achievement Chart for Science: Inquiry]

Criteria	Level 4 Performance	Level 3 Performance	Level 2 Performance	Level 1 Performance
Initiating and Planning • formulates question • make hypothesis • *designs fair test** • selects equipment and materials	* *significant variables are identified and controlled.*	* *variables are identified; some significant variables are controlled.*	* *some variables are identified; not all significant variables are controlled.*	* *few variables are identified or controlled.*
Performing and Recording • follows procedures • *collects, records and organizes information** • uses appropriate vocabulary • follows safe procedures	* *collects all appropriate qualitative and quantitative information in a skillful manner; data is displayed in a student created and well organized form*	* *collects sufficient and appropriate quantitative and qualitative information; data is displayed in an organized form*	* *collects some appropriate quantitative and qualitative information; data is displayed in a partially organized form*	* *collects some quantitative and qualitative information; data is poorly organized and displayed*
Analyzing and Interpreting • draws valid inferences • forms a conclusion which responds to the hypothesis • *generalizes from experimental results and conclusions to other situations**	* *generalizes independently from results and conclusions to situations in other subjects and beyond the school*	* *generalizes from results and conclusions to other situations in science with little or no support*	* *generalizes from results and conclusions in a limited way with some support*	* *requires considerable support to make generalizations from results and conclusions*
Communicating	Refer to Achievement Chart for Science			

Note: The process outlined above encompasses all elements of what is commonly called Scientific Method and places them in the broader context of inquiry.

Partial Rubric for Inquiry - Researching
[links to Achievement Chart for Science: Inquiry]

Criteria	Level 4 Performance	Level 3 Performance	Level 2 Performance	Level 1 Performance
Initiating and Planning formulates questions • *states research question** • identifies a variety of resources	* *research question is original and creative, focused, and relevant to student; likely to yield interesting and useful information.*	* *research question is focused, relevant to student; is likely to yield interesting information*	* *research question lacks focus; has some relevance to student and is likely to yield sufficient information*	* *requires assistance to formulate a research question*
Performing and Recording • *uses resources to find information** • records information • records sources of information • uses appropriate vocabulary	* *a very wide variety of recent, relevant, authoritative resources is used to find reliable, valid, accurate and complex information*	* *a variety of recent, relevant resources is used to find reliable, valid and accurate information*	* *an adequate number of relevant resources are used to find reliable, accurate information*	* *a few relevant resources are used to find simple information*
Analyzing and Interpreting • *organizes and integrates information in an appropriate format* • makes conclusions based on information provides reasons for conclusions	* *finds and evaluates key information that relates to the question and develops concepts into an insightful, original product*	* *finds and evaluates key information that relates to question and develops concepts into a well connected product*	* *finds and evaluates some key information that relates to question; product lacks order or logical sequence*	* *requires assistance to find and evaluate key information that relates to question; product lacks organization and flow*
Communication	Refer to the Achievement Chart for Science			

Marking Scale (Rubric) for Written Report

[links to Achievement Chart for Science: Communication; also Knowledge/Understanding and possibly Connections, depending on the task]

Trait	Level 4	Level 3	Level 2	Level 1
	Excellent Performance	***Good Performance***	***Inconsistent Performance***	**Limited Performance**
Ideas and Content • Clarity	Main idea is very clear	Main idea is reasonably clear	Main idea is recognizable	Main idea is generally unclear
• Accuracy	Facts, ideas and details are accurate	Facts, ideas and details are generally accurate	Facts, ideas and details exhibit some inaccuracies	Facts, ideas and details tend to be inaccurate
• Integration of source material	Material from sources is well blended. Difficult terms are explained in own words	Material from sources is fairly well blended; some terms explained in own words	Material from sources tends not to be well blended; many terms not explained	Material from sources is poorly blended, pieces may be directly copied
• Resource selection	Excellent choice of resource material to support writing	Good choice of resource material to support writing	Some resource material is well chosen and supports writing	Poor choice of resource material; limited support of writing
Organization	Very good overall logical plan forms well connected text	Adequate overall logical plan	Weak overall logical plan; some gaps in sequence of ideas	Minimal overall logical plan with ideas out of order
Use of Language	Excellent use of appropriate voca-bulary including correct scientific terminology	Good use of appropriate vocabulary including correct scientific terminology	Fair command of appropriate vocabulary	Weak command of appropriate vocabulary.
Conventions	Excellent command of spelling, punctuation, and grammar	Good command of spelling, punctuation, and grammar	Fair command of spelling, punctuation and grammar	Weak command of spelling, punctuation, and grammar

References

Marzano, Pickering and McTighe. Assessing Student Outcomes: Performance Assessment Using the Dimensions of Learning Model. Association for Supervision and Curriculum Development (ASCD). 1994. ISBN 0-87120-225-5

Jensen, Ken. Effective Rubric Design. The Science Teacher. May 1995. pp34 - 37

Ministry of Education and Training, Ontario. Assessment Planning Guide for Junior Division Science from the Ontario Assessment Instrument Pool. Queen's Park, Toronto. 1993.

Why Rubrics? **http://www.servtech.com/~germaine/rubric.html**

Sample Science Report rubric. **http://www.esuhsd.net/cluster4/rubrics/RU225.html**

Guidelines for developing rubrics. **http://www.esuhsd.net/cluster4/rubrics/RU227.html**

Understanding rubrics. **http://learnweb.harvard.edu/alps/thinking/docs/rubricar.htm**

TSM - Final Assessment Inquiry Rubric

The rubric below may be used to assess the scientific thought and creativity of an inquiry in a number of formats.

[links to Achievement Chart for Science: All parts]

Scientific Thought	***Description***	***Level 4***	***Level 3***	***Level 2***	***Level 1***
Experiment	An investigation to test an hypothesis using experiments.	Design and perform an original experiment which attempts to control or investigate most significant variables. Data is analyzed statistically.	Design and perform an original experiment which identifies significant variables and controls some of them. Data is analyzed with graphs and simple statistics.	Extend a known experiment through modification of procedures, data gathering and application.	Duplicate a known experiment to confirm an hypothesis. The hypothesis is totally predictable.
Innovation	The develop ment and evaluation of an innovative device, model, technique or process.	Integrate several technologies, inventions or designs and construct an innovative technological system that will have social or commercial benefit.	Design and build innovative technology, or adapt existing technology, that will have social or economic benefit.	Improve, or demonstrate new applications for, existing technological systems or equipment.	Construct devices ro models which duplicate existing technology.
Study	The collec tion and analysis of data from secondary sources to reveal evidence of a situation or fact of scientific interest. A study might consider cause-effect relationships or theoretical investigations of collected data.	Study correlates in formation from a variety of significant sources which may illustrate cause and effect or original solutions to current problems through synthesis. Significant variables are identified and data are treated statistically.	Study based on observations and library research illustrating various options for dealing with a relevant issue. Some significant variables are identified and data are analyzed using graphs and simple statistics.	Study of ma terial collected through compilation of existing data and through personal observations. The display attempts to address a specific issue.	Study of existing printed material relate to the basic issue.
Creativity		A highly original project or a novel approach. Shows resourcefulness creativity in design, use of equipment and /or construction of the project.	Imaginative project. Good use of available resources. Well thought-out above ordinary approach. Creative design and/ or use of materials.	Some cre ativity shown in a project of fair to good design. Stan dard ap proach using common re sources/ equipment. Topic is a current or common one.	Little imagination shown. Project design is simple with minimal student input. A textbook or magazine type problem.

4. Glossary

TSM-Glossary

The following terms are used in the profiles for Grade 9 Science, or are terms which have come in to use in education in the recent past and which have special meaning to teachers, including science teachers.

Criterion-referenced Assessment

- This kind of assessment is designed to determine whether an individual or group has met defined criteria for mastery of specific objectives, such as the Specific Expectations in The Ontario Curriculum. The driver's licence test is an example of a criterion referenced assessment. In a criterion-referenced system, the value of a grade or mark is only evident by comparison with the set of criteria on which it was based, not on the grade or mark of other individuals.

Culminating Task

- This is a student performance intended to draw on the skills and concepts developed in each unit. The performance, along with the assessment and evaluation procedures to be used to judge its value, are clearly defined to students early in the unit so that they can prepare for it. The evaluation of the Culminating Task will constitute a significant part of the summative evaluation of the Unit, and will also contribute to the summative evaluation of the course.

Declarative Knowledge

- Information, which may be simple facts at the lowest level, or concepts or generalizations at the highest level. 'All objects fall at the same rate in the absence of air' is a fact; 'gravity' is a concept; Newton's laws are generalizations.

Exemplars

- Exemplars are samples of student work which show the distinctions between levels of achievement as described on *The Achievement Chart for Science* in The Ontario Curriculum, Grades 9 and 10: Science. Ministry of Education and Training. Queens Park, Toronto. (1999).

Formative Assessment

- Assessment activities intended to provide feedback to both teacher and student about student progress are termed formative assessments. Evaluations of formative assessments lead to adjustments to instruction on the part of the teacher, and modification of learning strategies on the part of the student. Formative assessment reinforces for students that learning is an ongoing process, and that making mistakes and learning from them are part of that process. Students are encouraged to view assessment as an opportunity for further learning.

Graffiti Diagram

- This is a brainstorming strategy in which a recording sheet is placed in the centre of a table. Once a topic is defined, all group members at the table *simultaneously* write what they know of the

topic, in point form, for 30 to 40 seconds. The jottings are then reviewed by the group, and key points used to summarize the group's prior knowledge on the topic.

Habits of Mind

- The term encompasses thinking skills and strategies required in the doing of science, such as thinking critically, problem solving and decision making, as well as dispositions which are viewed as necessary to practising scientists, such as curiosity, honesty, open-mindedness and skepticism. Although some of these habits can be taught, the learning of others must be nurtured over a long period of time, through a variety of informal methods, with little explicit instruction or assessment.

Inquiry

- Inquiry is more than just doing activities; it involves interacting with peers, teachers, people outside of the classroom and the school, and all kinds of resources. In the inquiry classroom students work collaboratively on problems that are engaging and relevant; they ask questions; they access and use information from a variety of resources; and they challenge the ideas of others. Teachers, in turn, challenge their students about their observations, hypotheses, explanations, procedures and evidence.

Investigation

- Students design and conduct investigations using inquiry as a process. The form of the investigation might be an experiment or a research project.

Norm-referenced Assessment

- Assessment instruments which compare achievement to that of other individuals are norm-referenced. In the case of large scale tests, such as TIMSS or SAIP, the comparison may be between the average achievement of students in a school or board, and the provincial, national or international averages on the same test. In a school or classroom context, most past and much current practice in assessment is norm-referenced, since the value of a grade or mark is evident by comparing it with the grades or marks of others, or the class median or average.

Portfolio

- A portfolio is a purposeful collection of the student's work that provides a long-term record of the student's efforts, progress, and achievements in a variety of areas.

Procedural knowledge

- Strategies or skills, which may range from algorithms, like the steps in a laboratory procedure or a formula to calculate density, to generalized thinking strategies such as those required to critically assess the scientific validity of a claim in an advertisement. Procedural knowledge also describes manipulative skills, such as the care and use of a microscope.

Rubric

- Complex performance tasks must be judged using well defined criteria. The vehicle for guiding that judgement is the *rubric*. It consists of a set of *criteria* in one dimension, and a fixed scale of *indicators* in the other dimension. For The Ontario Curriculum, the most convenient scale is a four-point scale, which parallels the four levels in the Achievement Levels Chart. In the body of the rubric there is a list of characteristics describing performance for each criterion under each of the points on the scale.

Student Record-keeping

- Student should keep a record of material learned in class activities in a notebook which includes notes *taken* and notes *made* in a variety of formats (written notes and reports, diagrams, charts and webs) Students should also keep a Science Journal (Learning Log, Reflection Journal and other names), separate from their notebook, in which they can record reflective notes and questions.

Summative Assessment

- Assessment activities intended for both feedback and evaluation of achievement are termed summative assessments. Evaluations of summative assessments provide the information which is reported to parents and students about what students know and are able to do. Summative assessments take place at the end of a period of time or unit of instruction.

  Note: An assessment which is summative early in a course may be better viewed as formative later in the course because of subsequent learning which has taken place. This is especially true for the evaluation of skills which are an ongoing focus in Grade 9 Science.

Think-Pair-Share

- A CSGL strategy in which a question or problem is posed, each individual in a group is given a limited time to think of responses, then pairs of students share their thinking and report to the group or class on their collective response. The strategy can be extended by having pairs combine to groups of 4, then to groups of 8 before having the larger group summarize the key points.

Wonder Wall

- Throughout Grade 9 Science students should be encouraged to generate their own questions about science in general and about the science in the unit which they are studying. An important aim of the science course is to develop students' ability to ask questions which clearly identify an issue or variable for investigation. These questions are not to be answered by the teacher, but are available for use by students as topics for inquiry. They must also be practical to investigate, within limitations of time, resources and student knowledge required.

  It would be helpful to provide a permanent location in the science classroom where many of these questions that students wonder about could be posted for all to see – we have chosen to call this public space the Wonder Wall. From these questions, and other which they record in their own Science Journals, students can select an appropriate question to address in one component of the Final Assessment task.

5. Summary - Ontario Curriculum, Grades 1-8: Science and Technology

(See following pages.)

Ontario Curriculum, Grades 1-8: Science and Technology

Strand	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8
Life Systems	Characteristics & Needs of Living Things	Growth & Changes in Animals	Growth & Changes in Plants	Habitats & Communities	Human Organ Systems	Diversity of Living Things	Interactions Within Ecosystems	Cells, Tissues, Organs, & Systems
key words	body parts & functions, diet, movement, senses	comparisons, life cycles, behavioural characteristics	parts & functions, classification, life cycle, features for survival	food chains, structural adaptations, classification	cells, organ interactions, diet, life style	classification systems, pond study	biotic & abiotic factors, food webs, nutrient cycles, biomes	unicellular & multi- cellular (plants & animals) diffusion, osmosis
Investigation	predict how an animal will move	link teeth shape to function	seed germination or plant growth study (onset of wilting, build a terrarium)	habitat assessment	system studies (response times, impact of orthotics)	impact of food manipulation on insect growth	community changes & impact on plant/ animal populations	effect of chemicals on protists, flower wilting prevention
Equipment	field microscope, magnifier	magnifier		magnifier		magnifier, microscope	field microscope, magnifier	field microscope, microscope
Matter & Materials	Characteristics of Objects & Properties of Materials	Properties of Liquid & Solids	Magnetic and Charged Materials	Materials That Transmit/ Reflect/ Absorb Light/ Sound	Properties of Changes in Matter	Properties of Air & Characteristics of Flight	Pure Substances & Mixtures	Fluids
key words	physical properties, classification, use of senses	solubility, physical states, buoyancy, viscosity	polarity, electrostatics, conductor, insulator	sources, clarity, prisms, color theory	changes of state, physical & chemical changes, pressure	gravity, aerodynamics, sources of propulsion	particle theory, heterogeneous & homogeneous, saturation, solubility	hydraulic & pneumatic devices, viscosity, density, Archimede's principle, gravity
Design/ Construct	usable product (aesthetically pleasing)	buoyant object	system moved by magnets	instruments for specific purpose	product that minimizes heat loss	test structure that flies, device using pneumatic power	flowchart for manufacturing a product	system that uses pneumatic or hydraulics (model), hydrometer
Investigation	manipulation of materials for sound production & comparative studies	comparison of buoyancy, absorbancy & reactions	magnetic strength & friction	material properties & sound or light transmission	product assessment, rates of gas production, changes of state	Bernoulli's principle	saturated solutions & temperature variation, mixture separations, water testing	viscosity & temperature, M/V relationship, buoyancy/ gravity relationship
Equipment	magnifying glass		bar & rumen magnets, compass	ray box	balance, hot plates, graduated cylinder, thermometer	clinometer, propellers	balance, graduated cylinder, separation equipment	balance, graduated cylinder, overflow can, thermometer

The Ontario Curriculum, Grades 1-8: Science and Technology

Strand	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8
Energy & Control	Energy in Our Lives	Energy From Wind & Moving Water	Forces & Movement	Light & Sound Energy	Conservation of Energy	Electricity	Heat	Optics
key words	sun, food, consumption & conservation	renewable, hydroelectricity, windmills, gravity, water wheels	directional & gravitational forces, magnetism & electrostatics	sources, properties, shadows, pitch, human ear	non-renewable, natural resources, energy forms	circuits, energy transformations & consumption	Particle Theory, water cycle, heat capacity	sources of light, reflection, refraction, color theory
Design/ Construct	manually controlled device (e.g. fan), poster of energy forms	device propelled by air, device that controls flow of water/and or air	device that uses a specific form of energy	optical device, musical instrument	device that transforms energy	electrical circuits (operates a device) plan to reduce energy consumption	device that minimizes heat transfer	research brochure (eg. risks of radiation)
Investigation	alternatives in case of power failure, impact of senses on energy use	effect of wind direction & speed on the devices	forces affecting speed or direction of moving object	behaviour of light with various optical devices	stored energy, local recycling programs	converting chemical to electrical energy	factors affecting heat transfer	investigate light properties & reflection
Equipment	radiometer, potato clock		magnets, iron filings	tuning fork, sound level meter, mirrors, prisms		hand generator, circuitry equipment	ball & ring, bimetallic strip, conductometer, hot plate, thermometer	curved mirrors, laser, lenses, prism, ray boxes
Structures & Mechanisms	Everyday Structures	Movement	Stability	Pulleys & Gears	Forces Acting on Structures/ Mechanisms	Motion	Structural Strength and Stability	Mechanical Efficiency
key words	shapes, patterns, actions & responses	hinge, incline plane, wheel, axle, lever, wedge	loads, fulcrum, forces, levers, struts, ties	rotary motion, one to two planes (gears), tension, levers	load-bearing, tension & compression, torque,	linear, rotational, reciprocating, oscillating, levers & fulcrum, friction	solid, frame or shell structures, centre of gravity, loads	hydraulic & pneumatic power, Pascal's law, velocity, friction

Design/ Construct	structure (explain its function)	device using mechanisms	stable structure to support a mass (bridge/photo frame), levered structure, & stable structure with a mechanism	a pulley system that performs a task, a system of pulleys	frame structure that supports a load (bridge), mechanical system with a function	mechanical device that changes direction & speed of input (clothesline)	work plan outlining resource choice for product manufacturing	mechanical system operated by hydraulic or pneumatic power
Investigation	occurrence of various shapes, equipment shape & function	factors affecting movement of a load	impact of fulcrum position	impact of tension on pulleys, compare gear systems, modify devices built	effect of changing a pulley system to a lever system	measuring motion of moving objects, reducing friction	performance of a structure (mass versus load support)	measure forces that affect movement (friction)

The Ontario Curriculum, Grades 1-8: Science and Technology

Strand	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8
Earth & Space Systems	Daily & Seasonal Cycles	Air & Water in the Environment	Soils in the Environment	Rocks, Minerals & Erosion	Weather	Space	The Earth's Crust	Water Systems
key words	temperature, wind, light, plant & animal adaptations	physical properties, water cycle, weather	animal & plant life, root types, recycling (decomposition)	physical properties, classification, impact of human activities	major climatic factors and patterns, clouds, water cycle, barometric pressure	solar system, eclipses, tides, constellations, earth rotations (seasons)	plate tectonics, fossils, strata, rock cycle, soil formation	impact on climate & weather, various states, salt & fresh water systems
Design/ Construct	model of a structure for protection against weather conditions	instructions for constructing a pinwheel	useful clay models (eg. brick)	fossil mold to make replicas	model of a cloud in a jar, various weather instruments (& test them)	device to tell time (sundial)	models (i.e., volcanoes, time scale for earth formation or mining techniques)	
Investigation	changes in outdoor temperatures, sun position & shadow creation or flower movement	cloud study (indicator of weather changes), fabric comparison (drying times)	soil separation, water absorption by various soil types	erosion on various sand structures	compare fabrics (water proofing and insulating fabrics)			compare density of various objects & their buoyancy in fresh or salt water
Equipment			sieves					thermometers