Tth′ën (Dëne)

Acâhkosak (Cree)

The Night Sky

Shaun Nagy

La Loche Community School
La Loche, SK, Canada

A unit in the series:

Rekindling Traditions:
Cross-Cultural Science and Technology Units

Series Editor

Glen Aikenhead
University of Saskatchewan
Saskatoon, SK, Canada

CURRICULUM CONNECTION

Grades 8-11, astronomy

OVERVIEW

Aboriginal cosmology is validated through learning about the night sky from an Aboriginal point of view. This provides the context for learning astronomy concepts from Western science. Both knowledge systems, Aboriginal and Western, are explicitly acknowledged. Experiential learning is highlighted in both domains in this unit. Duration: about 2 to 3 weeks.

FUNDING

The CCSTU project was funded through a partnership among:

Cameco Access Program for Engineering and Science (CAPES)

Northern Lights School Division

Île-à-la-Crosse School Division

Saskatchewan Education (Northern Division)

Stirling McDowell Foundation

College of Education University of Saskatchewan

REKINDLING TRADITIONS PROJECT TEAM

TEACHERS:

Gloria Belcourt	Minahik Waskahigan School, Pinehouse Lake Unit: *Wild Rice*	
Morris Brizinski	Valley View School, Beauval Unit: *Nature's Hidden Gifts*	
David Gold	Rossignol School, Île-à-la-Crosse Unit: *Snowshoes*	
Keith Lemaigre	La Loche Community School, La Loche Unit: *Trapping*	
Shaun Nagy	La Loche Community School, La Loche Unit: *The Night Sky*	
Earl Stobbe	Timber Bay School, Timber Bay Unit: *Survival in Our Land*	

FACILITATOR / COORDINATOR*:*

Glen Aikenhead — College of Education, University of Saskatchewan

ELDERS:

Henry Sanderson	La Ronge
Ann Lafleur	Beauval
Alec Campbell	Beauval

TABLE OF CONTENTS

page

Purpose 1

Goals 1

Objectives 2

Background Information 3

Acknowledgement 5

Lessons

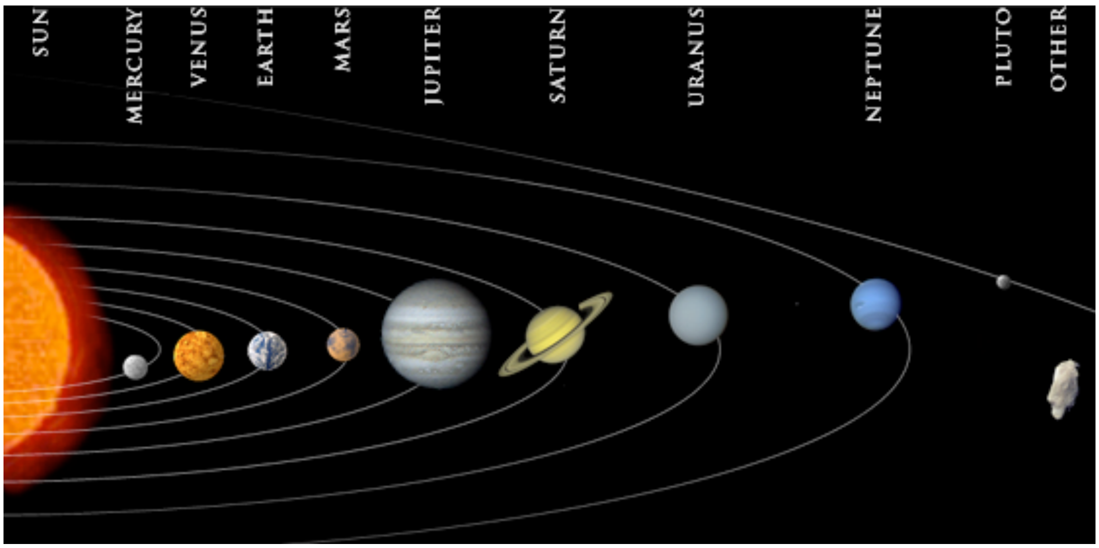
1. Interview With an Adult 6
2. The Calendar is Made 8
3. The Earth's Moon 11
4. The Universe 13
5. Seeing Through a Telescope 16
6. Life on Earth 19
7. The Spherical Earth 20
8. Why do Stars Twinkle? 22
9. Falling Star Scavenger Hunt 23
10. The Birth/Death Cycle of Stars 24
11. The Northern Lights 26
12. A Quick Tour of Our Solar System 28
13. Review 31

Appendix A Aboriginal Calendars

Appendix B A Short History of Calendars

PURPOSE

This unit is designed to enrich students' understanding and appreciation of Aboriginal science and Western science in the area often called astronomy, and to encourage students to continue their studies in school science in the future. The unit offers experiences for students to practice thinking in two worlds – the world of Aboriginal culture and the world of Western culture; thereby helping students feel more comfortable using ideas they may not believe themselves, but ideas they nevertheless can certainly understand and use to converse with others.



GOALS

1. To develop confidence in interviewing elders, working independently, understanding Western science, and expressing personal ideas and beliefs.
2. To gain knowledge of both Aboriginal and Western science concepts about the night sky.
3. To appreciate the wealth of knowledge held by elders of different cultures.
4. To become familiar with technologies such as calendars, internet, lenses, and telescopes.
5. To appreciate that the circle of life extends beyond the earth.
6. To answer students' common curiosities about the night sky.
7. To develop a habit of keeping up to date on current discoveries in the universe.
8. To get students to interact with their environment and their community.
9. To introduce students to career possibilities related to science and engineering.

OBJECTIVES

1. Students will develop their listening and remembering skills.
2. Students will learn how the year is divided into 13 moons, according to observable events related to the Moon; or can be divided into 12 months, according to assumptions about base 12 in mathematics.
3. Students will learn the 13 moons in Dëne and their English translation.
4. Students will analyse visual evidence about the Moon and make inferences about its motion around the Earth.
5. Students will be able to describe or role play the counter clockwise motions of the rotation of the Earth, the revolution of the Moon around the Sun, and the revolution of the Earth/Moon around the Sun.
6. Students will be able to explain how we see various phases of the Moon at different times, and explain the *infrequency* of lunar and solar eclipses.
7. Students will remember key aspects of our universe from the Western science cultural point of view.
8. Students will be able to describe how a telescope works, including such features as: (a) refraction of light, (b) focal length, (c) the equation: magnification = f_p/f_e
9. Students will write a short newspaper article for the *Pisa Press* about Galileo.
10. Students will describe one mystery about the night sky.
11. Students will appreciate various chemical, astronomical, physical, and biological factors that sustain life on our planet.
12. Students will describe evidence for the historical interest in the shape of the Earth.
13. Students will remember reasons for the view that the Earth is basically spherical.
14. Students will be able to explain the phenomena of twinkling and falling stars.
15. Students will collect evidence of meteoroids, and wonder where the material came from.
16. Students will remember that only 3 metals (iron, nickel, and cobalt) interact with a magnet.
17. Students will remember the type of matter that makes up plasma (positively and negatively charged fundamental particles: protons, electrons, etc.).
18. Students will be able to repeat the science story of northern lights.
19. Students will be able to describe one interesting feature of each planet in our solar system, and about the Sun.

BACKGROUND INFORMATION

The Dëne word "Tth′ën" (or the Cree "acâhkosak") strictly means stars; but is used as the title of this unit because the Dëne translation of "the night sky" is seldom used in La Loche and the word happens to sound similar to the Dëne word for "lice." The English word "astronomy" relates singularly to the context of Western science. The English title of this unit, "The Night Sky," seems to be a phrase encompassing both "astronomy" and "Tth′ën."

An historical overview of the development of calendars is found in Appendix B. This overview is particularly important for Lesson 2. Appendix B contains information on ancient, Julian, Gregorian, and other calendars. Appendix A discusses Aboriginal calendars that are based on a completely different way of knowing about the world. Examples of Aboriginal calendars are included.

This unit provides teachable moments that allow students to learn the idea that concepts in science and technology (e.g. the workings of a calendar) emerge from the culture of those people who develop the concept in the first place. Western science emerged from Euro-American culture. On the other hand, Aboriginal science emerged from First Nations cultures. This bicultural point of view underscores the validity of your community's Aboriginal knowledge of nature. In short, all knowledge is culture-bound.

Western science information related to this unit is found in standard physics textbooks, science resources (some are listed below), and web sites on the internet:

1. information about the motion of the Earth's Moon (Lesson 3).
2. information about our solar system, galaxy, and the universe (Lessons 4, 11, and 12).
3. information about optics and telescope technology (Lesson 5).
4. information about falling stars (Lesson 9).
5. information about the life and death cycle of stars (Lesson 10).
6. information about the four states of matter: solid, liquid, gas, and plasma. Plasma is material in space emitted from stars, some of which interacts with molecules in our atmosphere to cause the northern lights (Lesson 11).

The sequence of lessons is not rigid. Change the order of the lessons to suit your own purposes. For example, Lesson 5 (Seeing Through a Telescope) could come prior to Lesson 2 ("The Calendar is Made"), thereby giving students time to interview an adult (homework related to Lesson 1) before you begin Lesson 2.

Resources

Books:

Dëne Stories, by Margaret Reynolds, 1979, from the Saskatchewan Indian Cultural College, Federation of Saskatchewan Indians: Saskatoon.

Stars and Planets: A Visual Guide to the Night Sky, by Ian Ridpath, 1998, from Stoddart Publishing. ISBN 0-7737-5991-3.

Keepers of the Night, by M.J. Caduto & J. Bruchac, 1994, from Fulcrum Publishing. ISBN 1-55591-177-3.

Foundations of Astronomy, by M.A. Seeds, 1992, from Wadsworth Publishing.

Powers of Ten: About the Relative Size of Things in the Universe, by Philip Morrison and Phylis

Morrison, 1982, from Scientific American Books, ISBN O-7167-1409-4.
National Geographic Picture Atlas of Our Universe, by Roy A. Gallant, from National Geographic Society, Washington DC. Use the latest edition.
13 Moons on a Turtle's Back. (Alberta Science Council's "Science in a Crate" series.) Calgary, Alberta.
Northern Lights - Their heritage and science, Asgeir Brekke & Alv Egeland (ISBN 82-504-2105-1)
Aurora - The Mysterious Northern Lights, Candace Savage (ISBN 0-87156-374-6)

Academic References for Calendar Information:
Bernal, J.D. (1969). *Science in History*. Vol. 1. Cambridge, Mass: MIT Press.
Borst, Arno. (1993). *The Ordering of Time: from the Ancient Computus to the Modern Computer.* Chicago : University of Chicago Press.
Clagett, M. (1955). *Greek science in Antiquity*. New York: Collier Books.
Duncan, D. E. (1998). *Calendar: Humanity's Epic Struggle to Determine a True and Accurate Year*. New York: Avon Books.
Encyclopedia Britannica – On Line.
O'Neil, W. M. (1975) *Time and the Calendars.* Sydney: Sydney University Press.
Philip, A. (1921). *The Calendar: Its History, Structure and Improvement*. Cambridge: Cambridge University Press.
Richards, E. G. (1999) *Mapping Time: The Calendar and Its History*. New York: Oxford University Press.

Articles:
Sawyer, K. (1999). Unveiling the Universe. *National Geographic*, October (pp. 8-41). Most important is the map *The Milky Way* that accompanies the issue. The map situates phenomena in the Milky Way as seen by someone outside our galaxy. Pictures are amazing.
Kelly, I.W., & Culver, R. (1996). The Moon was full and nothing happened: A review of studies on the Moon and human behaviour and human belief. In T. Genoni (Ed.), *The Outer Edge*. CSICOP: Box 703, Amherst, NY.
Pappalardo, R.T. et al. (1999). The hidden ocean of Europa. *Scientific American, 281* (Oct.), pp. 54-63. Excellent pictures of Jupiter's moons, especially Europa.

Videos:
Galileo on the Shoulders of Giants, HBO (1998).

Software:
StarFinder II: Astronomy Software, Meade Instruments.

Web Sites:
www.nationalgeographic.com/solarsystem
www.seds.org/billa/tnp
www.astro.uva.nl/demo/sun Virtual tour of the Sun.
http://near.jhuapl.edu/iod/20000213b/index.html Exploration of astroids,
http://photojournal.jpl.nasa.gov/ NASA's photos from space exploration.
http://www.uit.no/npt/nordlyset/nordlyset.en.html northern lights
http://ecotourism.about.com/travel/ecotourism/msubnlimages.htm?iam=mt Connection to many sites

for northern lights.
http://encarta.msn.com The on-line Encarta Encyclopedia.
http://oposite.stsci.edu/pubinfo/latest.html Latest Hubble Space Telescope Observations
http://astronomydigest.com Commercial on-line magazine.
http://nssdc.gsfc.nasa.gov/ Makes many connections to photo galleries and information.
http://image.gsfc.nasa.gov/poetry/activities.html Some activities about solar storms etc.

ACKNOWLEDGEMENT

I would like to thank Walter Park (Dëne Language Consultant) and Albertine Piché (Counsellor at La Loche Community School) for their aide in translating information and contacting Elders. Special thanks to the Elders: Eugene Sylvestre (Turner Lake), Rose Tanvier (La Loche), and others who wished to remain anonymous, for their time and for sharing their stories.

I would also like to thank our sponsors for their funding which allowed this project to succeed.

Lesson 1: *Interview With an Adult*

Timing
1 class for a short introduction and preparation for interviewing;
time outside of class for the interview;
1 class debriefing (after a few days).

Goals
1. To develop confidence in talking to older people.
2. To become oriented to some Aboriginal knowledge of the night sky.

Objectives
1. Students will acquire Aboriginal knowledge of events seen in the night sky.
2. Students will develop interviewing skills.
3. Students will develop their listening and remembering skills.

Aboriginal Value to be Conveyed
obedience, respect for traditional knowledge

Instructional Strategies
independent learning, interactive

I. Introduction to "Tth′ën" (The Night Sky)
1. Display photographs of heavenly bodies (our universe, galaxies, nebulas, star clusters, stars, patterns of stars in the heavens, solar system, Moon, planets, moons of other planets, comets, shooting stars, northern lights, etc). Elicit from students what they understand about these bodies and events. When valid scientific facts are remembered by students, accept them as stories of the peoples of Western Europe.
   What other things in space have you heard about (for which we have no photograph)? List them on the board.
2. Get students, in small groups, to write down what they find mysterious about the night sky (things and events). Let these mysteries define the topics of high interest to the class.
3. To establish a framework about knowledge of the night sky, read one or two First Nations stories from *Keepers of the Night* (e.g. "The Birth of Light," pp. xvii-xxii; or "Oot-Kwah-Tah, The Seven Star Dancers"), or from *Dëne Stories*.
4. Explain to the class that there are many good stories that people in the community know because they heard them from the old people, who themselves were told by their grandparents, etc. Let students know that this unit will include those stories, and that the students are to discover what some of those stories are.

II. Lesson Outline (interview preparation, if not done in a previous unit**)**
1. Discuss with the class appropriate ways to approach and interview old people, some of whom may be Elders, giving special attention to showing respect for their knowledge about the night sky.
   a. Discuss the protocol of giving gifts to Elders. In La Loche, a basket of treats is appropriate. The baskets can be purchased or made by the students.
2. Assign students into groups so they know who they will be working with as they interview an older person..

3. Discuss the most appropriate method the class should use to organize the interview, paying attention to how we show respect for the people interviewed. Here are several organizational suggestions:
   a. Send students to the person's home, by appointment, during the school day.
   b. Let students choose an old person (an Elder possibly) and interview them.
   c. Invite old people (including Elders) for a special afternoon at the school organized by the students. Snacks and activities, in addition to interviewing, should be provided.
4. Develop a class example of an interview schedule (set of questions). Here is an example:
   a. What interesting events have you seen in the night sky in your life?
   a. What in the night sky interests you or is a mystery to you (e.g. light itself [what is it, where does it come from?], stars, pattern of stars, a particular star, the Moon, the motion of the heavenly bodies, falling stars, northern lights, etc)?
   b. What stories did the old people tell about that mystery?
   c. Do I have your permission
      a. to tell the story to my class at school?
      b. to write the story down to share with other students in other schools?

III. Lesson Outline (interview debriefing)

1. Let students share the stories they brought back from the interviews, the ones for which they have permission to repeat.
2. Add other stories from other Aboriginal nations (see references in the Background Information section).
3. Establish the idea that the stories make sense out of things and events in the night sky, and at the same time, help people know how they should treat other people and how they should respect Mother Earth.
4. Arrange to have a class booklet of these stories made as a textbook for the course.

CELs / Subject Integration: personal and social values and skills, communication, Native Studies

Resources

Philip & Phylis Morrison. (1982). *Power of Ten.*
Margaret Reynolds. (1979). *Dëne Stories.*

Teacher Notes

- Use local protocol. For example, the school’s counsellor or Elder committee chair person may be the appropriate way to approach the Elders and ask if they have stories to offer, as well as if they would be willing to come into the classroom for discussions. Official people at the school are the ones to ask for information about who to contact and what gifts are appropriate.

Lesson 2: *The Calendar is Made*

Overview
The calendar is introduced from the point of view of two different cultures, beginning with the Dëne's traditional 13-moon calendar, and then moving explicitly to Western culture (the developmental history of the Julian and Gregorian calendars with their 12-month years). Dëne and Western European cultures have powerful stories to tell about the night sky. The stories from Western science are known as "astronomy." There are two lesson outlines: an Aboriginal perspective and a Western science perspective.

Timing
1 to 3 classes, depending on the amount of detail you want students introduced to.
This can take place before the debriefing of Lesson 1.

Goals
1. Technologies for keeping track of time are related to the culture in which those technologies are invented.
2. Knowledge of the night sky has social power.

Objectives
1. Students will learn how the year is divided into 13 moons, according to observable events related to the Moon; or can be divided into 12 months, according to assumptions about base 12 in mathematics.
2. Students will learn the 13 moons in Dëne and their English translation.
3. Students will become familiar with:
   a. (optional) the invention of our Julian and Gregorian calendars (their developmental history),
   b. how these calendars are related to observable events of the Sun and stars, and
   c. how this knowledge (observable, predictable events) gives social power to those who possess it.

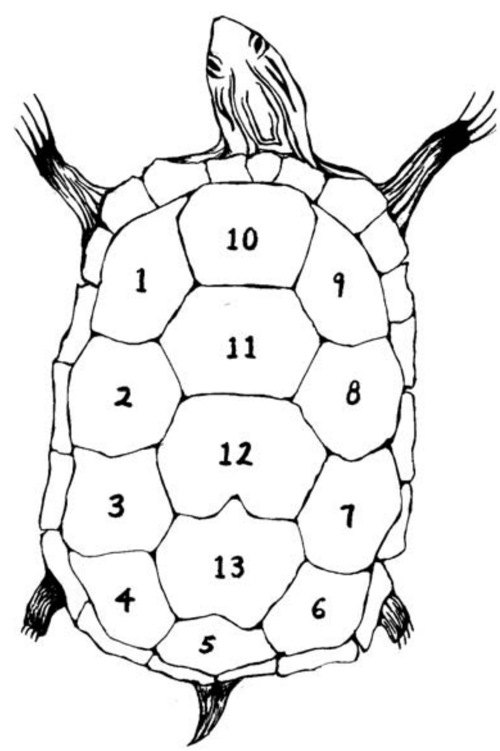


Figure 1. 13 sections on a turtle's back

Instructional Strategies
direct, interactive

Lesson Outline (Aboriginal Perspective)
1. Remind students of the significance of the turtle to some North American Aboriginal peoples.
2. Introduce students to the thirteen sections on a turtle's back (see Figure 1). Hand out two copies per student of a turtle's back without the numbers (see figure on page 10). Have students fill in the 13 moons in Dëne in one figure, and in English in the other figure. Have a year calendar that shows when the 13 full moons appear in the current year. Locate the Dëne 13 moons on this calendar. (Dëne and Cree calendars are found in Appendix A.) Encourage students to relate

what they know about seasonable events in La Loche that coincide with the 13 moons of the year. In doing so, get students to use Dëne as much as possible, to help them learn the correct names of the moons of the year. (This activity is loosely based on *Thirteen Moons on a Turtle's Back*, Alberta Science Council.)

3. Let students know when their first quiz on the Dëne calendar will be written.
4. Compare the Dëne moon calendar with a Cree moon calendar.

Aboriginal Value to be Conveyed
ideas are linked to cultural assumptions

Lesson Outline (Western Science Perspective)
1. Go over the Gregorian calendar and its relation to the movement of the Sun (solar cycles).
2. Clarify some differences and similarities between an Aboriginal perspective and a Western science perspective as they arise in Lesson 2.
3. As a story teller, relate the developmental history of the Julian and Gregorian calendars (see Appendix B), paying attention to cultural assumptions, e.g. the base 12 number system, and tribal, Mesopotamia or Egyptian mythologies.

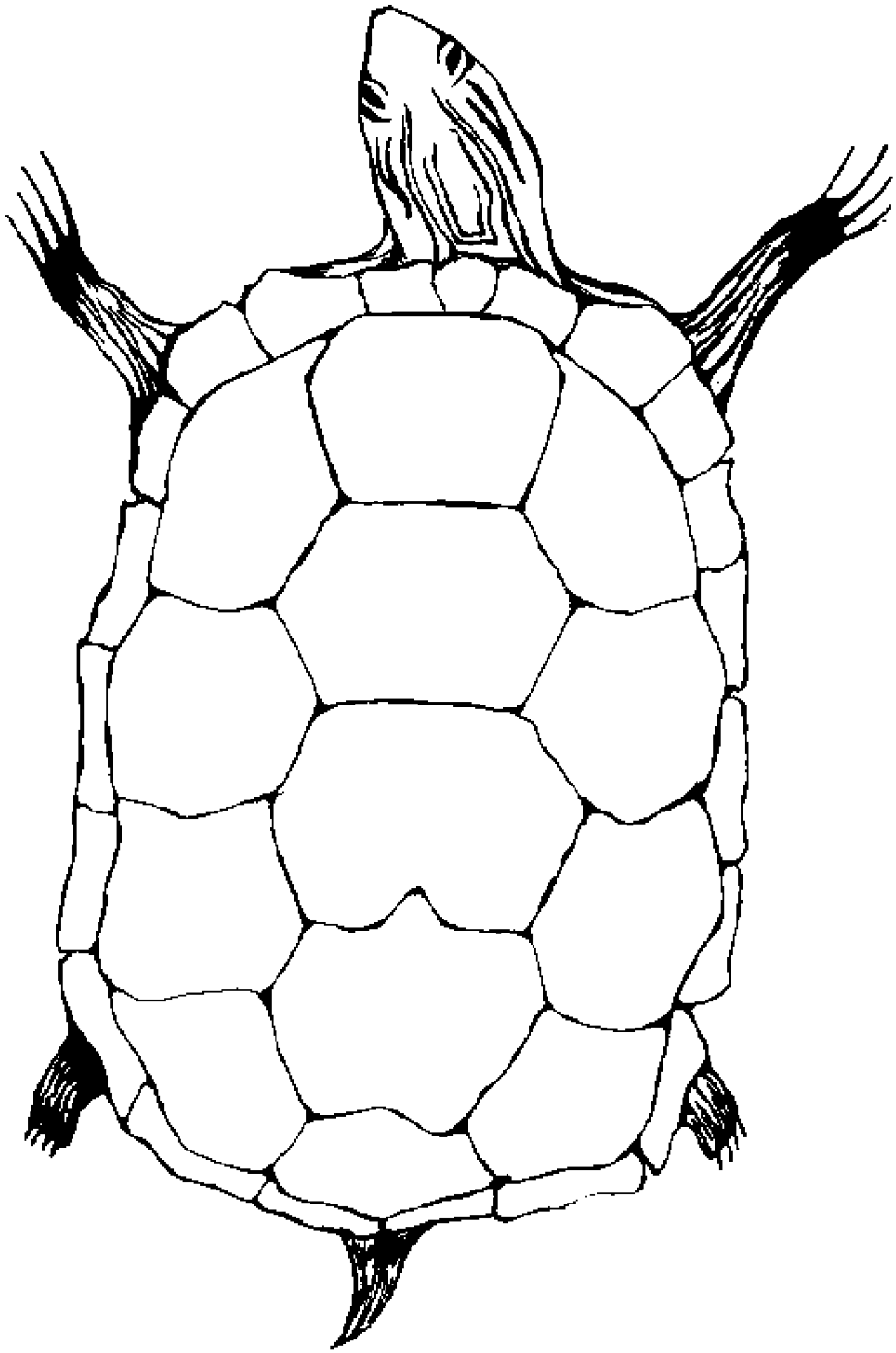
Scientific Value to be Conveyed
ideas are linked cultural assumptions

CELs / Subject Integration: technological literacy, Native Studies, Social Studies

Resources
Appendix A
Appendix B
2 copies turtle diagram for each of your students (see the following page)

Teacher Notes
! Duplicate turtle diagram.
! Review with students the problem of distorting 13 moons into 12 months, described in Appendix A, page 1. (That is, the problem of further colonization of Aboriginal peoples.)

13 Moons on a Turtle's Back



Lesson 3: *The Earth's Moon*

The Moon blocks out the Sun (solar eclipse)

Timing
1 or 2 classes, depending on the emphasis you wish to give this topic.

Goals
1. To validate both Aboriginal and Western scientific knowledge about the Moon.
2. To become familiar with the Moon's motions and its appearance to those on earth.

Objectives
1. Students will contrast the nature of evidence acceptable in the culture of Western science (systematic, independent verification) with the nature of evidence acceptable in the culture of the everyday world (anecdotal evidence; e.g. astrology – optional activity), and with the nature of authority acceptable in Aboriginal cultures.
2. Students will analyse visual evidence about the Moon and make inferences about its motion around the Earth.
3. Students will contrast 2 frames of reference for a lunar cycle: 29-day cycle referenced to the Earth and the 27-day cycle referenced to the Sun.
4. Students will be able to describe or role play the counter clockwise motions of the rotation of the Earth, the revolution of the Moon around the Sun, and the revolution of the Earth/Moon around the Sun.
5. Students will be able to explain how we see various phases of the Moon at different times, and explain the *infrequency* of lunar and solar eclipses.

Scientific Values to be Conveyed
information must be able to be verified by others before a fact is accepted by the group

Instructional Strategies
direct

Lesson Outline
1. Discuss how the full Moon is associated with bad or evil behaviour. Explain the terms “lunatic” and “lunacy.”
2. Review legends about the Moon. Include the description of how Christian religions determine the date of Easter Sunday each year: the 1st Sunday after the 1st full Moon that follows the spring equinox.
3. Discuss the evidence for believing the Moon travels around the Earth counter clockwise (from west to east). For instance, observe the Moon on consecutive days at the same time of day and you'll observe that the Moon has moved substantially eastward. Also, observe the Moon and a nearby star or planet at night over a 2 or 3-hour period. Both the Moon and the star travel from east to west of course (due to the rotation of the earth), but compared to the “fixed” star or planet, the Moon moves slightly eastward during that 2 or 3 hour period. As shown in Figure 2, the Moon's counter clockwise movement around the earth is in the same direction as the Earth's counter clockwise

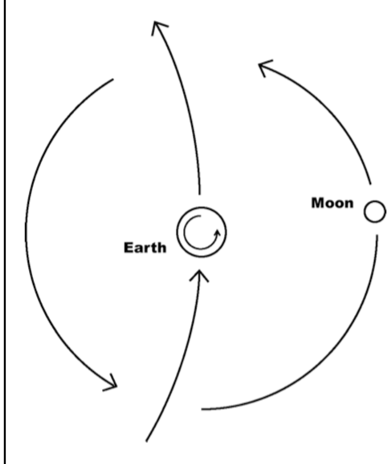


Figure 2. Earth and Moon motion

movement around the Sun, and in the same direction as the Earth rotates on its axis. Other evidence for the Moon's counter clockwise motion comes from watching the direction in which the eclipse of the Sun or the eclipse of the Moon takes place.

4. Contrast the appearance of the full Moon every 27 days with the Moon's actual orbit around the Earth (relative to the Sun) every 29 days. What are the implications for the number of Moons in the year, using both figures (27 and 29)?
5. Get students to role play the Earth-Sun-Moon system to show how we see phases of the Moon from earth.
6. Explain the science story of the Moon's orbit. Its orbit defines a plane (Moon-Earth plane). This plane is at an angle to the plane defined by the Earth's orbit around the Sun (Earth-Sun plane). As the Moon revolves around the earth, the Moon is most often either above or below the Earth-Sun plane; and therefore the Moon is seldom lined up in a 3-dimensional straight line with the Earth and Sun; which means that lunar and solar eclipses are infrequent events. Use props and student role play to act out this explanation of eclipses.
7. (OPTIONAL) Do a scientific investigation on the accuracy of astrology predictions. Cut out yesterday's astrological forecasts deleting the astrological sign associated with a forecast. Cut and paste these on a sheet of paper in random order. Number them 1 to 12. Photocopy a sheet for each student. Get students to write at the top of the page their name and the “sign” they were born under. (However, eliminate from the activity any student who remembers what yesterday's forecast was for them.) Then have them pick the astrological description which best describes the day they had yesterday. Next identify which “sign” is associated with which numbered forecast. Then collate how many students picked the “correct” forecast, and how many did not. This evidence is scientific because it was a “blind” test. Results always show that the number of “correct” astrological picks is very similar to random chance of picking one's “sign” without reading the description in the forecast.

CELs / Subject Integration: Geometry

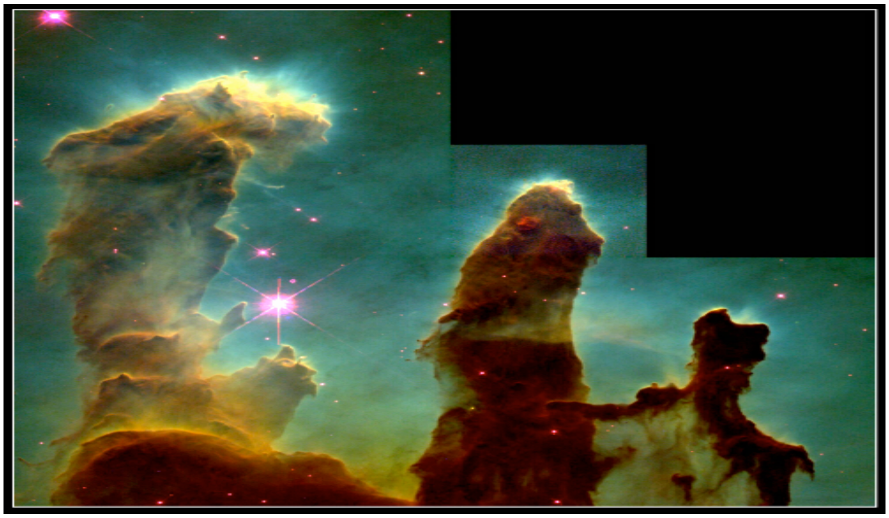
Resources

Physical props: light bulb for the Sun, volleyball for the Moon, globe for the Earth, etc.
Photographs of the Moon in different phases.

Teacher Notes

- You might want students to keep track of the position of the Moon in the day/night sky over a period of time, in order to establish evidence for the claim that the Moon travels from west to east with respect to the Earth, even though we see it go from east to west nightly/daily.
- You might want to review for students the scientific evidence that shows no association between the appearance of a full Moon and unusual human behaviour. See Kelly and Culver's 1996 article, referenced in the Background section to the unit.

Lesson 4: *The Universe*



The Eagle Nebula. Clouds of hydrogen gas in interstellar space.

Timing
3 or more classes, depending on the detail you want to go into at this time. (More information on the solar system will be introduced in Lesson 12.) One class is dedicated to working on a report.

Goal
To map out the astronomy content of the unit.

Objective
Students will remember key aspects of our universe from the Western scientific point of view.

Scientific Value to be Conveyed
a scientist has the desire to explain everything, leaving as few mysteries as possible.

Jupiter

Instructional Strategies
direct

Lesson Outline
1. Present a lecture/demonstration/role play that outlines and defines some key aspects of our universe, according to the stories of Western science:
   - planet as a wanderer in the night sky;
   - planet as a body revolving around a star, various types of planets in our solar system;
   - asteroids as chunks of, perhaps, a disintegrated planet;
   - the Sun as a close star (categories of stars according to size); the furnace that makes atoms and spews out stuff ("plasma" – the 4^{th} state of matter) in the process;
   - moon as a body revolving around a planet; some of the moons in our solar system;
   - solar system as the collection of bodies around a star;
   - comets as wanderers in and out of our solar system;
   - stars as different sizes and different ages (birth and death of stars); supernova;
   - nebula;
   - galaxies (various types);

An asteroid (space craft photo)

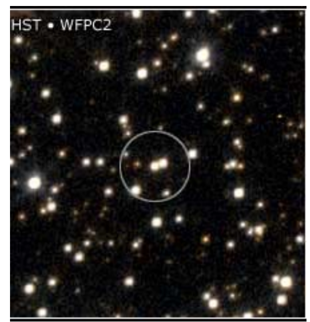
  - speed of light;
  - time/space warp (the farther into space you look, the further back in time you see)
  - curved space; black holes;

2. Have students divide into pairs and give each pair a book to research a given topic and write a one-page report on that topic. (Be guided by the mysteries students identified in Lesson 1.) Specify your expectations of the style/genre of writing.

CELs / Subject Integration: communication, Language Arts

A comet

A nebula that might form a solar system



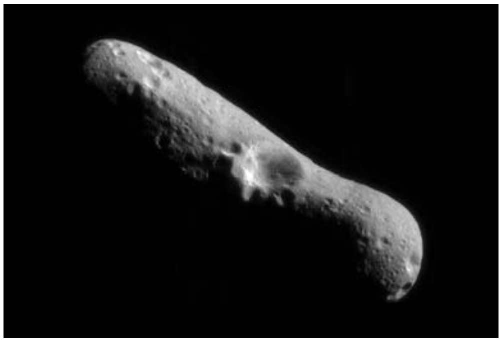
Evidence for a black hole, photo from the Hubble telescope.

Two colliding spiral galaxies seen through the Hubble telescope

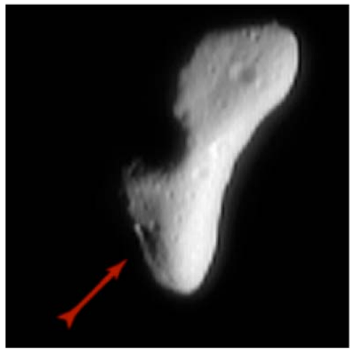
Resources

Visual aids to make the scientific ideas as concrete as possible
See the resource section in Background; e.g. *Power of Ten*, and National Geographic articles.

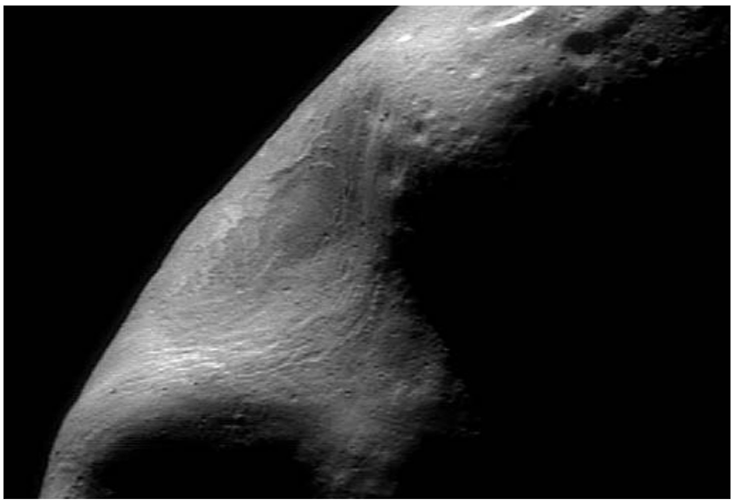
Internet web sites:
http://photojournal.jpl.nasa.gov/ NASA's photos from space exploration.
http://near.jhuapl.edu/iod/20000213b/index.html Exploration of asteroids.
http://encarta.msn.com The on-line Encarta Encyclopedia.
http://oposite.stsci.edu/pubinfo/latest.html Latest Hubble Space Telescope Observations
http://oposite.stsci.edu/pubinfo/SubjectT.html Same site, but organized by topic
http://astronomydigest.com Commercial on-line magazine.
http://nssdc.gsfc.nasa.gov/ Makes many connections to photo galleries and information.
http://image.gsfc.nasa.gov/poetry/activities.html Some activities about solar storms etc.
.



Asteroid Eros (photo from the NEAR space craft)

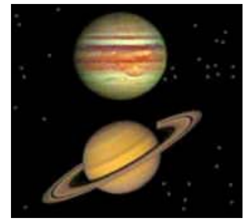


Asteroid Eros. Do you see the heart-shaped indentation? (Valentine photo, Feb 14, 2000)



Eros (photo close up)

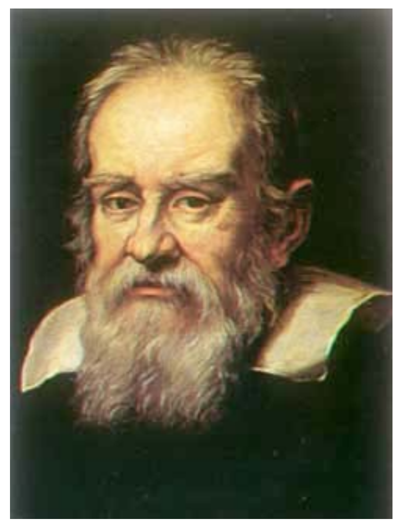
Lesson 5: *Seeing Through a Telescope*



Timing
3 classes, plus 1 evening

Goals
1. To become familiar with the science of optics.
2. To make a personal connection (via personal observations) to objects in space.

Objectives
1. Students will be able to describe how a telescope works, including such features as:
   a. refraction of light
   b. focal length
   c. the equation: magnification = primary focal length divided by eyepiece focal length = f_p/f_e
2. Students will learn some of the tribal Greek constellations (still used today in astronomy) on a need to know basis, as they use the telescope to local objects in the night sky. (The constellations act as points of reference. Indigenous constellations will work even better, though reference books will have the tribal Greek constellations.)
3. Students will write a short newspaper article for the *Pisa Press* about Galileo.



Galileo Galilei

Scientific Value to be Conveyed
express ideas in the language of math

Instructional Strategies
direct, indirect

Lesson Outline (Day 1)
1. Set up a telescope in class. Let students look at an object out the window.
2. Explain how light is refracted by lenses giving the illusion of the object being closer (magnified).
3. Discuss the most important features of the telescope:
   a. LGP comparison is diameter squared
   b. magnification = f_p/f_e
   c. we change the telescope magnification by changing the eyepiece.
4. Work through some sample problems, calculating comparable LGP and magnification.
5. Give students work sheets to practise speaking/writing math in the culture of science.
6. Arrange for evening viewing times, weather permitting.

Lesson Outline (Day 2)

1. Hand out optical bench kits, and a procedure for students to follow to get a concrete experience of focal lengths and how closely the magnification equation describes what students measure on the optical bench. (See example below.)
2. Have the students hand in their labs for assessment.

Lesson Outline (Day 3)

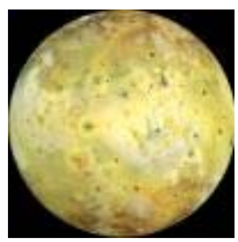
1. Show the video *Galileo on the Shoulders of Giants*.
2. Have students individually write a paragraph about an aspect of Galileo that is of most interest to them.

Lesson Outline (Evening Viewing)

1. Gather binoculars and the school's telescope, invite interested people from the community including parents, and set up an evening of night sky watching on a site away from electric lights on a clear evening.
2. Print out star charts from StarFinder II astronomy software so students can anticipate what there is to see and where to find it in the night sky.
3. Have students organize ahead of time ways to consult reference material in the dark (flashlights with red cellophane over the front) and to record what they observe (pre-planned observation charts). The red cellophane provides light for people to find their way and to look at a star chart, but doesn't interfere much with viewing the night sky.
4. The evening can be a successful social event as well as a memorable learning experience, if you wish.

CELs / Subject Integration: personal and social values and skills, Language Arts, Math

Europa



Io

Jupiter and its moons

Ganymede

Callisto

Resources

telescope, binoculars, flashlights

Stars and Planets: A Visual Guide to the Night Sky is a good reference book, showing when planets are visible at what times of the year etc.

StarFinder II astronomy software,

optical bench kits,

math problems to solve,

Galileo on the Shoulders of Giants video,

(The trial of Galileo is in Chapter 6, “The Starry Messenger,” in *The Ascent of Man* by J. Bronowski. This is a different type of resource – more intellectual.)

Internet: search for “Galileo Galilei” and you’ll find many different kinds of sites.

Teacher Notes

- Students who are hunters will be experts at adjusting the scope mechanism on the telescope.
- Set up telescope ahead of time.
- Check that all optical bench kits are complete.
- Borrow *Galileo on the Shoulders of Giants* ahead of time from a teacher.
- Fix flashlights with red cellophane over the front, and check their batteries.

Lesson 6: *Life on Earth*

Timing
1 class. Limit class time to only 1 period so the discussion does not extend itself into a full unit.

Goal
To give students a chance to express their beliefs about life in other parts of the universe.

Objectives
1. Students will describe one mystery about the night sky.
2. Students will appreciate various chemical, astronomical, physical, and biological factors that sustain life on our planet.

Scientific Value to be Conveyed
events in nature are interrelated

Instructional Strategies
interactive (group discussion)

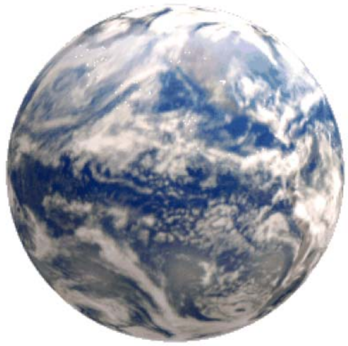
Lesson Outline
1. Listen to the mysteries of the universe that students describe, and follow up on those related to life on earth.
2. Get students to express opinions on the existence of life on other planets in our solar system, and in the universe.
3. Describe the scientific components needed to support life on planet Earth: temperature range, atmosphere, liquid water, organic and inorganic molecules, stable Earth orbit, Moon cycle, solar energy, Jupiter's contribution to controlling the asteroid belt, etc.

CELs / Subject Integration: communication, personal and social values and skills; Biology

Resources
Your background knowledge. If you have a good resource, please inform the *Rekindling Traditions* editor, Glen Aikenhead, who will update the unit with your information.

Teacher Notes
! Discussion on origins of life and the universe is planned as part of the review, Lesson 13.

Lesson 7: *The Spherical Earth*



Timing
1 class

Goal
To appreciate the original arguments and evidence for believing in a spherical earth.

Objectives
1. Students will describe evidence for the historical interest in the shape of the Earth.
2. Students will compare the diameter of the Earth measured two ways: around the equator and around the poles.
3. Students will remember reasons for the view that the Earth is basically spherical.

Scientific Value to be Conveyed
evidence needs to be interpreted before it has meaning in science

Instructional Strategies
direct

Lesson Outline
1. Review any legends about the shape of the Earth.
2. Brainstorm evidence and arguments for our belief that the Earth is almost spherical. Relate the story of how Aristotle reasoned the Earth must be spherical, and Hipparchus (who I refer to as “Mr. H”) and Erosthenes estimated the diameter of the Earth about 2000 years ago, a value quite close to the value used today.
3. Review the renaissance estimation/calculation of the diameter of the Earth. Christopher Columbus decided to use the more recent estimation (the one much smaller than today's calculation) to decide how long his voyage would take. Would he have gone on the voyage had he used the more “correct” figure (Mr. H's calculation)?

CELs / Subject Integration: Social Studies

Resources
Seeds, M.A. (1992). *Foundations of Astronomy*. Belmont, CA: Wadsworth.

Teacher Notes
! Aristotle (around 350 BC) travelled to different cities and countries to view the lunar eclipse (a big event prior to TV and video games). He noticed that wherever he viewed the lunar eclipse the Earth’s shadow cast upon the Moon was always round. He concluded that the only way the Earth could cast a round shadow in all directions is if it were spherical.
! Eratosthenes, while working in the great library in Alexandria around 200 BC, learned from some traveller’s that the city of Syene (Aswan) contained a well into which sunlight shone vertically (straight down) on the day of the summer solstice (first day of summer when the Sun is at its

highest point in the sky). In other words, on the summer solstice the Sun was directly above the city. On the same day in Alexandria, Erosthenes noted the Sun was not directly above, and he estimated it was off by 1/50 the circumference of the earth. Today we measure this angle as 7° (see Figure 3). Since the Sun was a great distance away, its light rays must be parallel to each other, Erosthenes assumed. He concluded that the Earth must be curved, and that the distance from Syene to Alexandria must be 1/50 the circumference of the Earth. By getting an approximate measure of the distance from Syene to Alexandria from travellers and by multiplying by 50, Erosthenes was the first to calculate the circumference of the Earth. His calculation was about 41 000 km, only 4% too large.

! Hipparchus lived around 150 BC and also used angles of the Sun and stars to produce many measurements. He was even able to determine that the Earth processes, like a toy top.

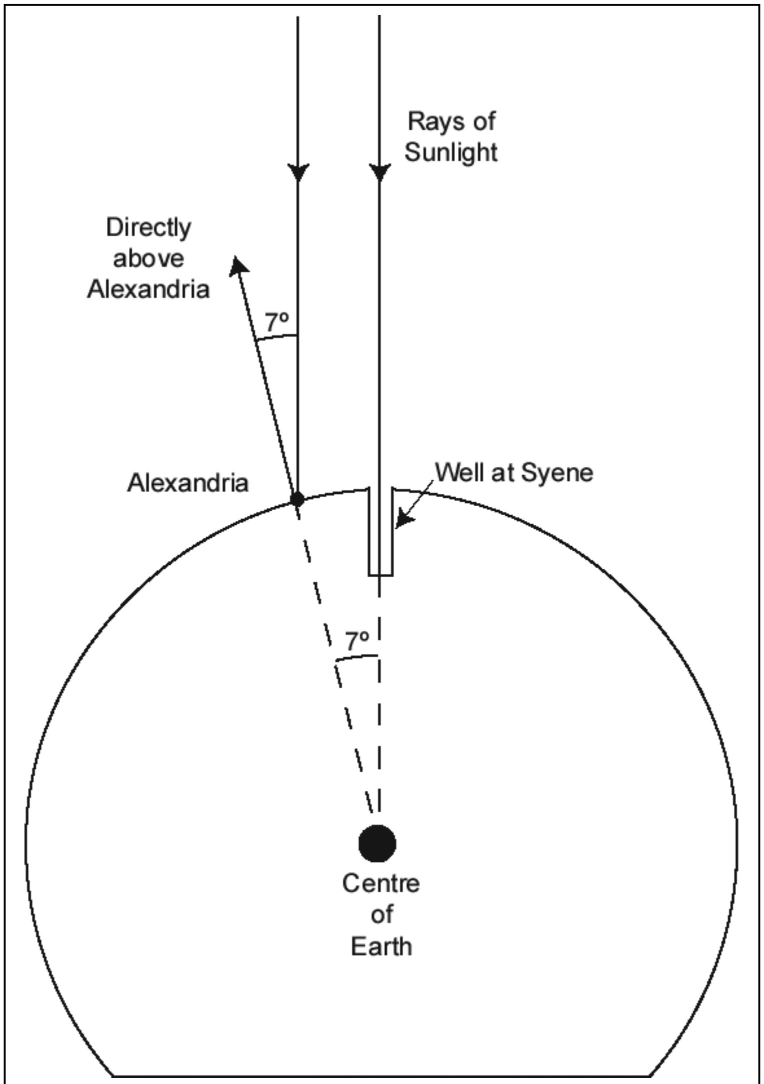


Figure 3. Using a well at Syene, the distance to Alexandria, and the angle of the Sun above Alexandria, to calculate the earth's circumference.

Lesson 8: *Why do Stars Twinkle?*

Timing
2 class

Goal
To resolve the mystery around the twinkling of stars when viewed through a telescope.

Objectives
1. Students will be able to explain the phenomena of twinkling stars.
2. Students will be able to distinguish between two types of variable stars: true (change their luminosity) and false (star pairs revolving around a common centre).
3. Some students will experience first hand the theory-ladenness of observations, e.g. observing a twinkling object only when one expects it to twinkle.

Scientific Value to be Conveyed
scientists search for mechanistic explanations that reduce the mysteries of the world

Instructional Strategies
direct

Lesson Outline
1. Review legends about stars (falling stars, constellations, or twinkling). Give attention to implications for human action (i.e. how people should behave, or what happens if they behave in certain ways). Focus on twinkling, today.
2. The scientific story of twinkling:
   - explain that stars are point sources of light while planets are area sources of light;
   - explain "upper atmospheric distortions" – how dirt particles block out stars, and how ice particles change the colour of lights (a prism may be useful to role play this);
   - explain how some people can distinguish between stars and planets based on twinkle, especially when viewing them through a telescope.
3. Define true and false variable stars.

CELs / Subject Integration: Native Studies

Resources

Teacher Notes
! False variable stars are only visible through a large telescope. True variable stars require viewing over a few days in order to detect the variability in their luminosity.
! Pulsars are fast spinning neutron stars (Lesson 10). They are stars that radiate radio waves which are outside our visual perception.

Lesson 9: *Falling Star Scavenger Hunt*

Timing
1/2 class

Goal
To gain personal experience with extra-terrestrial matter.

Objectives
1. Students will learn the science story of shouting stars (meteors and meteoroids burning in the earth's atmosphere), and will remember the difference between the two types of bodies.
2. Students will collect evidence of meteoroids, and wonder where the material came from.
3. Students will remember that only 3 metals (iron, nickel, and cobalt) interact with a magnet.
4. Students will compose a short paragraph related to what material they discover.

Scientific Value to be Conveyed
scientific language is created to be precise

Instructional Strategies
direct, experiential

Lesson Outline
1. As a story teller, relate the Western science story of: shooting stars (i.e. describe the scientific story for falling stars), the origin of the bodies, the cause of their light, and what happens if remnants of various sizes reach the earth. (Hollywood produced a few movies in the late 1990's about meteors striking our planet.)
2. In groups, students will move a plastic wrapped magnet through dust from eaves troughs to collect iron/nickel/cobalt fragments from meteoroids. Deposit fragments on white paper. Repeat the magnetic collection another time with a cleanly wrapped magnet to ensure purity of the fragments. Give students a magnifying glass so they will be able to write a description of the meteoroids they have collected.
3. Assign a one-paragraph report on their meteoroid find. A creative writing genre can work well; e.g. students might write a short newspaper story that describes: (a) what they found, (b) how they found it, and (c) speculate where the material may have come from in the universe.

CELs / Subject Integration: communication, Language Arts

Resources
dirt from eaves troughs
strong magnets protected by plastic wrap (used for food)
magnifying glasses

Teacher Notes
- This experience can be pleasantly emotional for some students. Sensitivity to students' creativity is required.

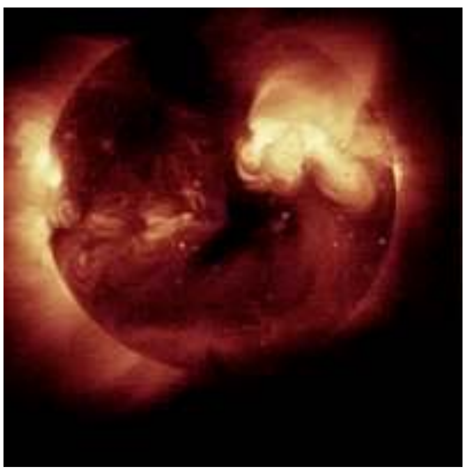
Lesson 10: *The Birth/Death Cycle of Stars*

Timing
1 or 2 classes, depending on the amount of detail you want students to deal with.

Goals
1. Students will see that stars have a life cycle.
2. To introduce students to uranium and nuclear energy for subsequent units.

Objective
Students will be able to repeat the Western science stories for how stars form and how stars disintegrate.

Stars are born



A super nova – the death of a star

Scientific Value to be Conveyed
scientists look for patterns to explain things, metaphors can supply such patterns

Instructional Strategies
direct (story telling)

Lesson Outline
1. Supported by photographs of nebulae, tell the science story of the birth of a star:
   - nebulae condensing under the influence of gravity;
   - hydrogen fusion reaction (producing helium) is started inside the stellar core;
   - after time (and if the star is large enough) other fusion reactions occur forming heavier elements, and eventually all the elements known to chemists;
   - stellar "pollution" from the fusion reactions (plasma) is spewed out in all directions from the star;
   - describe the "solar thermostat" concept.
2. Supported by photographs of nova and super nova, tell the science story of the death of a star:
   - formation of heavier elements leads to the end of fusion reactions within the star;
   - explain how a star collapses into itself and then explodes, producing a nova or super nova (depending on the mass of the star);
   - describe the three possible deaths of stars: the burn out, the neutron star, and the black hole.
3. Relate this information to our own Sun (it is several generations old, being formed from earlier nova or super nova), and relate the information to the matter (elements/atoms) that make up students' bodies – e.g. their carbon atoms came from stars that no longer exist as stars, the same

stars whose matter also formed the Sun. Thus, terrestrial students are made from celestial matter. We are all related to an earlier star! This topic should capture the creative imagination of several students.

CELs / Subject Integration:

Resources

www.astro.uva.nl/demo/sun Virtual tour of the Sun.

Here is a story from the Hubble internet site (http://oposite.stsci.edu/pubinfo/pr/1999/20/index.html):

In this stunning picture of the giant galactic nebula NGC 3603, the crisp resolution of NASA's Hubble Space Telescope captures various stages of the life cycle of stars in one single view.

To the upper left of centre is the evolved blue super giant called Sher 25. The star has a unique circumstellar ring of glowing gas that is a galactic twin to the famous ring around the supernova 1987A. The grayish-bluish colour of the ring and the bipolar outflows (blobs to the upper right and lower left of the star) indicates the presence of processed (chemically enriched) material.

Near the centre of the view is a so-called starburst cluster dominated by young, hot Wolf-Rayet stars and early O-type stars. A torrent of ionizing radiation and fast stellar winds from these massive stars has blown a large cavity around the cluster.

The most spectacular evidence for the interaction of ionizing radiation with cold molecular-hydrogen cloud material are the giant gaseous pillars to the right of the cluster. These pillars are sculptured by the same physical processes as the famous pillars Hubble photographed in the M16 Eagle Nebula.

Dark clouds at the upper right are so-called Bok globules, which are probably in an earlier stage of star formation.

This single view nicely illustrates the entire stellar life cycle of stars, starting with the Bok globules and giant gaseous pillars, followed by circumstellar disks, and progressing to evolved massive stars in the young starburst cluster. The blue super giant with its ring and bipolar outflow marks the end of the life cycle.

The colour difference between the super giant's bipolar outflow and the diffuse interstellar medium in the giant nebula dramatically visualizes enrichment in heavy elements due to synthesis of heavier elements within stars.

This true-colour picture was taken on March 5, 1999 with the Wide Field Planetary Camera 2. Credit: Wolfgang Brandner (JPL/IPAC), Eva K. Grebel (Univ. Washington), You-Hua Chu (Univ. Illinois Urbana-Champaign), and NASA.

Teacher Notes

Lesson 11: *The Northern Lights*



nayëlka nághëgëz

Timing
1/2 class

Goal
To feel more comfortable dealing with two different knowledge systems – Aboriginal and Western science.

Objectives
1. Students will remember the type of matter that makes up plasma (positively and negatively charged fundamental particles: protons, electrons, etc.) emitted from our Sun.
2. Students will be able to repeat the science story of aurora borealis.

Value to be Conveyed
Different cultures ask different questions about nature. Therefore, knowledge of nature will be as different as the questions posed. For example, people of the Wasanipi Cree culture will ask, "*Who* caused the northern lights to occur? On the other hand, Western scientists ask, "*How* were the lights of the aurora borealis caused?" A different story with a different vocabulary will be told in each culture.

Instructional Strategies
direct

Lesson Outline
1. Review local stories about the nayëlka n□ghëgëz (northern lights). Note the characteristics of Aboriginal stories (e.g. they are based on evidence, and they relate to human purposes).
2. Tell the Western science story of the aurora borealis (northern lights):
   ! plasma (negatively and positively charged particles) from the Sun and other stars travelling through space;
   ! the interaction between the charged particles in the plasma and the earth's magnetic field. This interaction funnels the plasma toward the poles;
   ! the collision between the plasma and molecules in the upper atmosphere, a collision that imparts energy to the molecules which in turn, radiate light as they get rid of that extra energy.
3. Note the characteristics of science stories (e.g. they are based on evidence, they are mechanistic and are devoid of human purpose).

CELs / Subject Integration: Native Studies

Resources
http://www.uit.no/npt/nordlyset/nordlyset.en.html General information.
http://ecotourism.about.com/travel/ecotourism/msubnlimages.htm?iam=mt Connection to many sites.

A solar eclipse allows us to "see" the plasma emitted from the Sun.

Teacher Notes
- Use the phrases "northern lights" and "aurora borealis" to identify which culture you are speaking in at any given moment – everyday Aboriginal or Western science.
- A demonstration, if possible, of charged particles being bent by a magnetic field would be good. A Crook's tube, high voltage source, and a magnet, are needed. Alternatively, one can simulate the phenomenon by a narrow constant stream of water from a tap (or container) being influenced by the electrical field from a comb recently passed through a head of dry hair. The water molecules are charged with both positive and negative charges (resulting in a neutral substance) just like plasma. The static electricity produces an electrical field, similar to a magnetic field.

Aurora borealis seen from the space shuttle

Southern lights over Antarctica – aurora australis

Northern lights over Europe

Lesson 12: *A Quick Tour of Our Solar System*


Mercury

Timing
1 class

Goal
To focus on the solar system.

Objective
Students will be able to describe one interesting feature of each planet in our solar system, and about the Sun.


Venus

Scientific Value to be Conveyed
technology is used to solve scientific mysteries (science is often applied technology)

Instructional Strategies
direct, experiential


Mars

Lesson Outline
1. Using posters, overheads, photographs, or computer-projected images, show the students an image of each planet and describe some special characteristics it has (including its moons). Students will take notes on this oral presentation. Hand out statistical information on each planet's distance from the Sun, its diameter, and the number of Earth years it takes to revolve around the Sun. These mundane data will be used in the ensuing activity.
2. Activity "Role Playing the Solar System":
    a. Assign each student the role of: Sun (1), a planet (9), a moon (as many as you need), asteroid belt, and comet. Assign one or two students the role of director. Give students time to calculate and visualize how they will move as that object when the class goes outside on the playground to re-enact the solar system. Time might be given for students to construct their object out of plasticine or paper, conforming to proper proportions, and perhaps illustrating a special characteristic of that object. This is meant to be a fun activity as well as a learning experience.
    b. Go outside to re-enact the solar system. Take a whistle to start and stop the motion. Be prepared for it not working smoothly the first time, and therefore be prepared to come back into class to discuss how they can make it work. Making a video of the final product could be a good motivation, as well as something concrete to show parents.
3. Have students prepare a one-page description (with pertinent data) of their heavenly body, to be collated into a class booklet. (This might be used as a resource by a teacher in an earlier grade.)

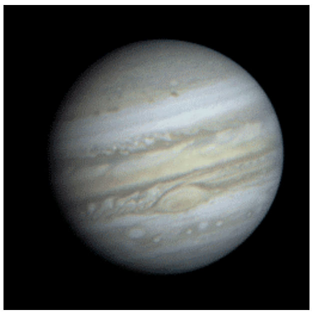
The Sun during an eruption

CELs / Subject Integration: communication

Resources
images of all the planets and Sun
materials to represent solar system objects (marbles, balls, plasticine, construction paper)
video camera and tape

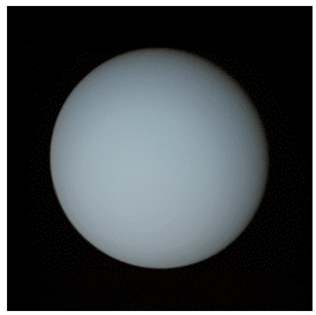
Teacher Notes

- Possibly a booklet could be put together with a small picture (bitmap) of each planet, and room for students to jot down important information while you are making your presentation.
- An actual working model of the solar system could be used to demonstrate prior to the role playing.
- Information regarding the role playing activity could be given to students before the lesson, giving them time to construct their object and visualize how they are to move in the re-enactment of the solar system.

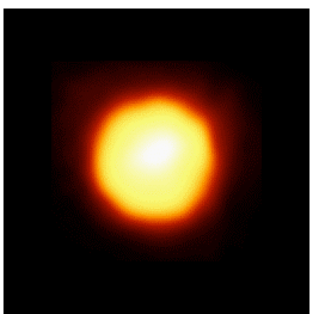


Jupiter

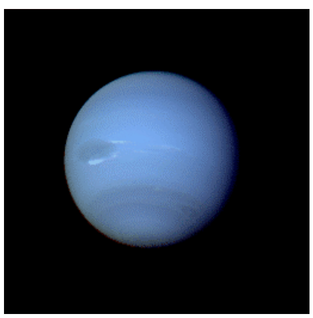
Saturn



Uranus



Pluto



Neptune

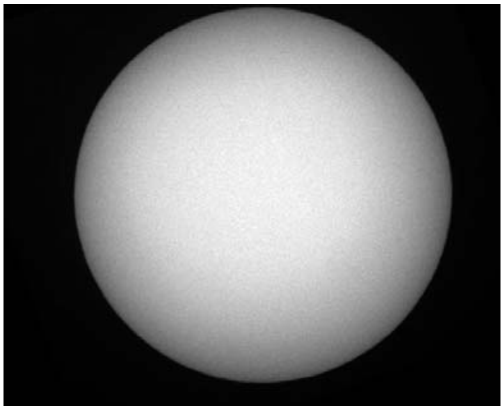
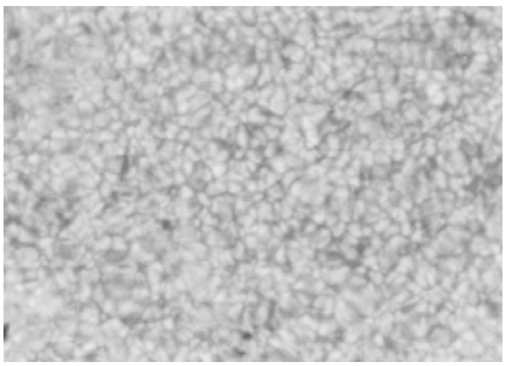
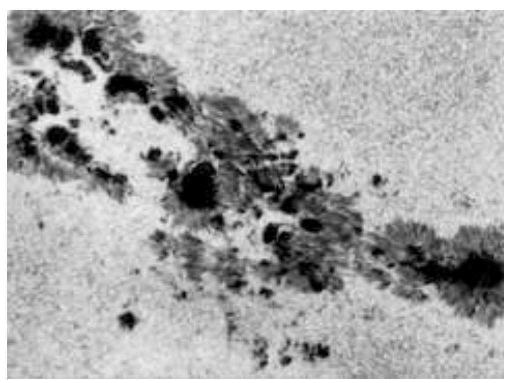


Photo of the Sun with no Sun spots



Close-up photo of the Sun with no Sun spots



Close-up photo of the Sun with Sun spots

Lesson 13: *Review*

Timing
1 to 3 classes

Goal
Make meaning out of the unit's content by using ideas in new ways or in new situations.

Objective
Students will revisit a number of concepts and principles introduced earlier.

Aboriginal Value to be Conveyed
respect for diversity

Instructional Strategies
interactive

Lesson Outline
1. Because the night sky raises questions about where did it (we) all come from, you might wish to review the similarities and differences between Aboriginal stories and Western science stories by discussing origins of matter and life, from both perspectives. It is a very complex and sensitive topic from both perspectives, but one that students find highly motivating. Within that discussion (from which few definitive conclusions will be reached) there will be many teachable moments for you to revisit content from earlier lessons.
2. Student reports and projects can be sources of review, as students teach other students about what they have learned.

CELs / Subject Integration: communication, Native Studies

Halley's comet will return in the year 2061

Solar eclipse over a mosque

Appendix A

Aboriginal Calendars

Aboriginal Calendars

Aboriginal calendars are lunar calendars that are logical in a culture in which people are acute observers of nature. The preciseness of keeping track of important yearly events does not rest on an accurate lunar calendar, but with the people's acute observations and rich knowledge of nature. An Aboriginal calendar does not need to be precise, just good enough for reasonable communication.

There are usually 13 full moons in each year. Aboriginal calendars are 13-*moon* calendars, not 13-month calendars. When we use the word “month” we are speaking from a Western cultural point of view. When we use the word “moon,” this indicates an Aboriginal cultural point of view. As pointed out in Appendix B (specifically the early history of our Gregorian calendar), there is no patterned relationship between a 12-month calendar and a 13-moon calendar. In spite of this fact, dictionaries and other resources today continue to treat the Aboriginal calendar as if it were a 12-moon calendar. These publications insist that each of the 12 months has a designated moon; for example, the Cree ayîkipîsim (the frog moon) is defined as April. Some years ayîkipîsim does correspond to April, but some years it doesn't. If we insist on using a 12-moon calendar for Aboriginal cultures (rather than a 13-moon calendar), we unwittingly engage in subtle assimilation (colonization). Our Cross-Cultural Science & Technology Units try to avoid this assimilation at all costs. It is accurate to say that ayîkipîsim in the Aboriginal calendar overlaps with some part of April, but a different part of April each year. The way we deal with the puzzle of non-correspondence between a 13-moon and a 12-month calendar is to get students to see the current year (with its 7-day weeks) in terms of the 13 moons (see Lesson 2).

Aboriginal communities will have variations on the names and spelling for each moon. Tables 1 and 2 show some variations within the Cree (Y dialect) and the Dëne (S dialect) communities. Traditional hunting and gathering cultures will be quite different from traditional farming and gathering cultures. Try to find at least one 13-moon calendar for your community. This task is made difficult due to the extensive assimilation that has occurred. If you want to know which month each moon corresponds to, you'll need to sketch out when the moons appear during this current year (as is done in Lesson 2).

When does a moon begin? The answer is different in different cultures. Ancient Egyptian lunar months began the day that they could first see a new crescent (a day after the “new” moon, weather permitting). Traditionally in Saskatchewan, a moon begins with a full moon. But you'll need to ask an Elder in your own community.

One point needs to be made again: what seems rationally logical to a person depends on the person's culture or point of view. This applies as much to Aboriginal calendars as it does to those that comprise the history of other calendars in use in Canada (Appendix B). Today in our highly technological culture, it seems logical to adjust our Gregorian calendar to correspond to the solar cycle, using the greatest precision our technological instruments can measure. Such fine-tuning occurs arbitrarily from time to time (usually at the beginning of a new year). This need for precision signifies how far removed from Mother Earth we have become by not using the 13 moon calendar.

Table 1. Moons of the Cree Year (Y dialect)

1.	kisêpîsim kisêpîsim	the elder moon, the great moon
2.	mikisowipîsim mikisiwipîsim	the eagle moon
3.	niskipîsim	the goose moon
4.	ayîkipîsim	the frog moon
5.	sâkipakâwipîsim	the leaf budding moon, the budding moon
6.	pâskâwihowipîsim opâskâwihowipîsim	the egg hatching moon, the hatching moon
7.	paskowipîsim	the moulting moon
8.	ohpahowipîsim	the flying up moon
9.	takwâkipîsim	the autumn moon
10.	nôcihitowipîsim	the mating moon
11.	pinâskowipîsim pimâhamowipîsim	the migrating moon
	kaskatinowipîsim	the freeze-up moon
12.	ihkopiwipîsim	the frosty moon
	iyikopîwipîsim	the frost moon
13.	pawâcakinasîsipîsim opawâcakinasîsipîsim	the frost-exploding moon
	pawahcakinasîs	the tree cleaning moon
	manitowkîsikanpîsim	God's moon

Note: Spelling, or sometimes the word itself, varies from community to community.

Sources: *Alberta Elders' Cree Dictionary* (LeClaire and Cardinal)
Fr. Beaudet Cree-English Dictionary (Beaudet)
Cree Language of the Plains (Bellegarde and Ratt)
First Nations Language Lessons: Plains Cree "Y" Dialect (OBI Systems)

Table 2. Moons of the Dëne Year (S dialect)

1.	ëdzahi zaghë ëłëlts′ëlts′ún zaghë ʔełets′ëlts′úni dzį̇né zaghë	the cold moon the kissing day moon new years moon
2.	dët′anichogh zaghë	the big bird moon, the eagle moon
3.	hah zaghë	the goose moon
4.	ts′ëłi zaghë	the frog moon
5.	ëghézë zaghë	the egg moon
6.	ëghéz yëhóli zaghë	the hatching moon, the egg hatching moon
7.	ʔ☼délza zaghë	the moulting moon
8.	ʔechëth zaghë	the bird moon
9.	ʔechëth zaghë naʔidéli zaghë	the birds going back moon the birds flying moon
10.	dën☼ ëłk′ën🖫d☼hi zaghë	the moose breeding moon
11.	eyunë dzinë zaghë	the crazy day moon
12.	hayë zaghë	the winter moon
13.	tëtłeghë yati zaghë zine doya zaghë	the praying night moon the shortest day moon

Note: Spelling, or sometimes the word itself, varies from community to community.

Sources: *Dene (Chipewyan) Dictionary* (L.W. Elford and M. Elford)
13 Moons on a Turtle's Back. (Alberta Science Council's "Science in a Crate" series.) Calgary, Alberta.
First Nations Language Lessons: Dene "S" Dialect (OBI Systems)

Appendix B

A Short History of Calendars

Calendars

This is an historical overview of some of the Christian calendars in use in Canada today. This summary draws upon a number of sources listed below in the "Resources" section. Students may become interested in learning more about details of the story summarized here. Our story line follows the historical thread from ancient Egyptian cultures to the culture of today's industrialized nations. Many fascinating stories about other calendars could be told (e.g. about Aboriginal, Chinese, Muslim, Hebrew calendars). These may interest some of your students (a science project?).

Throughout history, calendars have been invented by paying attention to either the Moon or the Sun. A lunar cycle is not a simple concept because its duration (number of days) is relative to the frame of reference one chooses (see Lesson 3). A solar cycle is the time, for example, between one vernal equinox and the next, measured today as 365.2422 days (rounded off). It turns out that a lunar cycle is completely independent of a solar cycle, and so the two are not related. There is no easy way to calculate a correlation between a lunar calendar and a solar calendar, there are only ad hoc procedures to keep the two in synchrony.

Another idea must be kept in mind – the nature of time itself. The reader probably assumes that time is rectilinear, that is, each interval of time is the same and travels in a "straight" line from the past into the future. This assumption is evidence that the reader grew up in a modern Western culture. Our notion of time is determined by our enculturation into our community. The concept of linear time in Western Europe as we understand it today emerged after the invention of the mechanical clock in the 13th century. Before that, spaces of time were inconsistent and relative. For instance, an hour was one-twelfth of either daylight or night time. Thus, the length of an hour depended upon whether it was a day-hour or a night-hour, and depended upon the time of year. An important idea is illustrated by these facts: scientific concepts, such as the definition of time, are understandably related to the culture of the people inventing those concepts.

In the abbreviated story that follows, one simplification has occurred to make the story easier for you to read. All dates for ancient calendars have been described in terms of modern Christian calendars that designate the "year of our Lord" as the boundary between AD and BC. For example, when we read that the Julian calendar was implemented in 46 BC, we need to remember that a totally different counting system of years was used by that calendar.

Ancient Times

World wide and through oral and written history, people have felt the need to keep track of the days of the year in some way or another. People who lived close to nature, relying on their knowledge of nature to survive as a people, looked to the cyclic appearance of the Moon 13 times a year to orient themselves to when natural events would generally occur or when religious events should occur during a solar year. These 13 moons organized their seasonal tasks in a logical way. There was no need to count the individual days. "An acute observer of Nature has a fairly good calendar without bothering to count the days at all" (Bernal, 1969, p. 122). For example, an Aboriginal trapper will pay attention to numerous signs in nature to determine what to do, but a trapper would not consult the Moon. The very ancient Egyptians (prior to 2700 BC) relied on their lunar calendar to decide when to hold religious ceremonies.

With the advent of agricultural societies located on large rivers (such as the Nile with its consistent spring flooding at a particular time of year), the *year* rather than the month became important to certain sectors of the society. As these societies became more organized, government administration relied more and more on keeping track of each day of the year in such a way that there would be consistency from one year to the next (i.e. in synchrony with natural yearly solar cycles). In Egypt this happened about 2700 BC. A civil calendar was invented which existed along with the traditional lunar calendar used for religious purposes. The civil calendar attempted to mimic the solar year by having 36 weeks of 10 days each, plus 5 days added ceremoniously at the end of each year (total = 365 days). This calendar was short by 1/4 day per year, and so every 4 years it was out by a day. The calendar was called the “wandering” year because it took 1460 years to come full circle back in its alignment with seasonal occurrences (e.g. the vernal equinox). Nevertheless, its use persisted for thousands of years in the field of government administration. In agriculture, however, this wandering year was not good. A second lunar calendar (related to the solar year) was invented. This was a lunar calendar that was arbitrarily altered from time to time to make it correspond to the solar year. It's accuracy improved to the point where it was only 12 minutes shorter than the true solar year. For much of Egyptian history, then, three different calendars seemed to have been in use for religious, government administrative, and agricultural reasons. The civil calendar, interestingly enough, *numbered* its days and months. Names of months, however, appeared on religious calendars.

In Mesopotamia, the Sumarians, Babylonians, and other cultures were too attached to the Moon to switch over to a solar-based calendar. So they constantly had to reconcile their lunar calendars (e.g. a 354-day year) with solar cycles (e.g. the vernal equinox). This required the addition of days, weeks, or months to correct their lunar calendars. One popular system had a 19-year cycle that included “leap” years having an extra month. This arbitrary act was systematized by 480 BC.

It's important to note that the problem of a wandering civil calendar in Egypt, and the problem of bringing the lunar calendar in line with the solar calendar, both spurred priests to make accurate and systematic observations of the night sky (e.g. the first appearance of the star we call Sirius after the vernal equinox was critical to the ancient Egyptians). It also motivated the ancient cultures (in Mesopotamia especially) to invent mathematical systems to make calculations with these observations. To some large degree, therefore, the social need to have a good calendar led to the invention of mathematics we use today. And it's all embedded in the culture of the people at the time.

Julian Calendar

In a cultural context different from that of Mesopotamia, a calendar would certainly be different. In Roman culture, for example, the calendar needed to fit into the worldview of ancient Rome with its emphasis on practical engineering feats (e.g. aqueducts, road systems, harbours, etc.). The Roman rulers needed a calendar that accurately predicted seasonal occurrences in all parts of their empire. Their current, lunar-based, Roman republican calendar (1 year = 366.25 days) was another “wandering” calendar. By 50 BC, the Ides of March occurred in mid-May. Something had to be done.

The Romans had the advantage of possessing Greek astronomical knowledge. In fact, Julius Caesar (100 - 44 BC) employed an Alexandrian astronomer, Sosigenes, to help him invent a better calendar. In 46 BC, they came up with a complex arrangement of 12 months (the popular number system was base 12 in those days, not base 10 as it is today). Each month had 30 or 31 days, except for February, which had 28 or 29 days depending if the year was a “bissextile” (leap) year.

Each month had a name that came from the republican calendar. The number of days in a month and names of some months changed for purely political reasons during the next few years. This new solar calendar, named the Julian calendar, averaged 365 and 1/4 days (365.25 days). By the way, it had only months and days; there were no weeks. The 7-day week came into effect with Emperor Constantine I in the 4th century AD.

An average 365.25-day year was the theory behind the new Julian calendar. However, there was a misunderstanding at first over what a bissextile year meant. Sosigenes intended it to mean “every 4 years,” but the Roman civil servants thought it meant “every 3 years.” This new misunderstood calendar was implemented in 46 BC and the misunderstanding wasn't noticed for 36 years! By this time, the erroneous calendar read 8 AD, but it was really 8 BC. Emperor Augustus, the ruler then, had the whole thing sorted out. But the confusion was immense. Imagine going back 36 years of business and government and figuring the dates out all over again. This was indeed a major Y0K problem!

If you have already compared today's measurement of the solar year, 365.2422 days (rounded off) with the Julian 365.25 days, then you will have predicted that the Julian calendar too will be out of wack after awhile. It is too long by 11 minutes and 14 seconds. In a century, this amounts to 18 hours, 43 minutes and 20 seconds. After 4 centuries, it’s out by 3.12 days. By the 15th century, the calendar was out by about 10 days. For Christians who needed to locate Easter precisely, this was a problem. Lots of solutions were proposed, but one finally was accepted, described in the next part of our story.

Gregorian Calendar

By 1545, the vernal equinox (used in the determination of Easter and other Christian holidays) had moved 10 days ahead of its proper date. The Pope at the time (Pope Paul IV) and his scholars couldn't decide on a solution to this problem. When Pope Gregory XIII was elected in 1572, he decided on a solution to the problem. He wanted the calendar to synchronize with the solar cycle just as it did in 325 AD, the year of an historical Roman Catholic meeting (the First Council of Nicaea). In 1582, he eventually drew upon someone's idea (Christopher Clavius') to correct the error of being out of wack 3.12 days in every 400 years. Clavius had suggested treating the 4 centennial years in a way that would eliminate 3 days over 400 years. Remember, a centennial year was always a leap year in the Julian calendar. You could eliminate 3 days per 400 years if you treated 3 of the 4 centennial years as non-leap years. A rule to follow is this: a centennial year will be a leap year only if it is divisible by 400. Therefore, the following centennial years would *not* be leap years: 1700, 1800, 1900, 2100, etc., whereas 1600 and 2000 would be.

The next problem, correcting the accumulated 10-day disparity, was solved by dropping 10 days out of the year 1582. This was accomplished by declaring that October 5 would become October 15 that year. (Too bad for people who were relying on something to happen on October 9th.) Now Easter could be determined reliably as the Sunday following the 1st full Moon after the vernal equinox. Also, Pope Gregory established January 1 as the first of the year. (Other times of the solar year, such as the vernal equinox or December 25, had been used as the beginning of a year.)

As usual after a scientific/technological breakthrough, the politics began. The Gregorian calendar was not adopted immediately in countries outside of Italy because it was associated with the Roman Catholic church. Religious loyalties can influence such decisions. Over the next 400 years the "New Style" calendar was gradually adopted throughout Europe, replacing the "Old Style" calendar. Scotland adopted it in 1600, but Anglican England waited until 1752 (170 years later, which required a 11-day correct by that time; Sept. 3 became Sept. 14 that year). Greece adopted it for secular purposes in 1923. Today in Canada, Greek Orthodox churches continue to use a version of the Julian "Old Style" calendar for religious events.

Other Calendars

Another calendar in wide use today is the Jewish calendar (modified in about 900 AD from an ancient Hebrew calendar). Its year one corresponds to the Old Testament's date for the creation of the world, 3761 BC. It combines lunar and solar events to keep track of days and to synchronize these days with the solar cycle. The months alternate between 29 and 30 days (lunar based) while an extra month is added every 3 years (solar based, using the 19 year cycle). This resembles the type of calendar described earlier from Mesopotamian cultures. How does this system deal with events prior to 3761 BC? These times are referred to as BCE ("before the common era") while events after 3761 are designated as AM (anno mundi, Latin for "the year of the world").

An Islamic calendar is found in many countries today, as well. It is a lunar calendar that stems from 622 AD, the flight of Mohammed from Mecca to Medina. It has a 30-year cycle composed of years having 12 lunar months, along with an arrangement of leap years.

Reform of the Gregorian calendar has continued over the years, but obviously without success. One example is the French revolution's new calendar with 1789 – the 1st year of liberty – as its demarcating year. It contains a number of other modifications to make the calendar more logical from the point of view of the French revolutionists. This "Republican" calendar was adopted in France on September 22, 1792 (the date of the autumn equinox and of an important anniversary for the revolution). Its 365 days were divided into 12 months, each having 30 days (total = 360 days, sound familiar?) with 5 festival days falling between September 17 and 22. In leap years, 6 festival days were celebrated. There were no 7-day weeks, but instead, 3-day "décades" – groups of 10 days, each day divided metrically into decimals. Other details about the Republican calendar distanced it from the Gregorian calendar, such as the names of the 12 months. The Republican year began with (translated into English) "vintage" (Sept. 22 - Oct. 21), and continued with "mist," "frost," "snow," "rain," "wind," "seedtime," "blossom," "meadow," "harvest," "heat," and "fruits." But because these months changed each year in relation to the Gregorian calendar, it was confusing to communicate dates between France and the rest of Europe. As a consequence, the French reinstated the Gregorian calendar in 1806.

Other logical suggestions continue to be proposed today. Two ideas are the International Fixed calendar and the World calendar. The International Fixed calendar has 13 months each with 28 days (total = 364) plus a day belonging to no month. The leap year day similarly belongs to no month. The International Fixed calendar uses the same month names as we do but adds the 13th month "Sol" between June and July. The leap year day is inserted after June 28, just before Sol 1. This calendar has consistency as its greatest advantage: half-years contain exactly 26 seven-day weeks, quarter-years contain exactly 13 weeks, and all Sundays occur on the 1st, 8th, 15th, and 22nd of each month.

The other idea for a new calendar, the World calendar, addresses business interests by dividing the 365-day year into 4 quarters of 91 days each (total = 364) plus an additional year-end day belonging to no month. While some people would enjoy certain advantages that accrue from the International and World calendars, there seems to be no pressing need do reform the Gregorian calendar today.

Summary

One point needs to be made again: what seems rationally logical to a person depends on the person's culture or point of view. This applies as much to Aboriginal calendars (Appendix A) as it does to those that comprise the history of our other calendars in use in Canada. Today in our highly technological culture, it seems logical to adjust our Gregorian calendar to correspond to the solar cycle, using the greatest precision our technological instruments can measure. Such fine tuning occurs arbitrarily from time to time (usually at the beginning of a new year). This is no more than a 1 second correction, and it can often be much less.

Many interesting student assignments (science reports) can emerge from students' questions about calendars. For example, if our Gregorian calendar corrected the 3.12 day error per 400 years in the Julian calendar by subtracting 3 days every 400 years, how do we correct the remaining 0.12 day error per 400 years? You and your students can have fun investigating such questions. Science reports can be responsive to any multicultural make-up in your class. Sensitivity is maintained by not stereotyping students. Let them choose what interests them.