Catholic District School Board Writing Partnership

Course Profile

Science

Grade 9
Applied

· *for teachers by teachers*

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Unit 3: Biology: Reproduction - Processes and Applications

Time: 27.5 hours

Unit Developer(s)

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Development Date: July 31, 1999

Unit Description

Students demonstrate an understanding of the processes of reproduction in plants and animals (including humans). They identify issues, formulate questions, and plan and conduct investigations related to reproductive issues. Students examine the impact of scientific research and technological developments on issues related to reproduction and are prepared to make decisions with an informed conscience in light of Gospel values.

Strand(s) and Expectations

Ontario Catholic School Graduate Expectations: CGE 1c, d, e; 2a, c, e; 3b, c, d, e, f; 4a, g; 5e; 6b, c.

Strand(s): Biology

Overall Expectations: BYV.01, BYV.02, BYV.03.

Specific Expectations: BY1.01 to BY1.07, BY2.01 to 2.09, BY3.01 to BY3.05.

Activity Titles (Time + Sequence)

Activity 1	Introduction and Review	150 minutes
Activity 2	Mitosis - The Process of Cell Division	300 minutes
Activity 3	Regulation and Control of Cell Division	375 minutes
Activity 4	Development and Design	375 minutes
Activity 5	Continuity and Complex Organisms	450 minutes
Activity 6	Issues and Challenges	Integrated above

Unit Planning Notes

"All should be persuaded that human life and the task of transmitting it are not realities bound up with this world alone. Hence they cannot be measured or perceived only in terms of it, but always have a bearing on the eternal destiny of men."

(From Paragraph 51; Pope Paul VI. *Gaudium et Spes*. *Pastoral constitution on the Church in the Modern World*. Dec. 7, 1965

This unit focuses on a variety of topical and relevant social issues and concerns. In the spirit expressed in the above quote from the Second Vatican Council, it is our responsibility as Catholic educators to ensure that Catholic students appreciate the miraculous nature of life and the inherent beauty of God's creation as we understand it today. In this respect, the teacher should be familiar with the Church's teachings on the role and use of reproductive technologies in the modern world, both as it applies to people and to other organisms. Appropriate references have been included as part of the appendices and in the references sections of this document. Many activities require students to either observe prepared slides or to prepare their own slides for the purpose of observing cellular processes of mitosis. Hence, a variety of specimens should be available for use (*Allium* root tip slides, whitefish egg slides, and wet mount preparation

materials). If students are to prepare their own root squash slides, teachers may wish to have onions or garlic started at the beginning of the unit to ensure sufficient roots for the class. Activity 6 is intended to allow students to relate material learned in the classroom to everyday events using a variety of reflective techniques and critical review based on Church teaching. As such, the time allocated for Activity 6 should be distributed throughout the unit, allowing time to address topical material as it develops in the media and in the class. In addition, the teacher may wish to prepare relevant quotations from the New Catechism/Scripture to help direct student reflection on the appropriate Catholic perspective of the topic under review. These should be general in scope, allowing a variety of applications depending on the student's choice of self-expression (science log, scrapbook, portfolio, essay, etc.). The school's chaplain is an excellent resource for this portion of the unit.

Many of the activities suggested in this unit require students to work with Home groups and Expert groups. Students should be assigned to a Home group of five students at the beginning of the unit. Expert groups are formed as needed. Some of the career related activities require students to use *Career Explorer*, a recent software acquisition by the Ministry of Education. Teachers should become familiar with its use. Human embryo development is explored from the context of comparative embryology. This allows students to consider developmental stages using representative organisms while keeping within the Church's teachings.

Prior Knowledge Required

Students studied the properties of cells in Grades 5, 6, and 8. At that time they also learned the techniques of microscopy. Teachers should review lab safety as well as the basics of microscopy with the class.

Teaching/Learning Strategies

This unit takes a problem-solving approach, asking students to assess the knowledge required to carry out certain common tasks in Medicine and Biology. This is followed by developing the basic knowledge and skills required to understand the processes involved. Individual activities have been structured to accommodate a variety of learning styles. Many activities are lab- or group-based, requiring students to demonstrate a variety of tactile skills as well as co-operative and group interaction skills.

Assessment and Evaluation

This unit provides students with a broad range of activities and opportunities to demonstrate their skills and knowledge. Process and product should be assessed as each of the activities progress. Teacher observation, conferencing, written and oral reporting, portfolios, and science logs provide a comprehensive assortment of assessment and evaluation opportunities.

Resources

Print

STAO lab safety

WHMIS safety charts

Lux Flanagan, Geraldine, and Heinemann. *The First Nine Months*. Medical Books Ltd., 1963.

Morholt, Brandwein, and Joseph. *A Source Book for the Biological Sc*iences. Harcourt Brace.

Video

The Living Cell; An Introduction. Britannica, Marlin Motion Pictures Ltd.

Various titles from National Geographic, Nature, Vista or Nova
e.g., *National Geographic Reptiles and Amphibians*. 1989 TV Video
Whale of an Idea Foils Salmon-Stealing Seals

The Seedy Side of Plants. Available from WNET Video Distribution. 1-800-336-1917 or WNET Distribution, P.O. Box 2284, South Burlington, VT 05407

Hummingbirds - Jewels of the Forest (1991) Video available from Amazon.com

Computer

http://members.aol.com/msnick1/waterdragons.html
Chinese Water dragons. Pictures and information about reproduction of these animals. Includes a photo-diary.

http://worms.zoology.wisc.edu/frogs/mainmenu.html
Amphibian embryology tutorial; includes embryo development pictures.

http://museum.nhm.uga.edu/herpphotos/MKomo.html
Pictures of various amphibians

http://www.uvm.edu/%7esnrdept/vmc/amp.html
data site for amphibian monitoring

http://asci.uvm.edu/bramley/REPRO.html
Mammalian reproductive cycles and related technologies.

http://www.cciw.ca/ecowatch/dapcan/
Environment Canada amphibian page

http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_DS089
AI in Dairy

http://embryo.mc.duke.edu/
Multidimensional human embryo site.

http://embryo.mc.duke.edu/animal/home.html
MRI images of embryos ... comparative anatomy.

http://www.visembryo.com/baby/index.html
Visible embryo by day of development.

http://www.sciam.com/1999/0399issue/0399smith.html
Scientific American article.

http://www.pbs.org/wgbh/nova/odyssey/
PBS online with comparative embryology.

http://www.pbs.org/wgbh/nova/odyssey/clips/
A series of clips showing development of embryos of different vertebrates.

http://www.pbs.org/tal/costa_rica/index.html
Rainforest animals and plants

http://www.csdl.tamu.edu/FLORA/gallery.htm
Digital Blossoms; online galleries of flowers ... more than 17000 images.

http://www.helsinki.fi/kmus/botpics.html

http://www.gov.on.ca/OMAFRA/english/livestock/swine/genetic.html
fact page on AI in swine

http://www.search.gov.on.ca:8002/compass?scope=artificial+insemination&ui=sr
gov't links on AI

http://www.ars.usda.gov/is/kids/teachers/WhizKidAct.htm
teacher resource packages and activities.

http://www.ars.usda.gov/is/kids/contents.htm
contents of site on food production

http://aceis.agr.ca/cb/factsheets/facindxe.html
agricanada fact sheets page

http://www3.ns.sympatico.ca/laexpress/repro/insemination.htm
AI in horses

http://informatics4.vetmed.vt.edu/HostedSites/dascanio/Parturition/parturitionhp.html
birthing in horses

http://informatics4.vetmed.vt.edu/HostedSites/create/createhp.html
AI techniques

http://informatics4.vetmed.vt.edu/HostedSites/create/createhp.html
Human embryo simulation/modelling

http://sdb.bio.purdue.edu/Other/VL_DB.html
Virtual Library of developmental biology

http://sdb.bio.purdue.edu/dbcinema/index.html
Developmental biology cinema on-line

http://www.med.upenn.edu/meded/public/berp/index.html
upenn's embryo movies.

Activity 1: Introduction and Review

Time: 150 minutes

Description

Students recognize the importance of cell division and how it relates to the reproduction of asexual cells.

Strand(s) and Expectations

Ontario Catholic School Graduate Expectations:

The graduate is expected to be:
1b,c,d,e,f,i; 2a,b,c,d,e; 3b,c,d,e; 4a,b,c,d,e,f,g; 5a,b,c,d,e,f; 6b, 7a,b,d,h,i,j.

Strand(s): Biology

Overall Expectations: BYV.01.

Specific Expectations: BY1.02, BY2.04❖, BY2.05, BY2.07❖.

Planning notes

- Ensure that microscopes and/or micro viewers are in working order and that appropriate prepared slides, microslides and micrographs are available.
- It may be necessary to review the proper use and care of the microscope, the correct techniques in preparing a microscope slide, the requirements for scientific drawings, calculating total magnification, and measuring the size of objects viewed under the microscope.

- Provide a variety of cell diagrams or micrographs of plant or animal cells if microscopes or prepared slides are not available.
- Remind students of the ethical use of the Internet and other information technology sources.
- Students work in co-operative groups for some activities. Refer to Appendix D2.

Prior Knowledge Required

The student is familiar with:

- cell structure;
- unicellular and multicellular systems;
- the care and use of a compound microscope.

Teaching/Learning Strategies

1. Students review cell theory and microscopy skills.
   Working in pairs, students examine diagrams, micrographs, and prepared slides of plant and animal tissues. These should also include unicellular organisms, such as amoeba, paramecium, or *Volvox*. Students draw labelled diagrams of their observations. Encourage students to include the magnification with each diagram. Students answer the following questions:
   - Are the cells in each sample of tissue alike?
   - Why do you think it is necessary for these cells to be alike?
   - From where do these cells originate?
   - Would another sample of the same type of tissue contain the same cell type?
   - Are all unicellular organisms the same?
   - Are all cells alive? Do they function on their own? Do they function as a unit?

   With teacher facilitation, students should arrive to the statements of the cell theory: all living things are composed of at least one cell, the cell is the fundamental unit of function in all organisms; and all cells arise from pre-existing cells. (Possible science log entry)
2. Students recognize the importance of cell division and how it relates to the reproduction of somatic cells.
   - Students, in groups of five, consider the following:
     Severe burn victims can now have skins grafts using "real skin" grown in the laboratory. This skin is grown from cells taken from a person's body. Students are asked to collaboratively brainstorm solutions to the following questions:
     i) What properties must this skin have so that it can be grafted onto the person's body?
     ii) What role must cell division play in this process?
     iii) How must these "new" cells relate to the "original" cells?
   - One group is asked to share their answers. Other groups then add alternative responses to the original answers given. A summary is compiled by the teacher and shared with the students. Student responses to the questions can be posted or copied and distributed to the class.
   - This list can be referred to throughout the unit. The teacher or student may use this list to review concepts taught and/or have further discussions on the topic. The list is useful in showing students the importance of cell division in maintaining correct cell function.

Assessment/Evaluation

1. Roving conference can be used to ensure students are using microscope correctly and that diagrams of cells are done correctly. The teacher record this using appropriate checklists and/or rating scales. (BY2.07)
2. Students submit a summary note on a scientist, summarizing his/her contribution to the cell theory or to cell division. This is used to assess knowledge and understanding, inquiry, communications, and making connections through the use of a product rubric (Appendix A3). (BY2.04, BY2.07)

Resources

Microscope manuals
Prepared slides of microorganisms

Accommodations

1. Where the student has an individual educational plan, IEP, this activity will be modified to meet the student's needs as outlined in the plan.
2. For ESL/D, students have opportunities to demonstrate their learning by alternative means while written English is developing (spoken English, direct demonstration and pictorial representation). At the same time, instruction in written, science-specific language continues.
3. For students with physical or learning impairments, classroom and laboratory activities are modified to permit participation as much as possible. Where possible, peers are encouraged to assist the student to permit participation in all group and individual activities.
4. For the purpose of providing extensions and enrichment, students have opportunities to investigate the topics presented here in greater detail. Close collaboration between teacher and student is required to ensure appropriate enrichment opportunities.

Activity 2: Mitosis - The Process of Cell Division

Time: 300 minutes

Description

Students describe the stages of mitosis and create a model to demonstrate their mastery of the concept. Students also observe and describe various methods of asexual reproduction in animals and plants.

Strand(s) and Expectations

Ontario Catholic School Graduate Expectations:

The graduate is expected to be: 1b,c,d,e,f,i; 2a,b,c,d,e; 3b,c,d,e; 4a,b,c,d,e,f,g; 5a,b,c,d,e,f; 6b; 7a,b,d,h,i,j.

Strand(s): Biology

Overall Expectations: BYV.01.

Specific Expectations: BY1.01❖, BY1.02❖, BY1.04❖, BY2.02❖, BY2.03❖, BY2.04❖, BY2.05❖, BY2.06❖, BY2.07❖, BY2.09❖.

Planning Notes

- Ensure that microscopes and/or micro viewers are in working order and that appropriate prepared slides, microslides, and micrographs are available.
- It may be necessary to review the proper use and care of the microscope, correct techniques in preparing a microscope slide, requirements for scientific drawings, calculating total magnification, and measuring the size of objects viewed under the microscope.

- Fresh garlic cloves should be made available for the preparation of slides, if possible.
- Students should not work with black bread mould (*Rhizopus nigricans*) since it has been linked to various health problems.
- Start to grow any plants required at least two weeks before this activity. Alternatively, photographs of the plants at various stages of growth could be made available.
- Remind students of the ethical use of the Internet and other information technology sources.

Prior Knowledge Required

The student should be able to:

- identify the main parts of a cell;
- use a compound microscope;
- recognize the nucleus as the control centre of the cell and DNA as the "storehouse" of genetic information;
- state the Cell Theory.

Teaching/Learning Strategies

1. Students are introduced to cell division. It is important that the teacher provide some background information on cell division. Students should understand that:
   - cell division is an ongoing process;
   - the cell undergoes these changes in regulated stages;
   - cell division consists of two major events: mitosis (nuclear division) and cytokinesis (division of the cytoplasm);
   - mitosis occupies only a small fraction of the time in a typical cell cycle. Stress that approximately 90% of the cell's life is spent in interphase.
   - the goal of cell division is the production of daughter cells with the same genetic information.

   Differences in mitosis between animal and plant cells may be discussed at this time or during Strategy 3 when students view plant and animal cells undergoing mitosis.
2. The Stages of Mitosis
   - Students are placed in home groups of five, with each group being responsible for producing a mnemonic to help remember the stages of mitosis, for example, "in parks mighty ants thrive."
   - Each student in the home group is assigned a letter: I, P, M, A, and T. All the I's come together forming the Interphase Expert Group. Likewise, the remaining students come together into their respective expert groups. Members of each expert group research their phase and return to their home groups with their information. Each member must teach their stage of mitosis, provide a diagram of the stage, and prepare a summary note for the other members of the home group.
   - Students can present the stages of mitosis in a variety of creative ways. Each home group could create a model showing the stages of mitosis using pipe cleaners, plasticine, marshmallows, styrofoam, etc. Students could also produce Mitosis T-shirts displaying mitosis information drawn with fabric markers. Other students may wish to use presentation software or simulation software, such as the Mitosis Dance to illustrate mitosis. The possibilities are endless.
   - Each home group produces a crossword puzzle, limerick or poem, word search, or other word game based on definitions/terms used to explain the parts of the cell and mitosis. These crossword puzzles could be used as review sheets.
3. Students observe mitosis in onion root tip and whitefish embryo cells, following procedures readily available in texts (see p. 20 of McGraw Hill's *SciencePower 9* or p. 154 of Nelson's *Science 9*). Students observe cells in various stages of mitosis and recognize that mitosis is not a static event. Students draw labelled diagrams of the various stages of mitosis which also include the magnification

factor and size of the cell. Students should record this information in their science logs. Students may use garlic root tips when preparing slides to observe mitosis. The following outlines the preparation of garlic root tip slides:

- Take a cleaned clove of garlic and put a toothpick through it so that the thinner end of the garlic sits in water. The rest of the garlic is supported by the mouth of a glass. Overnight, roots will grow from the submerged portion of the garlic. The next day, cut using a scalpel the ends of these roots and place them on a clean, dry slide. Add a small amount of aceto-orcein on the root tips and allow it to soak through. Gentle heating over a low flame may be required to breakdown the cellulose wall and allow the stain to enter the cells. Place a coverslip over the stained root tips and squash the cells before viewing them under the microscope. Slides produced using this procedure provide a good selection of cells in the various stages of mitosis.

4. Students observe and then describe in their science logs examples of asexual reproduction in plants and animals. Provide grown samples of each of the types of vegetative propagation methods (both in beginning and growth forms). Print resources, diagrams, videos, etc. can be used if grown samples are not available. Access to a greenhouse or a similar facility would allow students to grow plants using the various methods of propagation discussed allowing the student to experience, first-hand, the advantages and disadvantages of each method. (Possible ScienceWorld idea)
   Students return to the same expert groups as in Activity 1. Each expert group is assigned a type of asexual reproduction to research. Possible topics include the production of spores, cuttings, grafting, tubers, bulbs, modified stems, budding in *Hydra* and regeneration in planaria. Each expert group:
   - investigates and relates mitosis to topic assigned;
   - speculates on the advantages and disadvantages of the vegetative process;
   - produces a summary note and diagrams for the topic.

   The information gathered in the expert group is shared with the base groups.

Assessment/Evaluation:

- Students collaborate in a jigsaw setting to inform and be informed on cell division. Through collaboration, students set the direction of study, recognize relevant information, and assess self and peers. Collaboration can be assessed through the use of a collaborative rubric (Appendix A4) (BY1.01, BY2.02, BY2.04, BY2.05, BY2. 07)
- Students produce class notes and diagrams of the stages of mitosis. These are assessed for knowledge/understanding and communication through the use of a product rubric (Appendix A3). (BY1.01, BY2.04, BY2.05, BY2.07)
- Students produce visual presentations of mitosis to demonstrate understanding of the process. These are assessed for knowledge/understanding and communication using a product rubric (Appendix A3) and a self- and peer-evaluation sheet prepared by the teacher. (BY1.01, BY2.07)
- Students are assessed on the use of the microscope using an appropriate checklist. (BY2.03, BY2.09)
- Students are assessed on the preparation of a microscope slide of garlic root tip using an appropriate checklist. (BY2.03)
- Students produce a summary note and diagrams, detailing one form of asexual reproduction, that are assessed for understanding and knowledge, inquiry, communication, and making connections, using a product rubric (Appendix A3). (BY1.01, BY1.02, BY1.05, BY2.02, BY2.04, BY2.05, BY2.07)
- A paper and pencil test is given to ensure that students have understood mitosis and the types of asexual reproduction. (BY1.01, BY1.02, BY1.04)

Resources

Noelle and Schraer. *A Learning Program for Biology*. USA: Cebco Allyn and Bacon, Inc.

Ritter, et al. *Science 9*. Toronto: ITP Nelson, 1999.

Sullivan, Aleta. *Mitosis Square D*ance.
Http://www.accessexcellence.org/AE/Sullivan

Winchester, A.M. *Laboratory Manual of Genetics*. USA: W.C. Brown Co. Publ., 1979.

Wolfe, et al. *SciencePower 9*. Toronto: McGraw-Hill Ryerson, 1999.

Accommodations

See Accommodations in Activity 1 for general accommodations.

Activity 3: Regulation and Control of Cell Division

Time: 375 minutes

Description

Students complete an experimental inquiry into yeast growth. They design and perform an experiment; record, analyse, and interpret results. They then communicate their findings using graphs, charts, and written reports. Applications of mitosis and related careers are studied. Students relate mitosis to the growth and repair processes that occur in multicellular organisms. Regulated cell division is recognized as an important cell feature in maintaining cell function. Students investigate factors that could change regulated cell division and its outcomes.

Strand(s) and Expectations

Ontario Catholic School Graduate Expectations:

The graduate is expected to be: 1b,c,d,e,f,i; 2a,b,c,d,e; 3b,c,d,e; 4a,b,c,d,e,f,g; 5a,b,c,d,e,f; 6b; 7a,b,d,h,i,j.

Strand(s): Biology

Overall Expectations: BYV.01, BYV.03.

Specific Expectations: BY1.01❖, BY1.02❖, BY2.02❖, BY2.03❖, BY2.04❖, BY2.05❖ BY2.06❖, BY2.07❖, BY3.01❖, BY3.02❖, BY3.03❖, BY3.05❖.

Prior Knowledge Required

The student should be able to:

- describe the process of seed germination or plant growth;
- understand and describe the process of mitosis;
- understand the importance of cell division to the growth and reproduction of an organism.

Planning Notes

- Ensure that microscopes and/or micro viewers are in working order and that appropriate prepared slides, microslides, and micrographs are available.
- Prepare yeast cultures and yeast cell dilutions. Yeast grow to observable colonies at 30°C overnight or at room temperature in several days. Various methods of cell cultures are available. Check lab manuals or web sites for best suited method.
- Provide a safe source of UV radiation (UV lamp).
- Ensure that students are aware of the proper use of UV lamps.

- Collect a variety of career profiles or sources; a good one is the *Career Explorer* program recently licensed by the MEd. Try to link with TAG (Teacher Advisor Group)/AEP (Annual Education Plan) resources.
- Arrange for a guest speaker to discuss advances and career opportunities in cell biology. It is critical that the speaker's presentation is at a level appropriate for your class.
- Remind students of the ethical use of the Internet and other information technology resources.

Teaching/Learning Strategies

1. Students review the importance of regulated cell division in maintaining cell specialization. They conclude that daughter cells are identical to mother cells in nuclear content and therefore, designed to carry out a special function (specialization of cells).
   - Using diagrams or slides of mitosis, students review how daughter cells resemble the mother cells. Through teacher facilitation, students come to the conclusion of cell specialization (possible science log entry).
2. Students investigate factors that can change regulated cell division in yeast cells. The introduction of dependent and independent variables and interpolation and extrapolation are done through the graphing of experimental results. Yeast, *Saccharomyces cerviasae*, is used since these are eukaryotic cells and are more similar to human cells than bacteria. One of the following tests may be done or the students may form small groups so that a variety of tests may be done at the same time. Encourage students to continue the investigation by designing and performing their own experiment on yeast. They report their findings orally or in written form.
   - Test 1: Yeast cells exposed to different amounts of UV radiation.

   Students are given four petri dishes containing a constant amount of yeast cells of approximately 300 to 3000 cells per plate (prepared by teacher in advance). Each plate is exposed to UV radiation for varying amounts of time. One petri dish containing yeast should be kept as a control. UV exposure can be set from 10 seconds to 2 minutes. Let the petri dish sit for two to three days at room temperature. A good growth of yeast cells should occur within this time. Students can then calculate the yeast growth by comparing visible cell growth on the irradiated plate to the control plate (unirradiated plate). Students may do daily observations rather than one final observation. Students could continue this experiment by testing the UV protection levels of various sun screen lotions. A thin plastic film covered with a sun screen lotion is placed over the petri dish cover before the yeast cells are irradiated. The yeast cells may be irradiated for the same amounts of time or varied amounts of time. (Possible ScienceWorld idea)

   Students will be asked to
   1. Calculate the percent survivors per plate as compared to the control.
   2. What levels of UV light resulted in the highest survival and lowest survival rate?
   3. Look for changes (mutations) in the yeast colonies that survived irradiation (e.g., colour, differences in shape or size, etc.).
   4. What effects would lower count or changes in the yeast cells have on the ability of the cell to function as a cell on its own or as a colony?
   5. How does the change in function ability relate to mitosis and the regeneration of new cells?

   If sun screen is used:
   6. What does SPF stand for?
   7. Calculate the amount of protection each SPF level received by calculating the survival rate as in question 1.
   8. Which SPF level resulted in the highest survival and the lowest survival rate?

9. Was there a SPF level or levels that show consistent results?
10. How does the use of sun screen on our skin help maintain the cell identity?

- Test 2: Yeast cells tested with different amounts of sugar, temperature of incubation, incubation time, and addition of different contaminant such as salt, acid, base, and detergent. Students design and perform their experiment using one of the variables listed above. They produce a report including a hypothesis, description of their experiment, observations in the form of a graph, analysis of their data, a discussion of error, a conclusion, and some industrial uses of yeast.

3. Invite a guest speaker to discuss career possibilities in reproductive biology. Possible speakers include zoo technician, farm veterinarian, and representatives from the Ministry of Natural Resources or for the pulp and paper (reforestation) industry.
4. Students relate a specific career in biology to the process of mitosis. Students research one of the following topics: tissue repair, regeneration, grafting of skin (burn victims), cancer, and cloning of plants. The teacher may assign topics to be discussed in advance and have students bring in one or two relevant pieces of information on the topic.
   Students return to their base groups and are assigned a topic. The teacher also provides each group with the career profiles relating to their topic. Each group:
   a) describes their topic;
   b) shows how a knowledge of mitosis is applied to at least one career of the student's choice;
   c) identifies the potential benefits of continued research in this area;
   d) explains some of the ethical challenges associated with the career chosen, based on the Church's teachings (science log entry);
   e) produces a pamphlet, bulletin board display, or mural depicting the most important points of their topic;
   f) describes at least one Canadian contribution from their chosen topic.
5. In groups or individually, students complete their understanding of development and reproduction by exploring the contributions of Canadian scientists to the field of developmental biology and genetic engineering. This may be done in a variety of techniques including: researching the contributions of one particular scientist; collecting newspaper clippings; interviewing researchers at a local company, college, or university lab; Internet search or other means. Students present their findings to the class either orally or by preparing a Bristol board summary.

Assessment/Evaluation

1. Roving conference can be used to ensure students are using microscopes correctly and that observations are being recorded into student science logs. The teacher evaluates student microscope skills using appropriate checklists and/or rating scales. (BY2.09, BY2.05)
2. Students collaborate to inform and be informed on various mitotic processes and related careers. Through collaboration, students set direction of study, solve problems, recognize relevant information, and assess self and peers. Assess using a collaborative rubric (Appendix A4). (BY1.01, BY1.02, BY2.02, BY2.04, BY2.05, BY2.07)
3. The student's research project on a process of mitosis and related careers is assessed for the categories on the Achievement Chart, using a product rubric (Appendix A3). (BY1.01, BY1.02, BY2.01, BY2.02, BY2.04, BY2.05, BY2.07)
4. The student presentation on a process of mitosis and related career is assessed for knowledge/understanding, inquiry, communication, and making connections, using the process rubric (Appendix A1). (BY1.01, BY1.02, BY2.02, BY2.04, BY2.05, BY2.07)

5. Student understanding of the roles Canadian scientists are playing in the area of reproductive technologies may be assessed or evaluated by having students present an oral report or by evaluating student posters or bristle boards using the product assessment rubric (Appendix A3). (BY2.05, BY3.02)
6. Yeast lab reports may be collected and evaluated using the product rubric (Appendix A3). (BY2.05)

Resources

www.acessexcellence.org/AE/AEPC/WWC

www.phys.ksu.edu/gene/d3

www.clemson.edu/biolab/yeast.html

www-personal.ksu.edu/~bethmont/rl2k/yeast.html

Accommodations:

See Accommodations in Activity 1 for general accommodations.

Activity 4: Development and Design

Time: 375 minutes

Description

In this activity, sexual reproduction is introduced as genetic continuity between generations. Students also explore the process of embryonic development and relate it to the changes that occur in the female body during pregnancy.

Strand(s) and expectations

Ontario Catholic School Graduate Expectations:

The graduate is expected to be: 1b,c,d,e,f,i; 2a,b,c,d,e; 3b,c,d,e; 4a,b,c,d,e,f,g; 5a,b,c,d,e,f; 6b; 7a,b,d,h,i,j.

Strand(s): Biology

Overall Expectations: BYV.02, BYV.03.

Specific Expectations: BY1.03❖, BY1.07❖, BY2.02❖, BY2.03❖, BY2.04❖, BY2.05❖, BY2.07❖, BY2.08❖, BY2.09❖, BY3.01❖, BY3.02❖, BY3.03❖.

Planning Notes

- When discussing human development, students should have access to photos of various stages of embryonic development in a representative organism. Chick embryo microslides may be suitable for this purpose. Alternatively, ultrasound photographs may be obtained with permission from a local lab. Ideally, a set of ultrasound pictures of several different stages from each trimester would be available. The use of comparative vertebrate embryology is suggested as it is very similar to human development especially in earlier phases.
- A microviewer slide set for the developing chick embryo is necessary to carry out some of the activities.
- Teachers should be familiar with relevant Church teachings on reproduction and be prepared to discuss issues that students bring up in class. A sample background piece has been provided with this document in Appendices C4 and C5.

- All Internet sites to which students are directed should be reviewed for suitability of content with respect to the age and background of students as well as compatibility with Church teachings.
- Whitefish egg slides make excellent samples for observation of mitosis in animal cells and as a precursor to discussions on sexual reproduction and continuity and development.

Prior Knowledge Required

Students should be familiar with the stages of mitosis in order to identify them in slides they observe. In addition, students should be able to link the process of mitosis to the early events of development (increasing the number of germ cells) and to the later events of development (differentiation and growth of the fully formed embryo to birth size).

Teaching/Learning Strategies

1. In their home groups, students are asked to solve the riddle "Why are we similar yet different?" This is done by asking each group to discuss the following questions based on what they already know of cellular reproduction:
    - Look around the room and at your teammates. What features make each individual identifiable as human?
    - What features make us different from each other?
    - Can this be achieved if we reproduce in the same way as a hydra or paramecium? Why or Why not?
    - Students present their conclusions to the class.
    - This may be a good point for students to make a science log entry
2. Students are introduced to the concept of sexual reproduction as a union of sex cells, each carrying the same type of information but half the quantity. DNA, as the hereditary material, is discussed and related to genes, proteins, and physical/chemical characteristics of the individual. This is accomplished through teacher facilitation or through independent work with an appropriate student text.
3. Students are asked to revisit their answers to Teaching/Learning Strategy 1 and determine if this new information alters their perceptions. Students submit a written summary of their understanding of sexual reproduction by applying their knowledge to the statement: "You have your mother's eyes and your father's chin." Explain.
4. Students make detailed observations of vertebrate embryo development using micro-viewers, slides, or other resources as appropriate. Students make predictions based on their observations: Which structure will develop first? Which will develop subsequently? Why? How long will each stage of development take? Why? etc. Students then test their predictions and propose explanations for any inaccuracies. The material they gather, including biological drawings, observations, and discussion is prepared as a lab report for evaluation. Students' observations should be related to the role of the nucleus in controlling differentiation of cells and development of the embryo.
    - Development of the human embryo is introduced and related to the observations made above. Students match key events in human development to their observations in the vertebrate embryo, summarizing their work using the trimester approach.
    - Changes in the embryo are related to changes perceived by the mother using an appropriate chart of the menstrual cycle. Students list embryonic stages and the corresponding physical or biochemical changes observed in the mother. These should include but are not limited to observations such as cessation of menstruation after fertilization of the egg, nausea and nutritional changes as a result of hormonal changes, enlargement of the breasts and distention of the abdomen as a result of the growing fetus, lactation and contractions as a result of the birthing of the child.

- Using appropriate resources such as the Internet or, where available, ultrasound pictures, students prepare a photo-diary of the major stages of fetal development, which consists of at least two photos per trimester and a summary of the changes that are observed in the photos.

Assessment/Evaluation

- Student presentations may be assessed or evaluated using a product rubric (Appendix A3) or a checklist. (BY1.03, BY2.07, BY2.08)
- Student written responses to Teaching/Learning Strategy 3 are collected and evaluated for understanding of the role of the nucleus and DNA in heredity. A product rubric such as Appendix A3 may be used to evaluate their work. (BY1.03, BY2.04, BY2.07)
- Vertebrate embryo lab reports may be collected and evaluated using the product rubric (Appendix A3). (BY2.02, BY2.05)
- Student summaries of human development may be collected and evaluated using the product rubric (Appendix A3). (BY1.07, BY2.04)
- Student photo-diaries and reports are collected and evaluated using the product rubric (Appendix A3). (BY2.07, BY2.05, BY3.01 BY3.03)

Resources

Multidimensional human embryo site.
http://embryo.mc.duke.edu/

MRI images of embryos ... comparative anatomy.
http://embryo.mc.duke.edu/animal/home.html

Visible embryo by day of development
http://www.visembryo.com/baby/index.html

Scientific American article on embryo development.
http://www.sciam.com/1999/0399issue/0399smith.html

PBS online with comparative embryology.
http://www.pbs.org/wgbh/nova/odyssey/

Accommodations

1. See Accommodations in Activity 1 for general accommodations.
2. An enrichment activity or ScienceWorld project suitable for this activity would be for students to observe development in a living species. Fertilized frog eggs may be ordered and the appropriate aquarium conditions set up to allow these eggs to develop normally. Teachers have to pre-order these in advance to ensure availability when required. In addition, teachers ensure that adequate arrangements have been made to deal with the young frogs once the experiment has concluded. Teachers should check for compatibility of the frogs with the local flora/fauna and should not release a non-indigenous species into the wild. Alternatively, a local private or MNR operated fish hatchery may be a source for fertilized fish eggs, which may be released into local streams. Students are asked to make daily observations of the eggs as they develop, noting changes in colour, size, structure inside and out. These observations should be recorded in a science log with explanations as to what the students perception are. Some of the eggs may be set up using a stereoscope for more detailed observations. As they observe the development of the eggs, students should make predictions based on their observations ... which structure will develop first, which will develop subsequently, why? ... how long will each stage of development take, why? etc. Students then test their predictions and propose explanations for any inaccuracies. Students submit their science logs for assessment and evaluation. It may be supplemented by introducing variables such as changes in temperature, water

quality, oxygen content, etc., and the impact this may have on the development process. If this were the case, teachers should instruct students on the ethics of working with living creatures.

3. Other possible ScienceWorld ideas:
   - Interview a recent mother about her experiences or an interview with an obstetrician about the development and birthing process. This can be supplemented using interviews with an ultrasound technician or obstetrics nurse.
   - Visit a maternity ward and describe the setup, procedures, and use of the various technologies in the birthing process.
   - Prepare a report reviewing the possible consequences of alcohol consumption on the developing fetus or the role of environmental factors in development and reproduction or how some modern technologies may impact the developing child (X-rays, medications, microwaves).

Activity 5: Continuity and Complex Organisms

Time: 450 minutes

Description

In this activity, students examine sexual and asexual reproduction. Students compare these forms of reproduction, noting factors that affect each type of reproduction and the methods by which humans have been able to intervene.

Strand(s) and Expectations

Ontario Catholic School Graduate Expectations:

The graduate is expected to be: 1b,c,d,e,f,i; 2a,b,c,d,e; 3b,c,d,e; 4a,b,c,d,e,f,g; 5a,b,c,d,e,f; 6b; 7a,b,d,h,i,j.

Strand(s): Biology

Overall Expectations: BYV.01, BYV.02, BYV.03

Specific Expectations: BY1.05❖, BY1.06❖, BY2.04❖, BY2.05❖, BY2.06❖, BY2.07❖, BY3.01❖.

Planning Notes

- Students are involved in discovering various aspects of human development. In keeping with Church teachings and to instill in students the sanctity of human life, it is highly recommended that the teacher use ultrasound or MRI pictures of the living embryo/fetus. Several web sites have been included in the resource section of this activity and the unit summary to assist the teacher in locating resources.
- Provide photographs of flowers showing their reproductive structures. A variety of sources are available including the Internet, seed packages, gardening books, etc.
- In order to study asexual reproduction, prepared slides of hydra budding or paramecium undergoing binary fission should be available. Alternatively, photographic slides or pictures of various organisms undergoing asexual reproduction may be obtained from commercial sources or reference texts on invertebrates.
- *Nature*, *National Geographic*, and *Vista* have produced excellent videos cataloguing the relationships between plants and animals. These would be of value when discussing sexual reproduction, especially of plants. In addition, videos showcasing the life cycles of common vertebrates such as amphibians, salmon, and reptiles would be assets when describing sexual reproduction in animals.

- Picture sets of various organisms and their young may be obtained from institutions or corporations involved in the agriculture industry or the various government agricultural agencies and farm groups (4H clubs).
- The Ministry of Natural Resources has prepared several excellent fact sheets on indigenous organisms, which include reproductive cycles and statistics. In addition, the Federal Ministry of Fisheries and Oceans has several excellent resources available. These describe topics as diverse as aquaculture of salmonid species to recent studies on cod and salmon fisheries.

Prior Knowledge Required

- Some aspects of cell structure have been developed in the Grades 3 and 8 Life Systems strands.
- Knowledge of mitosis is essential for understanding the distinction between asexual and sexual reproduction.

Teaching/Learning Strategies

1. In their home groups, students view pictures of various organisms and their offspring. For each picture students answer the following questions:
   - How are the offspring similar to their parents?
   - How are they different?
   - Which offspring had two parents? How do you know?
   - Which offspring had one parent? How do you know?
2. Students present their results to the class. Their responses should indicate that asexually reproducing organisms produce identical offspring while sexually reproducing organisms produce a variety of offspring.
3. The students' presentations are summarized by the teacher and related to cellular division as observed by students in previous activities. In particular, the role of chromosomes as hereditary factors is developed.
4. Students develop a list of the pro's and con's of asexual reproduction, relating these to the process of mitosis, contents of the nucleus, and environmental factors that may impact on it.
5. With the class, the teacher develops a question similar to the following: For sexual reproduction to occur, the offspring must receive hereditary information from both parents. How does this happen in plants? ...in animals?
6. In their home groups, students observe pictures of at least five different flowers. Students identify the sexual organs, and describe their structure and their function. (This is in preparation for being able to relate physical adaptations to methods used by plants for pollination.)
7. Based on their observations and descriptions, students propose hypotheses of how each flower is pollinated. Each hypothesis must include the following;
   - Pollinator is …(animal, insect, wind, etc.)
   - Pollinator comes in contact with ... when it ....
8. Students present at least one of their hypotheses and must be prepared to defend it using their observations of the flower's structures.
9. If an appropriate video is available, (see Planning Notes), students view a video describing the relationship between plants and animal vectors of pollination.
   - After viewing the film, students review their hypotheses, modifying them based on information from the video and their observations of flower parts.

- Students prepare a final report listing their observations, their original hypotheses and the reasons for them, any modifications they made to their hypotheses, and the reasons for the changes. Their report must include a response to the question; How can we use this knowledge to improve food production? (This may be an appropriate topic for a science log entry.)

The next section of this activity focusses on animal reproductive strategies. Emphasis is placed on the way these strategies can be applied for food production and propagation of the species (aquaculture, stocking of lakes and streams, etc.). The background gained in this section helps students round out their responses for Activity 6 and leads into some of the Issues (such as in vitro fertilization) that students should be made aware of. Students may be encouraged to write a response in their science logs to an appropriate question related to this topic.

10. Students begin their investigation of animal reproductive strategies by viewing an appropriate video focussing on amphibian (*National Geographic*'s *Rainforest*) or fish reproduction. This should cover the topic of external fertilization, (an integral component of the aquaculture industry in Canada).
11. Students describe the aspects of animal behaviour that permit human harvesting for food production.
12. In their home groups, students receive a fact sheet on one indigenous species and its reproductive cycle. Students review the fact sheet then discuss the following topics.
    - How many eggs are laid during a typical cycle for your species?
    - Of the eggs that are laid, how many will survive the first year of life?
    - How does the reproductive strategy of your organism ensure that some offspring will survive to maturity?

    Organisms may include but are not limited to, salmon, trout, common leopard frog, spiders, termites, ants, etc., or any potential food source or organism that may affect our food supply.
13. Students compare the information above with that available for a representative organism that utilizes internal fertilization. (Available from a variety of sources, especially for farm animals - see Resources.) Similar questions should be answered for these organisms. Additionally, students should chart the reproductive cycle for the organism.
14. Students compile their findings in a report and present it to the class using appropriate strategies such as graphs, data tables, charts, etc.

Assessment/Evaluation

- Student presentation for Teaching/Learning Strategy 2 may be assessed for completeness, level of critical thinking, and communication skills using an appropriate checklist. (BY1.05, BY2.04)
- Student lists (4) may be evaluated using a product rubric such as one found in Appendix A3. (BY1.06)
- Student hypotheses (8) may be assessed for completeness using an appropriate checklist. (BY1.05)
- Student reports (9) may be evaluated using a product rubric (Appendix A3). (BY1.05, BY2.05, BY3.01)
- Student reports may be evaluated using a product rubric (Appendix A3). (BY2.06, BY2.07)

Resources

Hummingbirds - Jewels of the forest (1991) Video available from Amazon.com

The Seedy Side of Plants. Available from WNET Video Distribution. 1-800-336-1917 or WNET Distribution, P.O. Box 2284, South Burlington, VT 05407

Web Sites:

Amphibian embryology tutorial - includes embryo development pictures.
http://worms.zoology.wisc.edu/frogs/mainmenu.html

Environment Canada amphibian page
http://www.cciw.ca/ecowatch/dapcan/

AI in horses
http://www3.ns.sympatico.ca/laexpress/repro/insemination.htm

birthing in horses
http://informatics4.vetmed.vt.edu/HostedSites/dascanio/Parturition/parturitionhp.html

AI techniques
http://informatics4.vetmed.vt.edu/HostedSites/create/createhp.html

Accommodations

See Accommodations in Activity 1 for general accommodations.

Activity 6: Issues and Challenges

Time: Integrated throughout the unit (10 to 15 minutes per day)

Description

This activity is a work in progress as the unit unfolds. It requires students to accumulate information on a daily basis as they complete two pieces of work. All students are required to complete a scrapbook consisting of relevant newspaper and magazine articles. In addition, students compile a science log and prepare a report focussing on the uses of the knowledge they have acquired.

Strand(s) and Expectations

Ontario Catholic School Graduate Expectations:

The graduate is expected to be: 1b,c,d,e,f,i; 2a,b,c,d,e; 3b,c,d,e; 4a,b,c,d,e,f,g; 5a,b,c,d,e,f; 6b; 7a,b,d,h,i,j.

Strand(s): Biology

Overall Expectations: BYV.01, BYV.02.

Specific Expectations: BY1.02❖, BY1.03❖, BY1.05❖, BY1.06❖, BY2.01 to BY2.08❖, BY3.03 to BY3.05❖.

Planning Notes

- This activity should be started on the first or second day of the unit. Teachers prepare an outline containing their expectations for the final product as per the assessment and achievement chart in the curriculum guide (e.g., format, references, layout, etc.).
- The science log component requires students to reflect on each day's lessons and comment on their understanding and their role as Catholic students. To assist them in their reflection, prepare suitable quotes from the *New Catechism* or Scripture. Contact the school chaplain for assistance.

Teaching/Learning Strategies

Scrapbook (to be completed by all students)

1. Students review the daily news for articles related to reproductive science. These may include human, animal, or plant science. Each article must be clipped, pasted into a scrapbook, summarized, and

appropriately referenced. Students must accumulate at least ten articles as the unit progresses. Articles can be news or editorial in nature. (At the teacher's discretion, if the public media does not have sufficient newsworthy items, students may be directed to the Internet.)

2. For each article students respond to a general question such as "How does the information discussed in the article relate to the material learned in class?"
3. Students submit their scrapbook for evaluation.

Science log

1. Students make entries into their science log at appropriate times throughout the unit. Some suggestions have been noted in the Teaching/Learning Strategies of each Activity. Entries should address questions such as the following:
   - What have you learned today?
   - How has knowing this information about reproduction changed the way we deal with living things?
   - What does the Church have to say about how this information is used?
   - Comment on the quote. Do you feel it is relevant in today's society? What does it have to teach us?
2. Students submit their science logs for assessment.

Report/Presentation etc.

1. Students may choose one of the following topics for research and presentation.
   - Aquaculture - the Cod Problem - Reproduction of Cod and the Atlantic fisheries;
   - The Salmon story - Reproduction and Life Cycle of Salmon and the Atlantic/Pacific fisheries;
   - Hybrid seeds - How are they created, and how do they improve the crop?
   - Genetically modified animal feeds - advantages/disadvantages, their creation, production, etc.;
   - In Vitro Fertilization - uses in animal husbandry;
   - Any other topic that relates to reproductive technologies for people, animals, and plants (with the teacher's approval).
2. Student reports include the following components;
   - a description of the technology/process/industry;
   - how knowledge of reproduction is used in the process (conservation, quotas, etc.);
   - current commercial uses;
   - Church's viewpoint where appropriate;
   - impact on the environment.
3. Student reports must include source material from each of the following:
   - text
     - Scientific journal
     - Magazine/News/Journal
     - Reference text
   - multimedia
     - CD-Rom/encyclopaedia
   - Internet
     - a variety of web sites have been suggested in this resource. Many are Canadian and have relevance to the topics discussed above.
4. Students prepare a formal written summary and a short oral/visual presentation of their work.

Assessment/Evaluation

All of the expectations listed above may be assessed and evaluated throughout this activity. Some expectations are more readily assessed with specific topics. This activity allows for student choice,

therefore assessment and evaluation strategies are only suggested. It is left to the teacher's discretion to determine which to assess/evaluate for each individual student. Evaluation rubrics may be found in the appendices and serve to assist in developing specific rubrics for individual activities.

- Teacher conferencing may be used to assess student progress with the scrapbook. A checklist may be used to ensure that students are meeting all the requirements.
- Teacher conferencing may be used to assess student progress with science logs. A product assessment rubric may be used to evaluate progress with the science log on an ongoing basis.
- A checklist and conferencing may be used to evaluate/assess student progress with the essay and report. It is suggested that clearly defined stages and deadlines for each stage be established in advance as warranted by the school's resources.
- A product evaluation rubric may be used to evaluate student scrapbooks, science logs, and essays. (BY1.02, BY1.03, BY1.05, BY1.06, BY2.01 to BY2.08, BY3.03 to BY3.06)

Resources

An extensive list has been supplied in the Unit Resources.

Accommodations

See Accommodations in Activity 1 for general accommodations.

Unit 4: Earth and Space Science: Space Exploration

Time: 27.5 hours

Unit Developer(s)

Gerry Fuchs, Hamilton-Wentworth CDSB
Robert Warren, Hamilton-Wentworth CDSB

Development Date: July 31, 1999

Unit Description

This unit is the culmination of the course, making students aware of the wonder and awe of God's creation. Students demonstrate an understanding of the formation, evolution, structure, and nature of our solar system and the universe. They design and conduct investigations into the appearance and motion of visible celestial objects. As a result of this unit, students describe how space exploration has contributed to our understanding of outer space, the Earth, and living things. Emphasis is placed on Canadian contributors to space explorations. Students reflect on the cost/benefit of space exploration as a societal issue - is it ethical to spend money in this way when poverty is so prevalent?

Strand(s) and Expectations

Ontario Catholic School Graduate Expectations: CGE 1a,d,f,h,i; 2a,b,c,d,e; 3b,c,d,e,f; 4a,b,c,d,e,f,g,h; 5a,b,c,d,e,f,g,h; 7a,b,d,e,f,g,h,i,j.
Strand(s): Earth and Space
Overall Expectations: ESV.01, ESV.02, ESV.03.
Specific Expectations: ES1.01 to ES1.05; ES2.01 to ES2.08; ES3.01 to ES3.04.

Activity Titles (Time + Sequence)

Activity 1	Introduction to Observing the Universe	375 minutes
Activity 2	Theories and Models of the Universe	225 minutes
Activity 3	The Planets and the Solar System	375 minutes
Activity 4	The Sun and Stars	300 minutes
Activity 5	Space Travel and Living in Space	375 minutes

Unit Planning Notes

This unit requires that students observe celestial objects. Teachers should allow sufficient time to make these observations in the event of any poor weather conditions that might limit observations. Some observations may be initiated before the unit is taught. To facilitate this, a letter describing possible observations could be sent home in order that parents might assist their children in making the observations. It would be wise to plan this unit during the winter months to provide for early evening viewing. If possible, teachers should try to contact local astronomy clubs that might provide assistance to students in making observations. It is also worthwhile to help students learn to recognize celestial objects by taking them to a planetarium or using computer simulations such as *Starry Night.* Teachers should help students become aware of creation spirituality and the Catholic perspective on the creation of the universe. Teachers should also identify instances where students may engage in scientific inquiry/experience that students could include in their ScienceWorld portfolio. (See Appendix B.) Teachers should try to make use of any current news items relating to space exploration that would make the topics of the unit more interesting and relevant. Items such as the launch of new space probes; the detection of comets, new planets, and new moons; or new advances in satellite technology would be useful.

Prior Knowledge Required

In the Grade 6 Earth and Space Systems unit, students studied the basic structure of the solar system and the major constellations. Students should have knowledge of basic terminology as it relates to objects in the solar system. Students should also have knowledge of the proper use of the library, computers, and the Internet for research work. A review of the ethical use of information from information technologies may be required.

Teaching/Learning Strategies

The teaching and learning strategies suggested in this unit include teacher demonstration, student experimentation, computer simulations of the view of the stars and the planets, student observations of space using binoculars or a telescope (if available), collaborative/co-operative groups, model building, library research, student presentations, personal interviews, and a variety of independent experiences called ScienceWorld activities. (See Appendix B.)

Assessment/Evaluation

In this unit, student achievement of the expectations is evaluated based on a variety of assessments, tools, and strategies. Assessment strategies used include: teacher-student conferences, formal teacher observations, roving conferences, peer conferences, self-and peer-assessment, pencil and paper assessment, student journals or logs of celestial observations, and wrap-up activities. Sample rubrics have been included for the science process, lab product, and generic product which may be adapted by teachers to assess and evaluate students. Rubric A3 is intended to be a framework from which teachers could develop specific rubrics to assess research projects and not to be used "as is." As well as using these assessments, the teacher may also wish to evaluate students through the use of a pencil/paper test, a culminating project, a laboratory activity design/practicum, and/or extension essay.

Resources

Print

Andrews, et al. *Science 10 An Introductory Study*. Toronto: Prentice Hall, 1987.

Candido, et al. *Heath Science Connections 10*. Toronto: D.C. Heath, 1988.

Hesser and Leach. *Focus on Earth Science*. New York: Merrill, 1989.

Hirsch, et al. *Science Explorations 10*. Toronto: John Wiley & Son, 1987.

Ritter, et al. *Science 9*. Toronto: ITP Nelson, 1999.

Rosen, S. *Science Workshop Series: Earth Science: Volume: The Universe*. Cambridge: Prentice Hall Ginn Canada.

SkyNews: The Canadian Magazine of Astronomy and Stargazing. Ottawa: National Museum of Science and Technology.

Wolfe, et al. *SciencePower 9*. Toronto: McGraw-Hill Ryerson, 1999.

Computer Software

Starry Night. Sienna Software Incorporated 1991-1998.

A variety of commercially prepared software is available through science suppliers such as Tangent, VWR, Boreal, Northwest, Fisher and Merlan.

Community

Royal Astronomical Society of Canada

McLaughlin Planetarium

Web Sites

http://www.inspire.ospi.
Athena site

http://www.wednet.edu.800/sci_edu.sg/ssc.html
Making an Astrolabe

http:/www.seds.lpl.arizona.edu/nineplanets/overview.html

http://science.nasa.gov/http://spaceweather.com/

http://solstice.crest.org/index.shtml

http://www.ase.org/educators/lessons/index.htm

http://zebu.uoregon.edu/1998/phys162.

html http://www.est.gov.on.ca/english/en/en_renew.ht

http://www.cco.caltech.edu/~newman/sci-faith.html

also NASA, JPL, Space Gate, The Planetary Society and the Canadian Space Resource Centre at www.spacenet.eybe.on.ca (many print and videotape resources are available for reproduction cost only)

Videotapes

Astronomy Images of the Cosmos Series: *Our Invisible Sun, Good Seeing*

Bill Nye the Science Guy Series: *Space Exploration, Planets*

Earth, the Environment and Beyond Series: *The Solar System, What are Stars?, The Sun*

Exploring Space Series: *The Solar System, The Origin of Modern Astronomy, Astronomical Instruments, The Sun*

Global Education Associates: *The Earth Covenant*

Activity 1: Introduction to Observing the Universe

Time: 375 minutes

Description

This activity introduces the students to celestial objects while allowing time for the teacher to assess prior student knowledge. Students collect and graph sunrise and sunset, moonrise and moonset, and moon phase data; conduct an event horizon activity; construct an astrolabe for measuring star positions; and research any constellations that are visible at the time. Communication and planning skills are incorporated in these tasks.

Strand(s) and Expectations

Ontario Catholic School Graduate Expectations:

The graduate is expected to be: 1i; 2a,b,c; 3b,c; 4a,b,d,f; 5a,b,e,g; 7b.

Strand(s): Earth & Space: Exploring Space

Overall Expectations: ESV.02, ESV.03.

Specific Expectations: ES1.01❖, ES1.03❖, ES2.01❖, ES2.02, ES2.03❖, ES2.05❖, ES2.07❖, ES2.08❖, ES3.02.

Planning Notes

- Ask students to collect sunrise/sunset and moonrise/moonset data about one week before the unit starts. (See Teaching/Learning Strategy 3 below.) It is important that the student obtains the

information from the same source, such as the newspaper or the Weather channel. Students should collect data over a seven-day period including the weekend. It may be necessary for the student to predict Sunday data because this information is often not reported. (An almanac provides this data if it is wanted but it is good to leave some gaps in the data so that students may see the possibility of interpolating the data between the collected information)

- Prepare a letter to be sent home to the parents explaining the outside observations that the student is expected to make. The Event Horizon Activity is a way to encourage parental involvement in their child's education.
- Preview the video *New Universe* (or another suitable video that encompasses the complete unit), which provides a good introduction to the unit.
- Preview *Starry Night* CD-ROM
- Keep a logbook, along with your students, of all astral observations. The teacher needs to keep a log because astronomical data is not static and changes monthly. The logbook should be a single bound notebook.
- Order the magazines *Sky and Telescope* or *SkyNews* (preferably both). *Sky and Telescope* has a monthly feature called "What's Up" which provides monthly information of what is observable in the night sky. Teachers must realize that this information is not static and must be reviewed for the month this unit is taught.
- The appropriateness of research topics may vary with the time of year and the astronomical events that are occurring.
- Star charts can be ordered from the science suppliers.

Prior Knowledge Required

In the Grade 6 Earth and Space Systems unit on Space, students studied:

- physical components of the solar system;
- the moon, its phases and its influence on Earth;
- the major constellations;
- how space is explored through the use of land-based telescopes, the Hubble telescope, and various space probes.

Teaching/Learning Strategies

1. Space terminology can be introduced by having students brainstorm "space words." Students can then create a vocabulary of terms with definitions and make their own word puzzles to reinforce the vocabulary. Accommodations may be needed for ESL/ELD students.
2. Students brainstorm questions concerning the collection of space data or the teacher may direct students to consider the questions, "How do astronomers collect astronomical data? What data or observations are made? How can these vast distances be measured and what units are to be used?" Students take an active role, in a small group setting, to organize themselves co-operatively to discover the answers.
3. Students make the following astronomical observations:
   a) Sunrise and sunset times (over a 7-day period). Note: Try to start the collection of this information at least seven days earlier so that graphs can be constructed in the proper time frame.
   b) Moon rise and moon set times over the same period.
   c) Moon phases that are visible during this seven-day period. Using a blank calendar template, a representative picture can be drawn and the student can extrapolate phases for the entire month. The students should discover proper terminology of moon phases.

4. Event Horizon Activity. Students may be taken outside and asked to draw a line representing the horizon. They then sketch what they see above this line. Doing this in the daytime with teacher supervision prepares the students for the same activity to be done at night at home. In this activity students are introduced to the terms: azimuth, right ascension and declination of a star. This activity can then be completed in the evening when constellations are easily observed; the student should record in his/her logbook the position of the constellation in the sky and time of observation. A sketch should also be made of the constellation with its name and the historical significance of its name. A student-made planisphere could be used in this portion of the activity. The *Starry Night* CD-ROM can be used as a substitute for the night sky if night observations are hampered by poor weather.
5. Students draw a bar graph of sunrise, sunset, moonrise, and moonset data and make predictions of missing data values from their graphs.
6. Students construct an astrolabe for measuring star positions at night. (See the astrolabe Internet reference.) Astrolabes are sold by supply houses such as Fisher Scientific. Students keep a nightly log of their observations. Further stellar explorations can be incorporated in a ScienceWorld activity.

Assessment/Evaluation

- Communication and co-operative skills may be assessed in the introductory brainstorming session using a teacher checklist. (ES1.01)
- Thinking/inquiry skills can be monitored for formative evaluation when students are developing their space questions.
- Performance assessment may be used to ensure that activity-based observations are carried out daily and that the student is obtaining the required data and cataloguing them in an effective manner. (T/L Strategies 3a, 3b, 3c). (ES2.02)
- The graphical product of sunset/moonset, etc., data may be assessed for knowledge/understanding using a product rubric (Appendix A3).
- (ES1.03, ES2.05, ES2.07)
- A logbook of astronomical observations should be monitored. An appropriate checklist or rubric may be used. (ES1.01, ES2.05, ES2.08)
- The construction of the student astrolabe and planisphere can be assessed for inquiry, application of technical skills, and use of tools or materials using an appropriate checklist. (ES2.07)
- A small summative test may be given to assess knowledge and understanding of astronomical terms and ideas.

Resources

Starry Night CD-ROM

Sky and Telescope magazine

SkyNews magazine

Star charts (available from Science equipment suppliers)

Web Sites

Athena; Earth & Space Science
http://inspire.ospi.wednet.edu: 8001

Astrolabe; Use and construction
http://www.sci-edu.sg/ssc/ssc.html

Amateur Astronomer
http://www.geocities.com/CapeCanaveral/Lab/6816
http://science.nasa.gov/newhome/headlines/ast15dec98_1.htm
http://www.spaceweather.com/http://www.sec.noaa.gov/
http://www.bell-labs.com/history/laser/

Accommodations

1. Where the student has an individual educational plan, IEP, modify this activity to meet the student's needs as outlined in the plan.
2. ESL/D students are given opportunities to demonstrate their learning by alternative means while written English is developing (spoken English, direct demonstration, and pictorial representation). At the same time, instruction in written, science-specific language continues.
3. For students with physical or learning impairments, classroom and laboratory activities are modified, if possible, to permit participation. Where possible, peers are encouraged to assist the student to permit participation in group and individual activities.
4. For the purpose of providing extensions and enrichment, students have opportunities to investigate the topics presented here in greater detail. Close collaboration between teacher and student is required to ensure appropriate enrichment opportunities.
5. Possible ScienceWorld ideas:
   - Students research the 12 zodiac constellations and why almost all ancient cultures have stellar references in their beliefs and writings.
   - Students determine which of the zodiac constellations can be observed during the time frame of this unit and position these constellations relative to each other in a large-scale diorama.

Activity 2: Theories and Models of the Universe

Time: 225 minutes

Description

In this activity, students reflect on their observations of the sky and attempt to explain the organization of celestial objects in their own theory of the universe (their personal cosmology). They consider the explanations of the arrangement of the sun, the moon, the planets, and the stars as proposed by other cultures, particularly those of Canada's First Nations. The Biblical story of creation is reviewed and considered as one possible explanation of the origin of the universe. The arguments for the Earth-centred or the sun-centred view of the solar system is discussed. Finally, modern theories of the arrangement of the universe and its origin are presented. The Big Bang Theory is presented as the current model of the origin of the universe.

Strand(s) and Expectations

Ontario Catholic School Graduate Expectations:

The graduate is expected to be:
CGE 1d,h,i; 2a,b,c,d,e; 3b,c,d,e,f; 4a,b,c,d,e,f,g,h; 5a,b,c,d,e,f,g,h; 7a,b,d,e,f,g,h,i,j.

Strand(s): Earth and Space:

Overall Expectations: ESV.01.

Specific Expectations: ES1.02❖, ES2.04❖, ES2.05❖, ES2.06❖, ES3.02❖, ES3.04.

Planning Notes

- Have available resources relating to various cultures and their creation stories.
- Several copies of the Bible should be available in class so that all students may be familiar with the Biblical account of creation.
- Teachers should discuss the "Galileo Controversy" with their Religious Education Department in anticipation of possible questions. Teachers may wish to refer to *The Age of Reason* by Will and Ariel Durant pp 600-612 for additional background reference.
- The video *The Origin of Modern Astronomy* or another appropriate video dealing with a modern view of cosmology may be shown.
- Reserve time in your school's library/resource centre and make the necessary arrangements with the teacher-librarian to have appropriate resources available.

Prior Knowledge Required

During the Grade 6 Earth and Space Systems unit on Space, the student studied:

- the physical characteristics of the solar system;
- the causes for night and day and the seasons;
- the relative motions of the earth, moon, sun, and planets.

(These items, particularly the last one, should be reviewed during this unit.)

Teaching/Learning Strategies

1. The class is divided into groups and asked to develop their own explanations, along with supporting arguments, for the arrangements of the planets and stars and their origin (cosmology). Students present their explanations to the class by means of diagrams either on the blackboard or on large poster paper. Alternatively students may model the motion of the celestial bodies by using themselves and their group to walk through the motion.
2. Students from various cultural backgrounds may be asked to research the cosmology of their ancestors. Alternately, students may be asked to research and present the cosmology of a variety of cultures such as various Aboriginal North American, Greek, Mayan, East Indian, Chinese or Japanese. All students should read and reflect upon the "Creation Story" as presented in the Bible. Teachers read The Creation Stories (Appendix C6).
3. A brief summary of the conflict between Galileo and the Catholic Church in the 17th century concerning the sun-centred and the Earth-centred universe may be presented by viewing the film "Galileo Galilei" from the series *The Renaissance: The Origins of the Modern West*. Statements by Pope John Paul II about this controversy may be found in "Origins: CNS documentary services" November 12, 1992 (Vol. 22: No.22).
4. A suitable video may be used to present modern cosmology, giving evidence for the outward motion of the stars through the red shift and the Big Bang Theory.
5. Students explore career opportunities in space science using the CD-ROM *Real Science: Volume 3: Careers in the Physical Sciences* or *Career Explorer*.
6. Students may wish to extend their knowledge by carrying out related ScienceWorld activities focussing on other theories of the formation of the universe.

Assessment/Evaluation

- The presentation by students about different cultural perspectives on the universe may be evaluated for communication using teacher observation. (ES2.04, ES2.05, ES3.02)
- The student's ability to describe theories of the origin and evolution of the universe is assessed for knowledge/understanding through a pen and paper quiz. (ES1.02, ES2.06)

Resources

Candido, et al. *Science Connections 10*. Toronto: D.C. Heath, 1988.

Real Science: Volume 3: Careers in the Physical Sciences CD-ROM.

Career Explorer CD-ROM.

Ritter, et al. *Science 9*. Toronto: ITP Nelson, 1999.

Wolfe, et al. *SciencePower 9*. Toronto: McGraw-Hill Ryerson, 1999.

The Creation Story, Appendix C6

Accommodations

1. See Accommodations in Activity 1 for general accommodations.
2. Possible ScienceWorld ideas:
   - Build models to represent alterative models of the universe.
   - Interview a member of another culture to present in their own words their image of the universe or that of their ancestors and either videotape or audiotape the interview for later presentation to the class.
   - Compare and contrast the hierarchical (God, people, and the Earth in that order) and the inter-connected (God at the centre with people, the Earth and the universe surrounding him emanating from him) cosmology models.

Activity 3: The Planets and the Solar System

Time: 375 minutes

Description

In this activity students are introduced to the nine planets, comets, asteroids, and meteors. Students are expected to have some detailed knowledge of each of the planets such as position, size, and physical characteristics. The students build scale models of the solar system. Planetary observations are made if possible.

Strand(s) and Expectations

Ontario Catholic School Graduate Expectations:

The graduate is expected to be: CGE 1i; 2a,b,c; 3b,c; 4a,b,d,f; 5a,b,e,g; 7b.

Strand(s): Earth & Space

Overall Expectations: ESV.01, ESV.02.

Specific Expectations: ES1.01❖, ES1.03❖, ES2.02, ES2.03❖, ES2.05❖, ES2.06❖, ES2.07❖, ES2.08❖, ES3.02.

Planning Notes

- Be aware of which planets are visible in the evening sky and the best time and location to view them. (This information can be found on the Internet, in *Sky & Telescope* magazine, or in the *Starry Night* CD.)
- Become familiar with the use of the planisphere.
- Collect information on past space probes, which probes have visited planets, which are currently in operation, and what probes are to be launched in the near future. Much of this information is available on the Internet.

- Become aware of the various planetary symbols used in star charts.
- Become familiar with the *Starry Night* CD or appropriate Java applets that provide simulations of planetary motions, orbital velocity, and retrograde motion. Computer printouts may be obtained to provide graphical and numerical analysis of orbital data.

Prior Knowledge Required

In the Grade 6 Earth and Space Systems unit on Space, students studied:

- some physical characteristics of both inner and outer planets, planetary motion, and the positions of the major constellations.

Teaching/Learning Strategies

1. Students organize the solar bodies in positions relative to the sun. The activity is carried out such that the students, in groups, cut out scale circles representing planet diameters and then position them, to a different scale, as to their position from the sun. This activity could also be done using students to represent the planets (they make a large diagram of the planet's symbol to hold) and have them develop, via discussion, a correct scale. This alternative should be done either in a long corridor or outside.
2. Students investigate the formation of our solar system and why the orbits of all planets, except Pluto, lie on a plane. Does this mean that Pluto is not really a planet? What planet is farthest from the sun today? Is it always Pluto? Students research the answers to these questions.
3. By observing computer simulations and tabulating positions of orbiting planets, students discover the following orbital characteristics of the planets: relative velocities, orbital times, orbital perihelion, and aphelion. Appropriate units for measuring distances in space are introduced (km, AU (Astronomical Unit), LY (Light Year)).
4. Students explore the concept of retrograde motion. Two students can be used to model retrograde motion. The students rotate around a central point (the sun) with the inner student traveling faster than the outer one. The inner, faster student videotapes the motion of the slower, outer student for half a cycle. When viewed, the tape shows that the slower student's motion is retrograde with reference to the walls. This demonstration is probably best done in a large room such as the gym.
5. Students, in small groups, investigate the physical and geochemical properties of the 8 planets, asteroids and comets (1 per group). Earth has been left out but teacher may include if he/she wishes. Students should be directed to get as current information as possible. Information in older texts may be incomplete or inaccurate. The most current physical and chemical data of the planets can be found on the Internet, in astronomy magazines such as *Sky & Telescope* and in CD-ROMs such as *Starry Night*. Each group designs a data table to record their information. The groups present their findings in a variety of ways including: multimedia presentation, research report, skit, trifold travel brochure, planetary newspaper or magazine, web page, or Triptik (coiled booklet of the type CAA gives out when you travel).

Assessment/Evaluation

- The product assessment rubric (Appendix A3) can be used to evaluate the opening investigations for communications and making connections. (ES1.01, ES2.06)
- Peer-assessment of science logs (note taking and summation of data) is done using collaborative rubric. Teacher carries out similar assessment using the same criteria. (ES2.02, ES2.03, ES2.04)
- Planetary modelling is assessed using the appropriate rubric. (ES2.05, ES2.07, ES2.08)

- Student project on assigned planet can be assessed for knowledge/understanding, inquiry, communications, and making connections using the product assessment rubric (Appendix A3). (ES1.03, ES2.08)
- Data chart rating scale is used on planet project to assess factual information. (ES2.04)
- Peer-assessment on presentation of planet and modelling project (ES2.06)
- Pencil and paper quiz may be used to assess knowledge and understanding.

Resources

Andrews, William A., et al. *Science 10 An Introductory Study*. Toronto: Prentice Hall, 1987.

Candido, et al. *Heath Science Connections 10*. Toronto: D.C. Heath, 1988.

Starry Night Deluxe CD-ROM has an online site called LiveSky to ensure that the CD is as current as possible.

Web Sites.

Astronomy Net
http://members.aol.com/stevehben/sastro.html

Athena: Earth and Space for K-12
http://inspire.ospi.wednet.edu:8001 excellent site for a jump off point for the planet project

NASA, JPL, and Goddard Space Center are a few general sites located through YAHOO

Accommodations

See Accommodations in Activity 1 for general accommodations.

Activity 4: The Sun and Stars

Time: 300 minutes

Description

This activity introduces the physical structure of the sun and the thermonuclear reaction that produces its life-giving energy. Students investigate solar and lunar eclipses as well as the effects on Earth of such phenomena as solar wind, solar flares, and sunspots. Students study the evolutionary life of a star, star types, and constellations. An introduction to the electromagnetic spectrum is a starting point for star analysis: how colour and temperature are related. The use of the Hertzsprung-Russell diagram to differentiate stars is introduced. Binary stars and stars with solar systems are identified and positioned in the celestial field. Students also use star charts to locate objects such as planets, constellations, and Messier objects in the sky. Students investigate galaxies, starting with our own - the Milky Way. They then learn to locate some of the more observable galaxies such as Andromeda in the field of constellations.

Strand(s) and Expectations

Ontario Catholic School Graduate Expectations:

The graduate is expected to be: CGE 1i; 2a,b,c,b,c; 4a,b,d,f; 5a,b,e,g; 7b.

Strand(s): Earth & Space

Overall Expectations: ESV.01, ESV.02.

Specific Expectations: ES1.01❖, ES1.03❖, ES1.04❖, ES2.04❖, ES2.05❖, ES2.06❖, ES2.08❖, ES3.03, ES3.04.

Planning Notes

- Plan a visit to a local planetarium or observatory, if possible. Otherwise, software such as *Starry Nights* or *Distance Suns* can be used to simulate star fields.
- Review the concepts of electromagnetic spectrum; star sequencing as related to size, colour, and temperature; and the Hertzsprung-Russell diagram. Suggest a variety of star types when assigning stars for students to investigate.
- Become familiar with star sequencing, constellations, and the names of common, easily-viewed stars and Messier objects
- Observe solar events as they occur.

Prior Knowledge Required

During the Grade 6 Earth and Space Systems unit on Space, the student studied:

- the major constellations and the origin of their names.;
- how to safely view the sun and some of its characteristics.

Teaching/Learning Strategies

1. Students construct a large-scale model of the sun. A variety of colours can be used to indicate temperature variations. Explain the meaning of thermonuclear fusion as the source of energy of the sun.
2. Stellar vocabulary is introduced and reinforced using word-puzzles.
3. Demonstrate the proper way to observe the sun, using a telescope or binoculars. The real image of the sun should always be projected onto paper, NEVER viewed directly through telescope or binoculars; blindness may result! See Safety Memorandum No. 19, April 20, 1994 (Ontario Ministry of Education and Training).
4. Students research solar wind, solar flares, and sunspots and the effect they can have on weather and certain modes of communication on Earth.
5. Sunspots may be safely observed using a telescope provided you never look directly at the sun. The real image of the sun should always be projected onto paper.
6. Flame colour is an indicator of temperature. Ask students to predict which is hotter, the orange flame of a burning candle or the blue flame of a welder's torch. Their conclusion can be used to introduce the classification of the stars according to colour, using the Hertzsprung-Russell diagram.
7. Each student could adopt a star from one of the constellations to research and present information about it in the format of a "Stellar Astronomy Conference". Possible research information about the star includes: relative brightness, type of star, position in the constellation, appropriate time of the year to view the star and constellation, and distance from the Earth. An index card format may be used by the student to tabulate their data in preparation for their presentation. Students then colour a scale model of their star according to its temperature, and on a class poster board paste it in its appropriate position (colour, temperature versus size, and brightness). This produces the Hertzsprung-Russell diagram.

Assessment/Evaluation

- The product rubric (Appendix A3) can be used to evaluate sun diagrams for knowledge and communication. (ES1.03, ES2.04)
- Teachers can evaluate student inquiry by observations of student participation in the laboratory-based activities using process rubric (Appendix A1). (ES2.08)
- Knowledge of vocabulary may be assessed using word-puzzles created by the class.

- Collaborative rubric (Appendix A4) can be used to assess research on solar wind, solar flares, and sunspot activity. (ES1.04)
- Students' written reports are collected and evaluated for knowledge/understanding, communication skills, and making connections using a lab product assessment rubric (Appendix A2). (ES2.05)
- Peer-assessment on presentations involving student's star project. (ES2.06)
- Knowledge/understanding is assessed by student-teacher conferencing or summative pencil and paper test.

Resources

Andrews, William A., et al. *Science 10 An Introductory Study*. Toronto: Prentice Hall, 1987.

Candido, et al. *Heath Science Connections 10*. Toronto: D.C. Heath, 1988.

Hesser and Leach. *Focus on Earth Science*. Merrill, 1989.

Ritter, et al. *Science 9*.Toronto: ITP Nelson, 1999.

Wolfe, et al. *SciencePower 9*. Toronto: McGraw-Hill Ryerson, 1999.

Internet sites: see previous activities

Accommodations

1. See Accommodations in Activity 1 for general accommodations
2. Possible ScienceWorld ideas:
   - Use Hubble space telescope data to define and provide examples of binary star systems. Hubble data may also be used to suggest that some stars have orbiting planets.
   - Investigate the location of our solar system in the Milky Way and star groupings in the Milky Way called clusters. This can lead to a discovery as to what type of galaxy the Milky Way is and, further, to the question "Are there other galactic formations?"
   - Research the work of Edwin Hubble who introduced the scientific community to what he called "island universes". Explore the different types of galaxies and how they are grouped in the universe. (**Note:** In order to locate galaxies students must be introduced to Messier cataloguing of deep space objects and their interpolation onto constellation star fields.)

Activity 5: Space Travel and Living in Space

Time: 375 minutes

Description

Through research and investigation, the students gain an understanding of how space exploration has had an effect upon their world. The students also consider the future of space exploration - Are future space settlements a possibility? Is the cost of continued space exploration justifiable in light of conditions that could be addressed on Earth such as homelessness, poverty, and poor medical care for much of the world?

Strand(s) and Expectations

Ontario Catholic School Graduate Expectations:

The graduate is expected to be: CGE 2b,c; 3c; 4a,b,d,e,f; 5a,b,e,f,g; 7b,j.

Strand(s): Earth and Space

Overall Expectations: ESV.03.

Specific Expectations: ES1.05❖, ES2.02, ES2.03❖, ES2.06❖, ES3.01❖, ES 3.03, ES3.04❖.

Planning Notes

- Collect information about the International Space Station or any new space probes that are being planned.
- Collect posters and pictures of various space satellites for reference from the Canadian Space Resource Centre or NASA.
- *Earth-Ocean-Atmosphere Explorer* CD-ROM contains information on satellite remote sensing technologies and applications that students could use as a reference.
- If students are expected to research a particular space probe or space mission they should be given advance warning and the opportunity to search the Internet for relevant information.
- If a debate is planned, the question to be debated should be given well in advance in order that students may research their position. Refer to Appendix D1 for information about debates and possible topics.
- Review the ethical use of the Internet and other research techniques.

Prior Knowledge Required

In the Grade 6 Earth and Space Systems unit on Space, students studied:

- the tools and techniques that humans use in space exploration;
- how astronauts meet their basic needs in space;
- problems arising from space exploration;
- the ways in which materials and technology for space exploration have led to the use of new technologies and materials on Earth.

Teaching/Learning Strategies

1. Students reflect upon any science fiction film dealing with space travel that they have seen (*Star Wars, Star Trek*, etc.) and identify the key reason that the film is set in space instead of on the Earth. If possible the teacher could collect clips from several science fiction films, particularly older ones that the students may not have seen, and show them as an introduction to the activity. Students could then compare travelling in space to travelling on Earth as presented in the films. Do they think these are reasonable representations of space travel? Are there any signs of things on Earth that have changed to reflect ideas or technologies presented in the older films? Has the image of space travel affected our life upon Earth? Students could reflect upon these questions individually and then join into groups of three or four and share their reflections with each other and with the class.
2. Students could be asked to identify as many artificial satellites of Earth as they can and to identify their function. This information may be found by checking the NASA site for a listing of satellites. Additional information may be obtained for any space probes that have been sent beyond Earth to view the planets or other celestial objects. Students may work in pairs to collect relevant information about the satellite or the probe such as its cost, size, launch date, and function and then share the information with the class in the form of a poster or a brief oral presentation.
3. The culminating task for this activity (and perhaps the whole unit) should be a debate of the value of space research for people given its tremendous cost and uncertain value to people on Earth. This can be made immediately relevant by focussing on the International Space Station and the costs involved in its construction and Canada's involvement in it. Teachers should refer to Appendix D1 for information concerning debate procedures and evaluation.

Assessment/Evaluation

- The teacher observes the presentations of students reflections performed in Strategy 1 for communication and making connections using the collaborative rubric (Appendix A4). (ES2.06, ES3.01)
- The teacher assesses the poster or research presentation about satellites for knowledge/understanding and communication using a modification of the product assessment rubric (Appendix A3). (ES1.05, ES2.04)
- The debate may be assessed for inquiry, communication and making connections by means of the process and product assessment rubrics (Appendices A3 and A4). Also refer to Appendix D1 for possible scoring sheets for use in assessment/evaluation of debates. (ES2.03, ES2.06, ES3.01)

Resources

Andrews, et al. *Science 10 An Introductory Study*. Toronto: Prentice Hall, 1987.

Candido, et al. *Heath Science Connections 10*. Toronto: DC Heath, 1988.

Various web sites such as The NASA Homepage (http://www.nasa.gov/) or the Canadian Space Resource Centre (http://www.spacenet.eybe.edu.on.ca)

Appendix D1, Debate Procedures and Evaluation

Accommodations

1. See Accommodations in Activity 1 for general accommodations.
2. Possible ScienceWorld ideas:
    - Students could be asked to propose a future satellite or space probe that they think would be worthwhile. They should try to justify whether the probe should have people on board or just robots. They should present reasons for including or excluding humans from the space probe. (They should consider the needs of humans and the needs of robots in order to function in space.)
    - Students could also propose uses for the International Space Station.

Appendix C4: A Catholic Perspective on the Applications of Science: Guiding Principles (Teacher) Bioethics

The new reproductive technologies have ushered in an era of increasing ethical complexity. There are more than thirteen different technologies available in order to enhance, artificially, the probability of having a baby. Anyone attempting to unravel the ethical complexities, from a secular philosophy, is doomed to the uncertainty of relativism.

The Catholic church has a clear set of teachings in the area of human sexuality and the human person. These teachings, through their reflection on the mysteries of Creation, Incarnation and Redemption, present us with criteria based on the Truth of what it means to be fully human. As such, they provide all Catholic teachers with a set of criteria from which to evaluate the new reproductive technologies.

There are essentially two criteria for moral judgment: The first is the life of the person who is called into existence. The second is the special nature of the transmission of life. For the purposes of this article one could consider the first criterion as being associated with the post-conception period and with issues around respect for human embryos. The second criterion is associated with the conditions leading up to conception and the meaning of the conjugal act.

Once a human person is called into existence (at the moment of conception) he/she has certain inviolable rights based on human dignity and unity. Every human person has an inalienable dignity because each is a reflection of the Creator. We were made in the image of God (Genesis 1:27) and as such are of inestimable value and worth. Every human person has certain rights. These rights include the right to be seen as an end and not a means to another end; the right to life; the right to be conceived and carried in utero; the right to family. Any violation of these rights constitutes a violation against the inherent dignity of the person and is morally unacceptable.

The calling of a human person into existence is an act that co-operates with the power of the Creator. Life is a gift from God and always finds its origin in God. The human person by his/her very nature should always seek to promote goodness, unity, and integrity. The conjugal act is not one that can be separated from the integrity of the person. Based on the two creation accounts in Genesis, the conjugal act finds its meaning in its procreative and unitive dimensions (Genesis 1:27-28, 2:24). Reproductive technologies that willfully remove the procreative dimension for the sole purpose of avoiding conception diminish the meaning of the conjugal act as an open expression of the life-giving love of the Creator. This is morally unacceptable. The unitive dimension of the conjugal act is expressed both physically and in its totality as the fruit of marriage. Any attempt to separate the corporal and spiritual components of the act from each other or from the indissoluble bond of marriage diminishes the dignity of both the act and the persons involved in the act. This, too, is morally unacceptable.

Ultimately all the new reproductive technologies can be analysed in terms of their procreative and unitive dimensions. Extra-utero fertilization, surrogacy, embryo transfer, intrauterine insemination, gamete intrafallopian transfer, zygote intrafallopian transfer, intracytoplasmic sperm injection, egg donation, embryo donation, cytoplasmic transfer, egg freezing and nuclear transfer are all violations of the unitive dimension of the conjugal act. A number of these technologies are also used in a manner that is a violation of the created person's right to family. In addition, all experimental procedures involving the fetus, other than those interventions that are therapeutic, are a moral violation of the dignity, integrity, and unity of the human person.

Appendix C5: A Catholic Perspective on the Applications of Science: Guiding Principle (Student Guide) Bioethics

The Catholic church has a long tradition of teaching within the sphere of human sexuality. These teachings have focussed on the dignity of the whole human person. All of these teachings guide us in the direction of the preservation of life. When we talk about the preservation of life we are referring to more than physical life, we are also speaking of the integrity (physical, spiritual, emotional, intellectual, and social dimensions of being human) of the life of the person. To be fully alive is to be alive in all the various dimensions of our humanity. If any of these dimensions are ignored then it brings a "partial death" to the whole person.

Science and technology are the fruits of human intelligence and as such reflect the goodness of the Creator. However, because we have been given free will by our Creator, it is possible to use science and technology in ways that are sinful. Any use of science or technology that does not use a good means for a good end is considered unholy and morally wrong.

When we analyse the contributions of science and technology to the human race, we must ask some fundamental questions. Are these technologies life-giving to the whole person? Are these technologies life-giving to all human persons affected by the procedures? If the answer to either of these questions is no, then the technologies are unholy (lack life-giving benefit to the whole person or persons involved). Technologies or procedures that are unholy are not morally acceptable.

Not all technology is unholy. There are many technologies that are therapeutic (restore the health of the person) and as such are life-giving and morally acceptable. The key question that needs to be asked in the case of therapeutic technologies is: what is the risk to the life of the person involved? If the risk of death is greater than the chance of life then the procedure may not be justifiable. Often, in these cases, the proper religious and medical personnel need to be consulted before a decision is made.

For the purposes of this course we can evaluate the value of a particular action from two criteria. The first is with respect to the purpose and goodness of sexual intercourse. The act of sexual intercourse has two fundamental purposes: the first is to create life (procreative dimension) and the second is to express the love between a man and a woman (unitive dimension). Any technology whose purpose is artificially to prevent procreation diminishes the value and goodness of the sexual act. In addition, any technology that separates conception from sexual intercourse also diminishes the value and goodness of the sexual act. These technologies are morally unacceptable.

The second criterion applies to human life from the moment of its conception. At the moment of conception a human person is formed. This person, who is made in the image and likeness (dignity) of God, has the right to be respected as a completely whole (holy) and indivisible person (unity and integrity). Each person has a soul (spirituality) and a body and as such is a good in him/herself. A person must never be used as a wrong means for another good (using aborted human fetuses for experimentation).

Appendix C6: The Creation Stories

As teachers of science from a Catholic perspective, we are often faced with the “either/or” type of question from our students - which is correct, the Bible or Science? Our students seem to view the truths of the Bible and Science as being mutually exclusive. To view the world in this way is to have a fundamental misunderstanding of the two types of truths and the methods by which these truths are conveyed. Science searches for its truth through empirical methods. Religion searches for its truth through revelation and reason. The convergence of both disciplines on a common phenomenon can create the “either/or” dilemma in the minds of our students. The Creation stories are a case in point.

When students recognize the truths of both religion and science within a common phenomenon, they add meaning to knowledge. The Biblical account of creation is a story told to explain the meaning of the universe. The scientific account of creation is a theory on the material origin of the universe.

There are two creation stories in the Bible. Each emphasizes a different meaning in creation. It is important to realize that these two accounts of creation are narratives and, as such, contain religious truths in allegorical form. The first creation story was written in the Priestly tradition in the sixth century B.C.E. Its emphasis was on a single God who created the universe. God created order and goodness. God also created man and woman in his own image. In this story humankind was given dominion over creation. As Science teachers, we can appreciate the close parallel between the order of creation in a story written 2600 years ago and our modern scientific understanding of the order of evolution. The second creation story was written by the Yahwist (who referred to God as Yahweh) in the ninth century B.C.E. This story represents God as being more personal and intimate with creation. The imagery used in the story is that of a gardener. It is from this story that we get the notion of “stewardship,” as man and woman are to cultivate and care for the garden (life). The human person is given a special status in this story. God forms “man” out of the soil of the earth (Adam - meaning 'of the earth'; Eve - meaning 'life') and breathes life into “him.”

Many people subscribe to the theories of the "Big Bang" and evolution. As teachers of Science from a Catholic perspective, we can teach both theory and meaning. Neither the Big Bang nor evolution theory provides an answer to the fundamental questions of human existence. In a secular culture, which trivializes all forms of religious beliefs and culture, students could fall victim to the malaise of our time, which is despair. Despair means without hope. When we teach Science from a Catholic perspective, we lead our students out of the despair of meaninglessness toward the hope of our salvation.

Appendix D1: Debate Procedures and Evaluation

Introduction

In this unit the students are given the opportunity to research, think about, analyse and discuss various controversial issues related to space travel and colonization. They further discuss the moral and ethical perspectives of the issues, by means of engaging in a formal debate

1. Group Structure and Debating Timetable
   - Two teams, each made up of two students, will debate the topic. One team speaks in support of the resolution and the other one speaks against it.
   - Two other students are assigned to work with each team to research and compile background information required to formulate a strong case for the position that the team is defending.
   - The remaining students in the class act as the jury. In preparation for their role in the debate, they also should research in order to understand the science and their responsibilities behind the issues raised.

2. The Audience Role
   - Audience members are not able to talk to the debaters while the debate is occurring, but ask questions during the question-answer session after the debate.

3. The Debater Role
   - Each debater is required to submit, to their teacher, a neatly printed or typewritten copy of their speech. The speech includes a bibliography that cites the sources for all factual information contained in the speech.
   - Debaters must also be prepared to cite their sources if asked during the debate.

4. Order of Debate
   - The debate is called to order once both debaters, both researchers and all audience members are assembled. The teacher acts as timekeeper and judge.
   - First affirmative speech of six minutes
   - First affirmative is questioned by negative side for three minutes. (Please note that either of the negative members may ask a question by raising their hand. The speechmaker decides which questioner to select.)
   - First negative speech for six minutes
   - First negative is questioned by affirmative side for three minutes.
   - Second affirmative speech for six minutes
   - Second affirmative is questioned by negative side for three minutes.
   - Second negative speech for six minutes
   - Second negative is questioned by affirmative side for three minutes.
   - Debate is called to an end by the judge.
   - Audience question/answer period for five minutes. (Audience members may ask questions of either side by raising their hand and identifying who the question is directed to.)
   - Debate session ends. (Debaters shake hands with each other and the judge.)

Appendix D1: Debate Procedures and Evaluation (Continued)

5. General Information
    - Encourage students to obtain their information from as many different sources as possible, both from within the school and without, including local libraries and other community sources.
    - The school library, religion department, and social sciences and science departments are a good starting point for help in the search for information. Also, don't forget the Internet!
    - Students are required to explore all areas of study that pertain to your resolution: technical, scientific, moral, ethical, religious, and legal.
    - Students may use props during the debate. References, books, posters, pamphlets, photos, video clips, or any other paraphernalia that might help persuade others that one side is right may be brought to the debate.

    Let's make these debates incisive, stimulating, intellectual, and fun!
    Good Luck!

Debating Skills

- Points should be well organized. The strongest points go to the beginning and the end.
- Do a “dynamic” introduction.
- Make sure that your points are supported by evidence.
- Take notes when your opponents are speaking. Find weaknesses.
- Speak with confidence and a loud, clear voice.
- Avoid getting rattled, angry, or visible shakes by your opponents.
- Beware of arguments that appeal to pity and play on people's feelings.
- The artful sense of humour can win over your audience.

Other Possible Astronomy Debate Resolutions

Debate resolutions are written as positive statements with "be it resolved that" (BIRT) preceding the statement.

BIRT governments should continue to fund space exploration.

BIRT life forms exist beyond planet Earth.

BIRT space should be used as a waste disposal site for earth.

BIRT UFOs have visited the earth.

BIRT the universe will expand forever.

BIRT Pluto is a planet.

BIRT Earth's moon was formed when a large asteroid collided with the earth.

BIRT the Earth will collide with an asteroid in the future.

BIRT there is enough dark matter to close the universe.

BIRT there is only one universe.

BIRT animals should be sent to Mars before humans.

Appendix D1: Debate Procedures and Evaluation (Continued)

Debate Evaluation

Affirmative Team
Group #_____
First Affirmative_____
Second Affirmative_____

Negative Team
Group #_____
First Negative_____
Second Negative_____

CATEGORY	PTS	1st AFF.	2nd AFF.
Organization & Strategy	10		
Evidence	10		
Delivery	10		
Refutation	10		
Question & Discussion	10		
Sub Total	50		
Total	100		

CATEGORY	PTS	1st NEG.	2nd NEG.
Organization & Strategy	10		
Evidence	10		
Delivery	10		
Refutation	10		
Question & Discussion	10		
Sub Total	50		
Total	100		

Win or Loss
_____

Win or Loss
_____

Judge's Comments: 1st Affirmative
Judge's Comments: 2nd Affirmative

Judge's Comments: 1st Negative
Judge's Comments: 2nd Negative

Appendix D1: Debate Procedures and Evaluation (Continued)

Judges Debate Comments:

Delivery: • good tone, good speaking voice • avoid reading • good voice projection • enthusiastic delivery • indignant • expressive body language • good gesturing	• articulate • too dependent on notes • good eye contact • good intonation (lack of) • authoritative • composed, poised • persuasive
Content: • effective • organized, sequenced • creative • well researched • good analogies • attempted to squirrel resolution • negative team did not refute opponent's arguments	• well defined resolution • logical reasoning • valid fact • logical conclusion • excellent authorities • require more evidence to support resolution
Answering: • thoughtful, confident • lacked conviction • no questions please • clarified and stretchered argument	• concise, articulate • confusing, evasive • no speech making
Questions: • questions only • persistent • avoid personal questions • direct questions related to opponent's speech • strengthened arguments	• carried questions through to logical conclusion • be sure to quote opponent correctly • no speech making • do not interrupt • logical questions
Rebuttal: • refuted opponent's argument • no new information • spoke with confidence and authority	• emphasize the strengths of your position • summation of own arguments • respectful tone
Miscellaneous: • emotional appeal • persuasive arguments • reasoning: specific to general (vise versa)	• comparison and/or contrast relevant (irrelevant) • convincing arguments • make your points more clearly

Appendix D2: JIGSAW ACTIVITY- The Process of Mitosis

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The process of mitosis may be introduced to students through the following jigsaw activity:
Students are placed in groups of five, where each student represents one phase of mitosis. This group is known as the **HOME GROUP**. Each of these students is asked at specific times to leave their home group and enter into an **EXPERT GROUP**. The expert group is comprised of one student from each of the home groups. Individuals in this group are responsible for becoming the experts in the particular topic or task given.

The following is an example of how the jigsaw method could be used to introduce each phase of mitosis.

MITOSIS

All living organisms, from bacteria to the most complex animals and plants, grow and reproduce by processes taking place at the cellular level. Following a period of growth, cells reproduce by dividing. In this division the cell's DNA sequences are copied exactly and passes on to daughter cells.
In this activity you discover the processes involved when cells divide. Most cells follow a common pattern when dividing. This is a co-operative activity and is divided into two parts. In Part A each student is assigned a particular stage in a cell's life cycle to explore and become an expert on. Following this, in Part B, each student is placed back into their home groups and presents the knowledge they gained about their stage. When Part B is completed each student has a comprehensive understanding of how cells divide.

Materials: text, other resources, pipecleaners, chalk, tape, etc.

PART A: (EXPERT GROUPS)

1. Each student is assigned to one of the following expert groups:

(1) interphase (2) prophase (3) metaphase (4) anaphase (5) telophase

2. All students in each group meet and have a set time to do the following:
   (a) define the following terms:

INTERPHASE DEFINITIONS:	CHROMOSOMES, G1, G2, CHROMATIDS
PROPHASE: DEFINITIONS:	CHROMATIDS, CENTRIOLE, SPINDLE FIBERS, CENTROMERES
METAPHASE DEFINITION:	EQUATORIAL PLATE, SPINDLE FIBERS, CENTRIOLE
ANAPHASE DEFINITIONS:	CHROMATIDS, DAUGHTER CHROMOSOMES, POLES
TELOPHASE DEFINITIONS:	CELL PLATE, CYTOKINESIS, FURROW, DAUGHTER CELLS

   (b) make a sketch of what is happening in this phase when four chromosomes are present;
   (c) write a brief description of the major events of this phase.

Appendix D2: JIGSAW ACTIVITY- The Process of Mitosis (Continued)

PART B:

1. Students form new groups of five students. These groups must have one student from each of the five phases investigated in part A. (HOME group).
2. Students present their information in the appropriate order to the other members of this group. All students must make notes on all the phases.
3. As part of the group report each member must prepare a visual representation (model) of the phase they presented. Pipe-cleaners or other materials are used to represent the four chromosomes.

Evaluation: (possible rating scale)

Group Work:	
- Part A:	1 2 3 4 5
- Part B:	1 2 3 4 5
- individual report	1 2 3 4 5 6 7 8 9 10
- individual model	1 2 3 4 5