The Canada Science and Technology Museum
presents:

Astronomy:
A Virtual Exploration Guide

Section 1

About this Guide

CANADA SCIENCE AND TECHNOLOGY MUSEUM

Canada

Introduction

For thousands of years, people have looked to the sky with awe and wonder. What lies beyond the confines of the Earth? What causes the spectacles that we see in the night sky? How have different peoples, from the ancient Greeks to current Canadians, studied and interpreted the universe?

Astronomy is a teaching resource package that enables students to discover the wonders of Astronomy from their own classrooms. This virtual program presents astronomy in a way that is accessible and interactive, combining hands-on activities with online discovery.

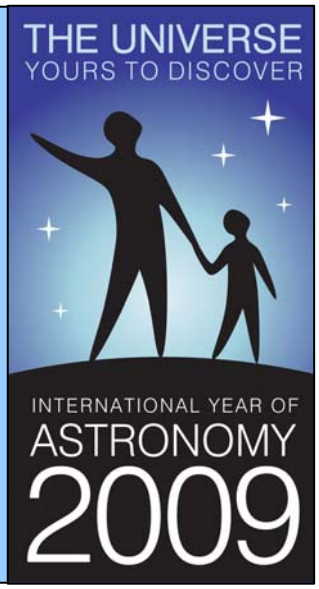
International Year of Astronomy 2009

This year has been officially declared the International Year of Astronomy (IYA 2009). 2009 marks the 400th anniversary of Galileo's discovery of the stars using his now-famous astronomical telescope.

Educational organizations worldwide will be celebrating this exciting discovery by offering a variety of programs and resources to encourage people, particularly children and youth, to discover astronomy for themselves.

This Exploration Guide provides you with the tools you need, as an educator, to enrich your student's learning in the area of astronomy. Our focus on science, technology, social sciences, history, and environmental studies will enable you to contextualize and celebrate IYA 2009 with your students.

For more information, visit the IYA 2009 international website at www.astronomy2009.org, or Canada's IYA website at www.astronomie2009.ca.



What this Exploration Guide Can Do For You

This Exploration Guide lets you and your students discover astronomy using your school's internet connections. Our activities and worksheets will enrich your exploration of the Canada Science and Technology Museum's website, as well as other excellent online resources. Blank worksheets and detailed examples can be freely reproduced for use in your classroom. Our activities are modular, and can be completed independently.

In addition to addressing Canadian science, history, and technology, the Exploration Guide's activities reinforce knowledge and skills in areas such as geography, mathematics, and writing. As well as activity sheets, you will find suggestions for classroom discussions, class projects, and independent study assignments (summative evaluation projects).

Teachers may requests an "answers" package, which includes educators' copies of the more complicated worksheets within this Exploration Guide, by emailing **virt_prog@technomuses.ca**. Please allow about a week for us to reply.

Navigating Through the Exploration Guide

Each section of this Exploration Guide can be downloaded as a separate Adobe PDF file, allowing you to select the sections that you would like to use. Alternately, you can download the entire guide as a single Adobe PDF file. The content is identical in either case.

While the Exploration Guide's sections are thematic, they also embody scope for cross-curricular learning. There are activities within each section to suit the needs of students at a variety of grade levels.

For your convenience, all of the Exploration Guide's activities are listed below, along with their suggested grade levels:

Section 1 Introduction

Section 2 Science in the Skies: Discovering our Universe

		Primary (K to Grade 3)	Junior (Grade 4 to 6)	Intermediate/Senior (Grade 7 to 12)
2.1	Daily Cycles: Rotation and Revolution	X		
2.2	Tracing the Sun's Heat: The Reason for the Seasons!	X		
2.3	Making Sundials		X	X
2.4	Comparative Study: The Earth, Venus, and Mars		X	X
2.5	Pacing it Out: A Scale Model of the Solar System		X	X
2.6	The Lifecycle of a Star			X

Section 3 Tools of the Trade: The Technology of Astronomy

		Primary (K to Grade 3)	Junior (Grade 4 to 6)	Intermediate/Senior (Grade 7 to 12)
3.1	Measuring the Sun's Heat: Thermometers	X		
3.2	How Telescopes Work		X	
3.3	Artifact Study		X	X
3.4	Observatories Across Canada			X
3.5	International Observatories: Canadian Partnerships			X

Section 4 Astronomy, Canada, and Society

		Primary (K to Grade 3)	Junior (Grade 4 to 6)	Intermediate/Senior (Grade 7 to 12)
4.1	Daily Rituals: The Sun in our Lives	X		
4.2	Canadian Astronomers: A Biographical Study		X	X
4.3	Native Canadian Perspectives		X	X
4.4	Across Cultures and Time: Comparing Constellation Myths		X	X
4.5	Canada's Astronomical Institutions: A Research Activity			X

Section 5 Astronomy and our Environment

		Primary (K to Grade 3)	Junior (Grade 4 to 6)	Intermediate/Senior (Grade 7 to 12)
5.1	Canada's Seasonal Cycles: Dressing for the Weather	X		
5.2	The Seasonal Behaviour of Canada's Animals		X	
5.3	All About Tides		X	X
5.4	Solar Winds & the Aurora Borealis		X	X
5.5	Satellites and their Environmental Applications			X

Distinctive icons throughout the Exploration Guide indicate its key features, helping you to find your way through the text quickly and efficiently.

	**Classroom Activity**		**Discussion or Essay Topic**
	**Deeper Study**		**Website to Visit**

Curriculum Links

This Guide is cross-curricular. The included activities focus on astronomy from a scientific, technological, historical, and social perspective. By completing the worksheets and activities in this Guide, students will also exercise their literacy, numeracy, artistic, and critical thinking skills, fulfilling specific requirements of various curricular areas.

Science and Technology Links

Pan-Canadian Protocol

The Common Framework of Science Learning Outcomes, developed by the Canada's Council of Ministers of Education, includes links to astronomy at the Primary (Daily Cycles, Seasonal Changes), Junior (Space and the Solar System), Intermediate (The Universe and Space Exploration), and Senior (Earth and Space Sciences) levels. A breakdown of links to the Protocol is as follows:

Grades 1 to 3:	100-1, 2, 3, 14, 26; 101-2, 6; 102-2, 6; 103-4; 200-1; 201-1 to 8; 202-1, 4, 7; 203-3, 4, 5; 400; 401; 402; 403; 404; 405; 406; 407; 408
Grades 4 to 6:	104-1, 2, 4, 8; 105-1, 2, 3; 106-1, 2; 107-3, 6, 11, 12, 15; 205-3 to 10; 207-1 to 6; 300-23; 301-19, 20; 302-13; 303-1; 409; 411; 413; 415; 418; 421
Grades 7 to 9:	109-11; 110-1, 2, 7, 8, 9; 11-1 to 6; 112-4, 5, 6, 11, 12; 209-2, 4, 5; 210-1, 2; 211-1, 2, 3; 312-1, 2, 3, 5, 6; 424; 425; 426; 427; 428; 430; 431
Grades 10 to 12:	115-4; 117-7, 10, 11; 213-5, 6, 7; 215-1, 2, 3; 333-1, 2, 3, 5, 6; 428; 439; 440; 441

Ontario Curriculum

Grade 1	Daily and Seasonal Cycles
Grade 4	Understanding Matter and Energy – Light and Sound
Grade 6	Understanding Earth and Space Systems – Space
Grade 9	Earth and Space Science: The Study of the Universe (Academic) Earth and Space Science: Space Exploration (Applied)
Grade 12	Earth and Space Sciences

Quebec Curriculum

Cycles 2/3	Solar Energy, The Rotation of the Earth, Tides, Techniques and Instrumentation, The Solar System, The Night Sky

Social Studies and History Links

Ontario Curriculum

Grade 2 Social Studies:	Heritage and Citizenship – Traditions and Celebrations
Grade 3 Social Studies:	Heritage and Citizenship – Settlement of Upper Canada
Grade 4 Social Studies:	Medieval Times
Grade 5 Social Studies:	Early Civilizations
Grade 6 Social Studies:	First Nations and Canada's Links to the World
Grade 9 Geography:	Global Connections
Grade 10 History:	Communities: Global, National, and Local Change and Continuity

Quebec Curriculum

Cycle 2 & 3	Students study different societies and their territories, focusing on the themes of organization, change, and diversity.
Secondary II	General History: Module 7 – The Twentieth Century • 7.1 – to show the relationship between technological innovations and the recent evolution of Western societies. • 7.2 – to identify some aspects of the continuity, pace, and relative nature of change in the world today.
Secondary III	Geography of Quebec and Canada: Module 1 – Quebec and Canada in the World • 1.2.1 – to describe the geographic and geopolitical position of Canada (involvement in the international community).

Other Generalized Curricula Connections

Mathematics	Number Sense and Numeration, Data Management and Probabilities, Geometry and Spatial Sense
English Language Arts	Reading, Writing, Oral Communication, Media Literacy/Studies
Fine Arts	Visual Arts, Drama

Resource Information

Couper, Heather and Nigel Henbest. ***The Space Atlas: A Pictorial Atlas of Our Universe***. Toronto: McClelland & Stewart, 1992. ISBN 0-7710-2860-1.

Dickson, Terence. Exploring ***the Night Sky: The Equinox Astronomy Guide for Beginners***. Scarborough, ON: Camden House, 1987. ISBN 0-920656-64-1.

Franknoi, Andrew, ed. *The* ***Universe at your Fingertips: An Astronomy Activity and Resource Notebook***. San Francisco, CA: Astronomical Society of the Pacific, 1995. ISBN: 1-886733-00-7.

Parker, Steve. Galileo ***and the Universe (Science Discoveries)***. New York: HarperCollins, 1992. ISBN 0-06-020735-3.

The Visual Dictionary of the Universe (Eyewitness Visual Dictionaries). Toronto: Stoddart, 1993. ISBN 0-7737-2751-5.

Walpole, Brenda. ***I Wonder Why The Sun Rises (and other Questions about Time and Seasons)***. New York: Kingfisher, 1996. ISBN 1-85697-668-8.

Webb, Michael. ***Helen Sawyer Hogg: A Lifetime of Stargazing***. Mississauga, ON: Copp Clark Pitman, 1991. ISBN 0-7730-5047-7.

Useful Web Sites

Notice Regarding Internet Sites

The Internet links below are provided as a convenience only. We have taken care to suggest web sites that are appropriate for education, but we cannot guarantee the content of any sites that are not under the control of the Canada Science and Technology Museum Corporation. Such web sites may provide content or express opinions that do not necessarily represent the views of the Canada Science and Technology Museum Corporation. Should you choose to visit such websites, please do so solely at your own discretion.

Given the dynamic nature of the internet, web addresses can change without warning.

Canada Science and Technology Museum Online Resources

http://www.scientech.technomuses.ca/english/whatson/2009-astronomy-resources.cfm

http://www.sciencetech.technomuses.ca/english/schoolzone/Info_Astronomy.cfm#seasons

http://www.sciencetech.technomuses.ca/english/collection/nocturnal.cfm#menu

http://www.sciencetech.technomuses.ca/english/collection/surveying_instr.cfm

http://www.sciencetech.technomuses.ca/english/collection/space2.cfm

http://www.sciencetech.technomuses.ca/english/collection/dominion_observatory.cfm

http://www.sciencetech.technomuses.ca/english/whatson/hogg_observatory.cfm

http://www.sciencetech.technomuses.ca/english/schoolzone/Info_Light.cfm

http://www.sciencetech.technomuses.ca/english/about/hallfame/u_i33_e.cfm

http://www.sciencetech.technomuses.ca/english/about/hallfame/u_i39_e.cfm

Other Online Resources

Canadian Space Agency
http://www.asc-csa.gc.ca

Canadian Astronomical Society (CASCA) Education Resources
http://www.cascaeducation.ca/files/index.html

Royal Astronomical Society of Canada (RASC)
http://www.rasc.ca/index.shtml

Canada-France-Hawaii Telescope Website
http://www.cfht.hawaii.edu/

Hawaiian Starlight (Images with information from the Canada-France-Hawaii Telescope)
http://www.cfht.hawaii.edu/hs/

National Research Council
http://www.nrc-cnrc.gc.ca/

Canada Under the Stars (Virtual Museum of Canada/ASTROLab of Mont-Mégantic National Park)
http://astro-canada.ca/_en/index.html

Astronomy: A Virtual Exploration Guide was developed by a team of experienced educators and astronomy content experts at the Canada Science and Technology Museum.

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The Canada Science and Technology Museum
presents:

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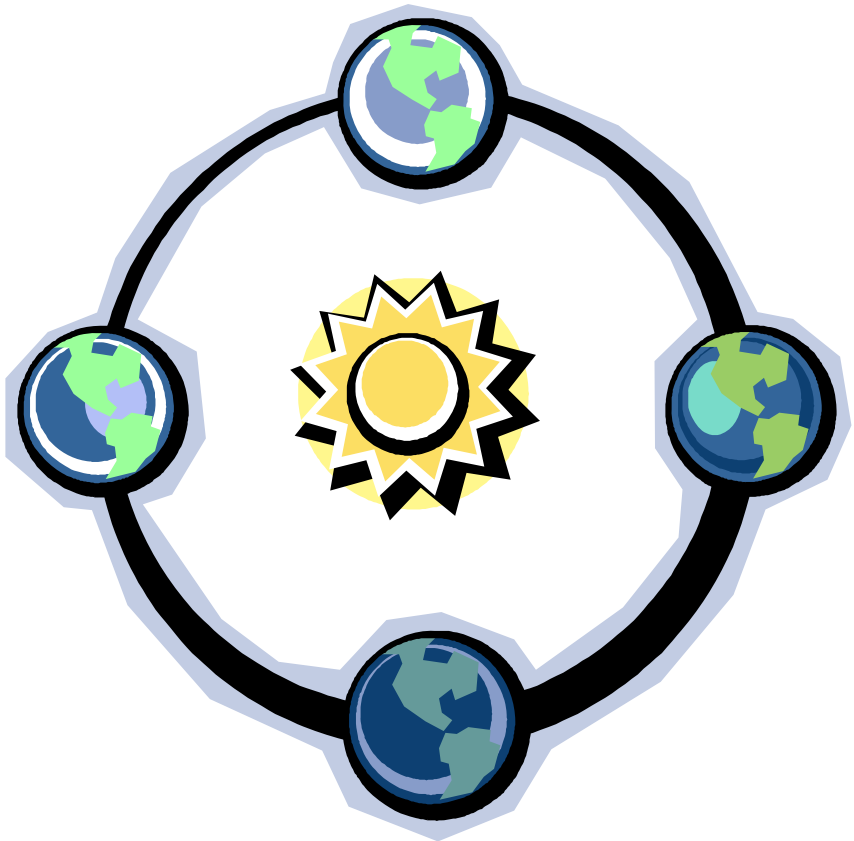
A Virtual Exploration Guide

Section 2

Science in the Skies:
Discovering our Universe



CANADA SCIENCE AND TECHNOLOGY MUSEUM

Canada

Introduction

Astronomy plays a key role in our everyday lives. Daily cycles and seasonal changes inform all aspects of our lives, from what we wear to how plants and animals survive in different climates. The following activities will help your students to discover the science of Astronomy, and what it can teach us about the Earth and its place within the Universe.

Section 2 Content

The following is an outline of this section's structure, and intended activity grade levels. For a comprehensive overview of the whole Exploration Guide, please see Section 1.

Primary (K-3)

2.1 Daily Cycles: Rotation and Revolution
2.2 Tracing the Sun's Heat: *The Reason for the Seasons!*

Transitional (Grade 4 and up)

2.3 Making Sundials
2.4 Comparative Study: The Earth, Venus, and Mars
2.5 Pacing it Out: A Scale Model of the Solar System

Intermediate/Senior (Grade 7 and up)

2.6 The Lifecycle of a Star

Distinctive icons throughout the Exploration Guide indicate its key features, helping you to find your way through the text quickly and efficiently.

 **Classroom Activity**	 **Discussion or Essay Topic**
 **Deeper Study**	 **Website to Visit**

Resources for the Activities

Many of the following activities require students to conduct research online. Worksheets for all activities are included at the end of this section. Teachers may request an answer package for the more detailed Activity Sheets by e-mailing **virt_prog@technomuses.ca**. Please allow about a week for us to reply.

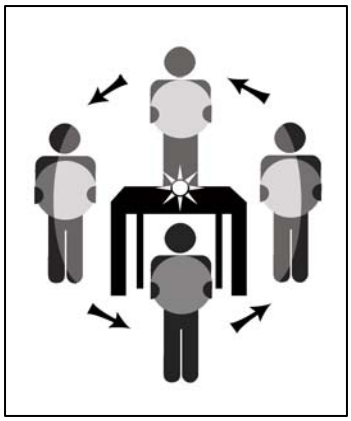
For a brief explanation of how the Earth's revolution causes seasonal changes, access the Canada Science and Technology Museum's explanation of the Seasons at: http://www.sciencetech.technomuses.ca/english/schoolzone/Info_Astronomy.cfm#sun. This content is suitable for teachers and older students.

Activities

Activity 2.1: Daily Cycles: Rotation and Revolution

(Suitable for Kindergarten to Grade 3)

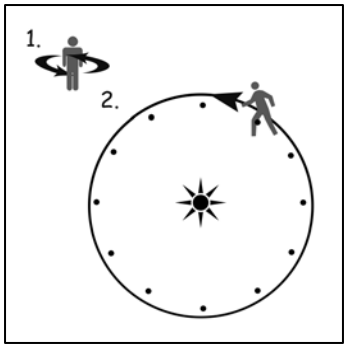
Part 1: The Earth's Rotation and Revolution



The purpose of this activity is to enable students to visualize the Earth's rotation and revolution. Demonstrate the rotation and revolution of the Earth, using a globe (or beach ball) and a lantern-style flashlight (a table lamp or candle will also work). Set the flashlight on a desk at the front of the room, and tell the class to pretend that it is the Sun. Stand behind it, face to the class, to demonstrate how the "sunlight" touches your face. Stand in front of it, to show how it doesn't touch your face (as your back is to the "Sun"). Then stand beside the flashlight, demonstrating that the "sunlight" only touches the parts of you that are facing the light source. The other parts of you are in shadow.

Repeat this exercise while holding up the globe (if using a beach ball, ask your students to pretend that it is the Earth). Rotate the beach ball on its own axis: explain that the Earth rotates once per day (causing day and night). Revolve the beach ball around the "Sun" in an elliptical motion, demonstrating the passage of a year.

Part 2: "Running Circles" Around the Sun



Have students play a kinaesthetic game to reinforce the difference between rotation and revolution (this is best done outdoors, or in a gymnasium).

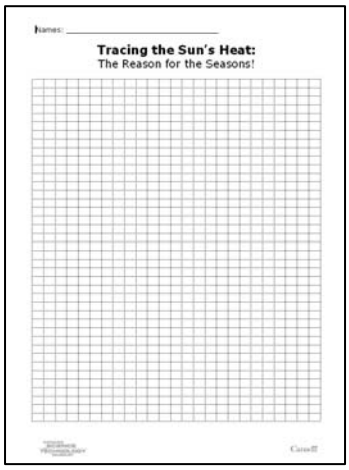
1. Review the fact that **rotation** occurs when an object "spins around itself." Have students act out the motion, twirling in circles.
2. Review the fact that **revolution** occurs when an object "spins around something else." Have students act out this motion by walking in a circle around the pylons.

Set a large pylon in the middle of the playing area. Set twelve smaller pylons around it, to form a circle. Explain to the students that the pylon is the center represents the Sun, the small pylons are each of the twelve months, and that they are the Earth. Have students walk around the circle, acting out the motions "rotate" and "revolve" (as you would in the game "Simon Says").

Challenge the students to do both actions at the same time; spinning as they walk around the pylon. Explain that as they face the centre pylon, it is daytime on their face. When their back is to the pylon, it is night-time on their face (as in Part 1). Finally, ask students to rotate roughly thirty times as they pass between each smaller pylon (as there are roughly 30 days, or 30 rotations of the Earth, in one month). Explain that to act out the Earth's path, they would have to rotate 365 times over the course of one revolution around the centre pylon.

Activity 2.2: Tracing the Sun's Heat – *The Reason for the Seasons!*
(Suitable for Kindergarten to Grade 3)

Introduction: Review the fact that that Earth **rotates** once every 24 hrs (relative to the Sun), while at the same time **revolving** around the Sun once every 365 days. Introduce the concept that as the Earth orbits the Sun, its axis of rotation is not straight up and down, but rather it is tilted (by 23.5 degrees). Show students the Earth globe, demonstrating how it is tilted when set on a table (it its stand). Explain to your student that this tilt affects the amount of light and heat Earth receives; it is actually the reason for the seasons!


Names: _____

Tracing the Sun's Heat:
The Reason for the Seasons!

Activity Process:

1. Group students into pairs. Give each pair an activity sheet and a flashlight.
2. Have students hold the flashlight (the Sun) about 5 cm away from the activity sheet (Earth's surface).
3. Instruct students to trace a light circle:
   a. holding the flashlight straight up and down,
   b. with a little tilt (on a slight angle),
   c. with a medium tilt (with a moderate angle),
   d. with a huge tilt (on a large angle).
4. Have students count the number of squares within each circle they traced, and write their findings inside the circles.

Explanation: (Also see the attached Answer Sheet)

Note: More squares DOES NOT equal higher temperatures!

- Temperatures are warm in Summer because the Sun is higher overhead - causing more concentrated heating of the Earth's surface – this corresponds to the circle with fewest squares.
- In Winter, the Sun is lower in the sky - its rays and energy are spread over a larger area and can't provide as much heat. The temperature goes down – this corresponds to the oval with most squares, the Sun's energy is spread out!

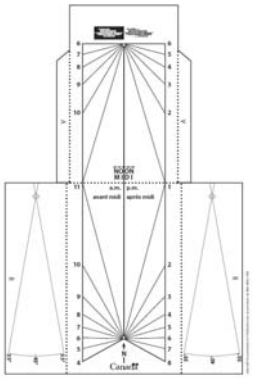
Extension Activity: *You can further illustrate this concept using an incandescent flashlight (or a lamp with a shade). Have a student stand far away from the light's beam, noting that more of their body is covered in light. Then have them stand with their hand nearly touching the lens or bulb. Less of their body's area is covered in light, but their hand will feel greater warmth.*

Activity 2.3: Making Sundials
(Transitional – Grades 4 and up)

Have your students construct sundials, discovering how the Earth moves in relation to the Sun as the day progresses. Below are two variations on the sundial, suitable for students at different levels of ability and understanding. Plans, material lists, and instructions are available on the Canada Science and Technology Museum's website, at the web addresses listed below.

Junior Students: The **Paper Plate Sundial** resembles a traditional clock in so much as its face is round and numerated. Constructed with materials that are easily accessible, this project serves as an excellent introduction to the science of sundials.

www.scientech.technomuses.ca/english/whatson/astronomy-resources.cfm



Intermediate & Senior Students: The **Diptych Sundial** is more complex and sophisticated in its form. Constructed with materials that are easily accessible, this project further develops students' knowledge of the science of sundials.

www.scientech.technomuses.ca/english/whatson/astronomy-resources.cfm

Activity 2.4: Comparative Study: The Earth, Venus, and Mars

(Transitional – Grades 4 and up)

Name: _____

The Earth, Venus, and Mars

Planet Studied: _____

Describe the planet's surface: _____

What gases are in the planet's atmosphere? _____

Describe the climate and temperatures on the planet's surface: _____

How many days does it take the planet to orbit the sun? _____

How long does it take the planet to revolve once on its axis? _____

Other Interesting Details: _____

Websites Visited: _____

Venus and Mars are the Earth's two closest neighbours. By comparing these three planets, students can better understand the factors that make the Earth inhabitable.

Send students on a "Web Quest," finding information to fill in the attached factsheet. Allow student to select the planet that they wish to study, or assign planets ahead of time. Remind students of the importance of using reputable websites. Ensure that they record the URL of each site that they visit.

Following this activity, students could share their gathered information, charting it on the blackboard. This will reinforce the differences between the planets.

Suggested Websites:

The following websites will be useful for your students. For other suggested websites, please see Section 1 of the Exploration Guide.

Canada Space Agency: www.asc-csa.gc.ca
Child-friendly planet factsheets: www.asc-csa.gc.ca/eng/educators/resources/kindergarten.asp

National Research Council: nrc-cnrc.gc.ca
You might choose to direct students straight to:
nrc-cnrc.gc.ca/eng/education/astronomy/topic/solar_system.html.

Poster Assignment: *Students can use the information that they gathered to create "Intergalactic Travel Posters." Have students use humour, exercising their artistic and writing skills as they promote the merits of one of these "exotic destinations" to space tourists.*

Activity 2.5: Pacing it Out: A Scale Model of the Solar System

(Transitional – Grades 4 and up)

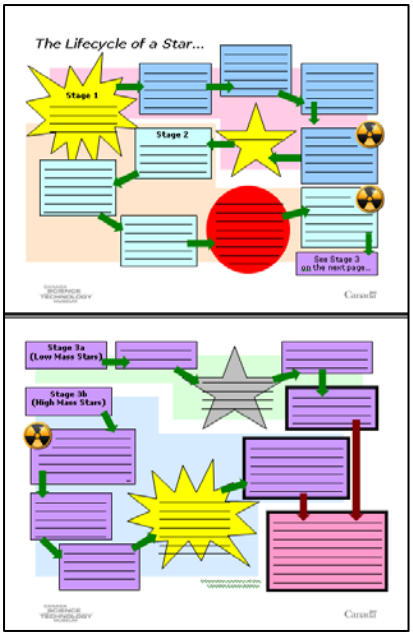
Help your students to better appreciate the scope of our solar system by pacing out a scale model in your schoolyard. You will need to ensure that your school has a paved area that is adequately long (you may choose to end your diagram with Saturn at 100 m). Using a compass, chalk, and the table below, trace the Sun (to scale) on the pavement. Then use a meter wheel to pace out the distance (to scale) from the Sun to each planet. Draw each planet to scale, and be sure to label your diagram. **For more advanced classes, have the students calculate the scale.**

The Solar System: A Distance Scale				
	Distance from the Sun	Scaled Distance	Diameter	Scaled Diameter
Sun	Nil	Nil	1 391 980 Kms	9.762 cm
Mercury	57 900 000 Kms	4.1 m	4 880 Kms	0.034 cm
Venus	108 200 000 Kms	7.6 m	12 100 Kms	0.085 cm
Earth	149 500 000 Kms	10.5 m	12 800 Kms	0.089 cm
Mars	227 900 000 Kms	16.0 m	6 800 Kms	0.047 cm
Jupiter	778 300 000 Kms	54.5 m	142 000 Kms	1.002 cm
Saturn	1 427 000 000 Kms	100 m	120 000 Kms	0.845 cm
Uranus	2 869 600 000 Kms	201 m	51 800 Kms	0.358 cm
Neptune	4 497 000 000 Kms	315 m	49 500 Kms	0.347 cm

Extension Activity: *It can be difficult for students to grasp the relative size of each of the planets. It can help if students are able to visualize the planets as a series of household items of varying sizes. Referring to the chart below, you can illustrate the approximate comparative scale of the planets in our solar system.*

The Solar System: A Size Scale	
If the Sun is a Bowling Ball…	
Sun	*A five-pin bowling ball (or any ball with an 8" diameter)*
Mercury	*A pinhead*
Venus	*A peppercorn*
Earth	*A peppercorn*
Mars	*A pinhead*
Jupiter	*A gooseberry or large marble*
Saturn	*An acorn*
Uranus	*A coffee bean*
Neptune	*A coffee bean*
	Information taken from: The Universe at Your Fingertips by the Astronomical Society of the Pacific.

Activity 2.6: The Lifecycle of a Star
(Suitable for Grades 7 and up



It can be difficult for students to grasp complex concepts, such as the lifecycle of stars. This requires students to learn and apply new vocabulary in relation to subject matter that is highly theoretical. Having students incorporate their new knowledge into a graphic organizer can be very helpful.

Have your students research the lifecycle of a star on the internet. Distribute copies of the activity sheet, to help your students to organize their thoughts. You may wish to collect students' sheets for formative evaluation.

Following your research session, take up the answers with your students. You may wish to create an overhead and distribute fresh worksheets so that each student can copy down the answers and come away with an accuate chart.

Suggested Website:

The Canadian Space Agency has a webpage devoted to explaining the science behind the Sun and stars. To complete this activity, direct your students to this webpage, at the following address:

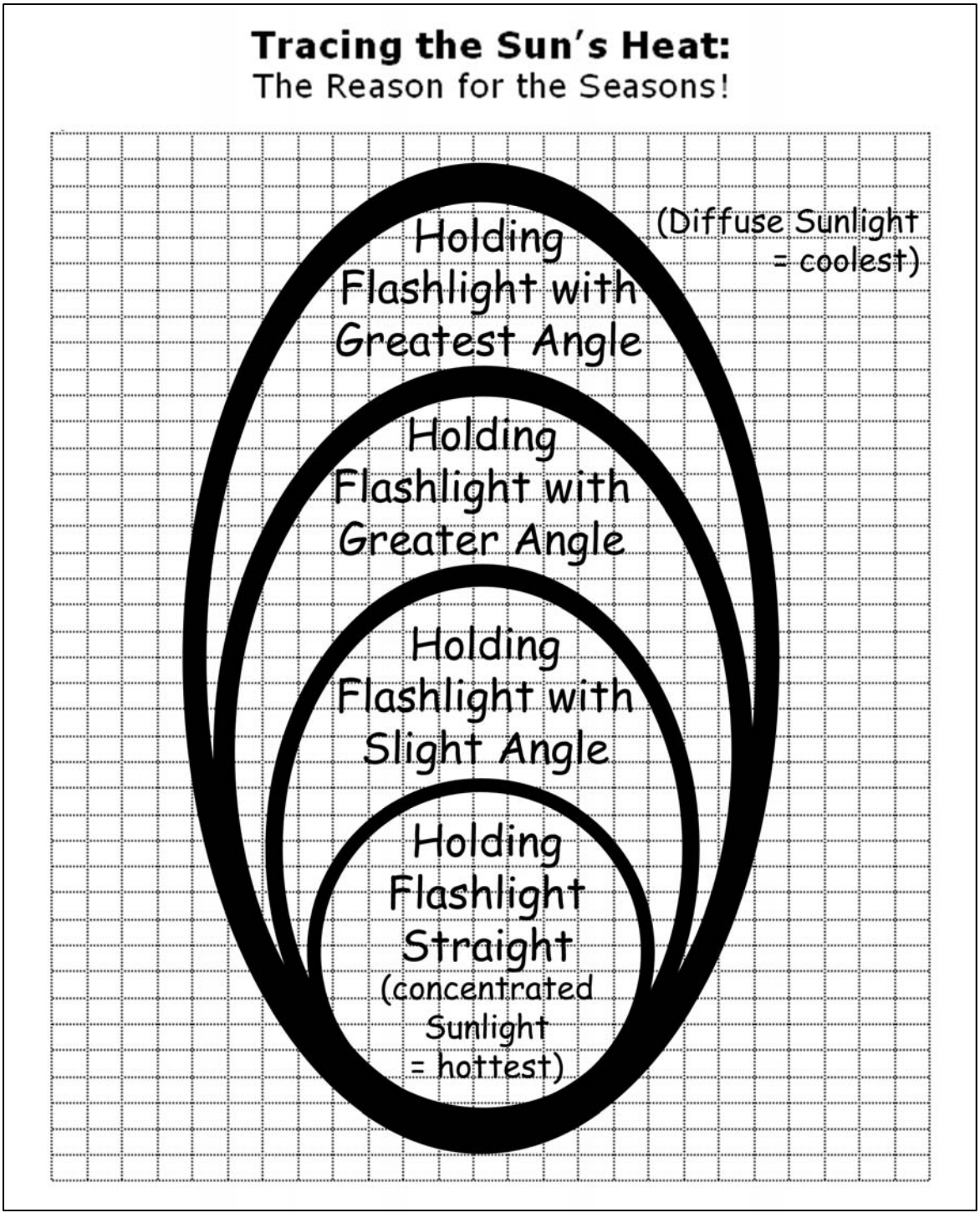
www.asc-csa.gc.ca/eng/educators/resources/astronomy/module2/content.asp

Topic for Further Study:

The Sun holds a place of central importance within our solar system. As our only star, the Sun generates the majority of the light and heat energy that we require for survival on Earth.

Have students conduct research about the structure of the Sun, discovering more about specific elements and phenomena such as the chromosphere, corona, solar wind, etc. Research could be presented for evaluation through a variety of media such as essays, PowerPoint presentations, or informational posters.

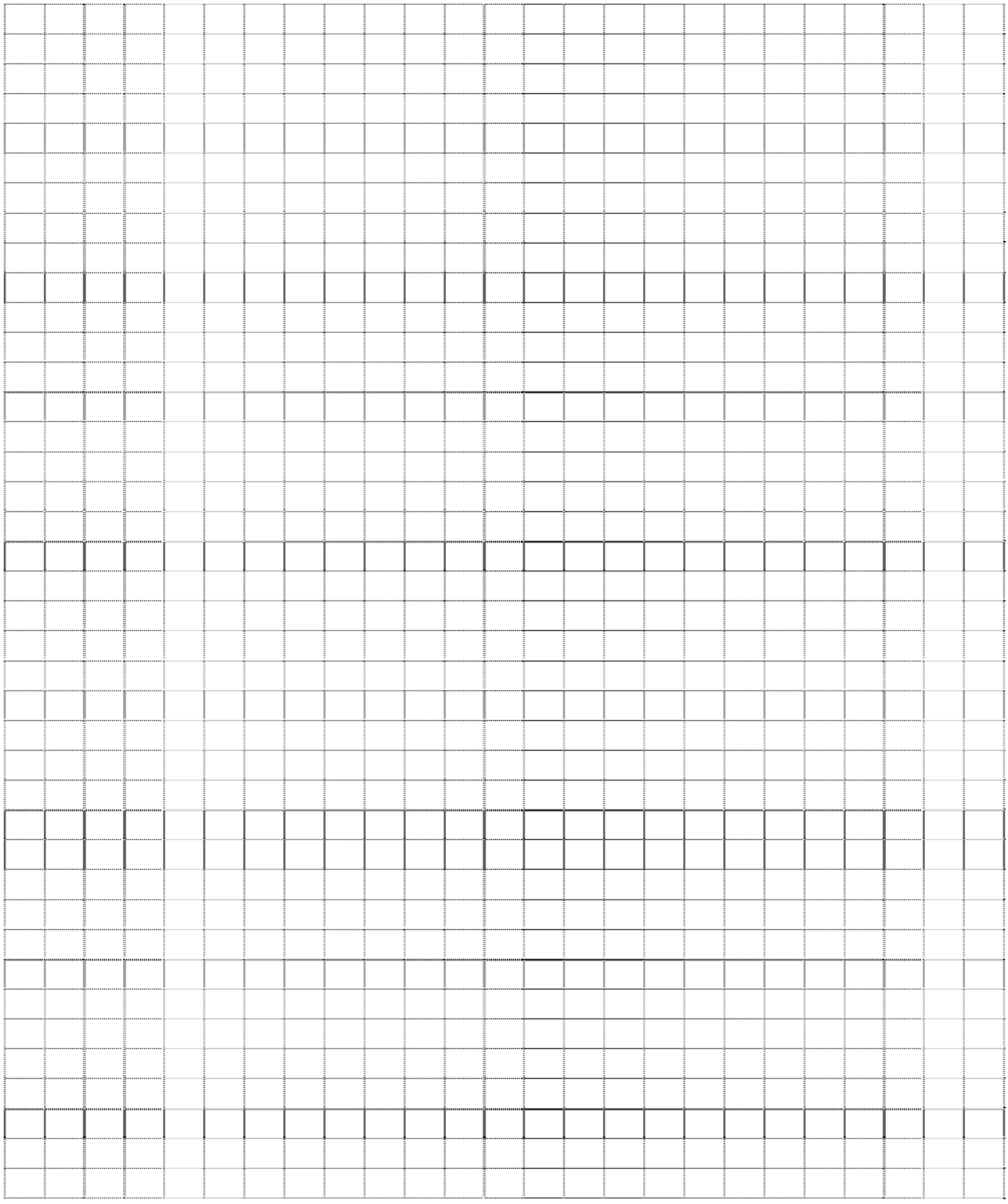
Answer Sheet
(Activity 2.2 – Tracing the Sun's Heat)



Names: _____

Tracing the Sun's Heat:

The Reason for the Seasons!



Name: _____

The Earth, Venus, and Mars

Planet Studied: _____

Describe the planet's surface:

_____
_____
_____

What gases are in the planet's atmosphere?

_____
_____
_____

Describe the climate and temperatures on the planet's surface:

_____
_____
_____

How many days does it take the planet to orbit the sun?

_____

How long does it take the planet to revolve once on its axis?

_____

Other Interesting Details: _____
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_____
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Websites Visited: _____
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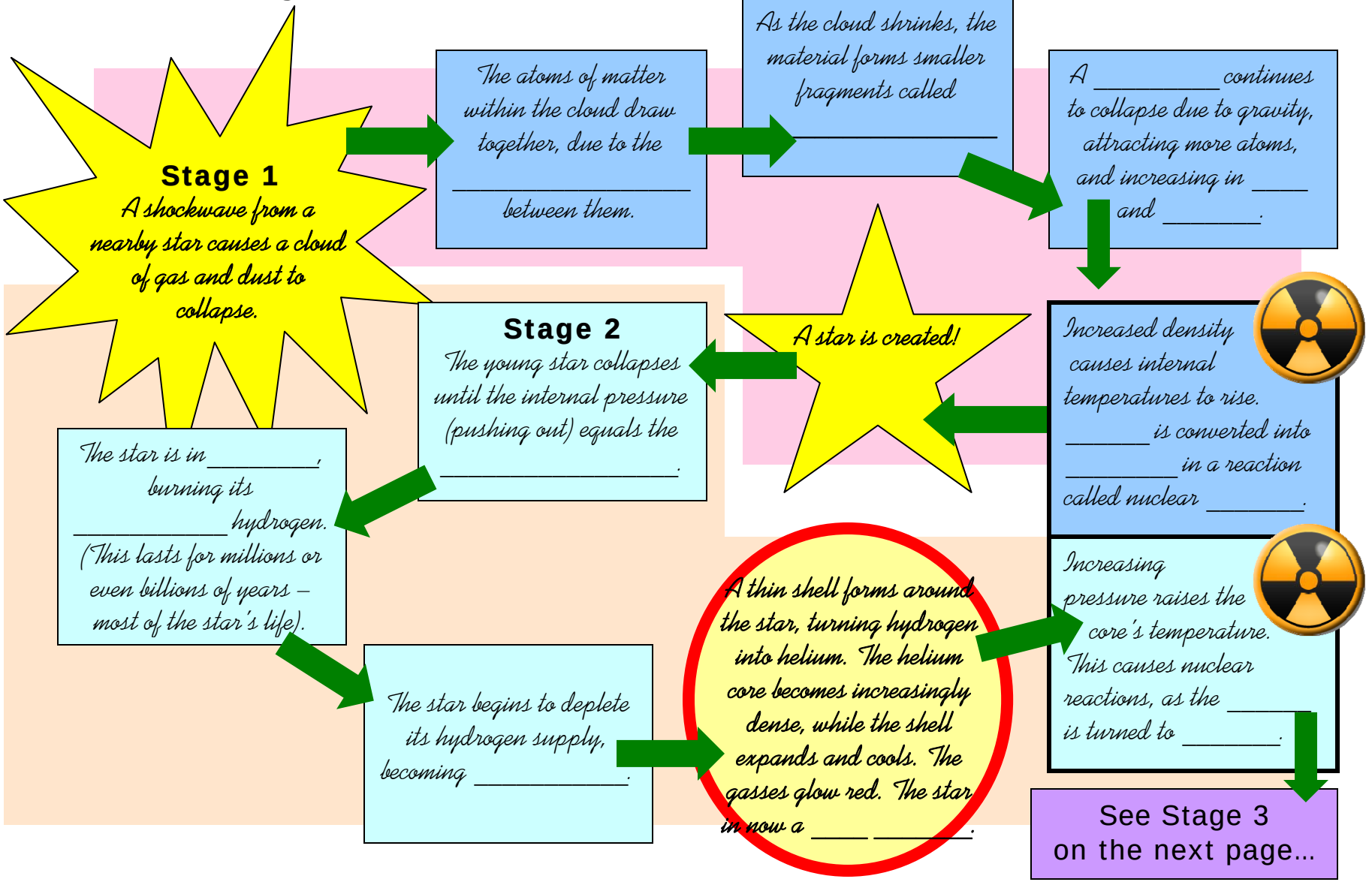
The Lifecycle of a Star...



CANADA SCIENCE AND TECHNOLOGY MUSEUM

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Stage 3a (Low Mass Stars)

The star consumes all of its _____.

The star dies by ejecting its outer layers, creating a _____ _____.

The carbon core continues to shine, due to its stored heat. It is called a _____ _____ _____.

The star gradually cools and dims, becoming a _____ _____.

Stage 3b (High Mass Stars)

The internal pressure and temperature continues to rise, causing a chain of nuclear reactions which create elements that are increasingly _____.

_____ is eventually produced. _____ is the heaviest element that a star can produce.

The star no longer produces enough energy to generate the _____ _____ required to match the star's _____ _____.

The inner core "sucks in" its surrounding layers, and implodes. The collapsing matter rebounds off of the core, exploding into space. This is called a _____.

The _____ burns for a few weeks or months, until it dims. It will eventually become a _____ star or a _____ hole, or will blow itself apart. The remaining nebula of gas is called a _____ _____.

The dust and gas that remain are used in the formation of other _____ and _____.

The explosion of stars produces shockwaves that can trigger the collapse of nearby _____ – starting the process all over again!

CANADA SCIENCE AND TECHNOLOGY MUSEUM

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The Canada Science and Technology Museum
presents:

Astronomy:
A Virtual Exploration Guide

Section 3

Tools of the Trade:
The Technology of Astronomy

CANADA SCIENCE AND TECHNOLOGY MUSEUM

Canada

Introduction

Our ever-increasing understanding of astronomy would not be possible without constant technical innovation. Galileo would not have been captivated by the Universe had he not built his first telescope and turned it skyward. A myriad of equipment, from hand-held binoculars to multi-million dollar observatories, is essential for our study of the universe. The following activities will help your students to discover the tools of the astronomer's trade, and better understand how they function.

Section 3 Content

The following is an outline of this section's structure and intended activity grade levels. For a comprehensive overview of the whole Exploration Guide, please see Section 1.

Primary (K-3)
- 3.1 Measuring the Sun's Heat: Thermometers

Junior (Grade 4 to 6)
- 3.2 How Telescopes Work

Transitional (Grade 4 and up)
- 3.3 Artifact Study

Intermediate/Senior (Grade 7 and up)
- 3.4 Observatories Across Canada
- 3.5 International Observatories: Canadian Partnerships

Distinctive icons throughout the Exploration Guide indicate its key features, helping you to find your way through the text quickly and efficiently.

 **Classroom Activity**	 **Discussion or Essay Topic**
 **Deeper Study**	 **Website to Visit**

Resources for the Activities

Many of the following activities require students to conduct research online. Worksheets for all activities are included at the end of this section. Teachers may request an answer package for the more detailed Activity Sheets by e-mailing **virt_prog@technomuses.ca**. Please allow about a week for us to reply.

For a brief explanation of how the Earth's revolution causes seasonal changes, access the Canada Science and Technology Museum's explanation of the Seasons at: http://www.sciencetech.technomuses.ca/english/schoolzone/Info_Astronomy.cfm#sun. This content is suitable for teachers and older students.

Activities

For all Grade Levels: KWL Charts

You may wish to have your students complete **KWL charts** for all Section 3 activities (see attached worksheet). This graphic organizer will help students to better grasp "what they **K**now," "what they **W**ant to know," and (later) "what they **L**earned" through the course of this program's activities.

KWLs can be completed individually, or though group brainstorming. Those teaching younger classes might wish to post a KWL poster prominently in the classroom during the astronomy unit. Level and activity-appropriate KWL prompts are provided at the beginning of each activity.


Name: _____

The Tools of the Trade:
The Technology of Astronomy

KWL Chart

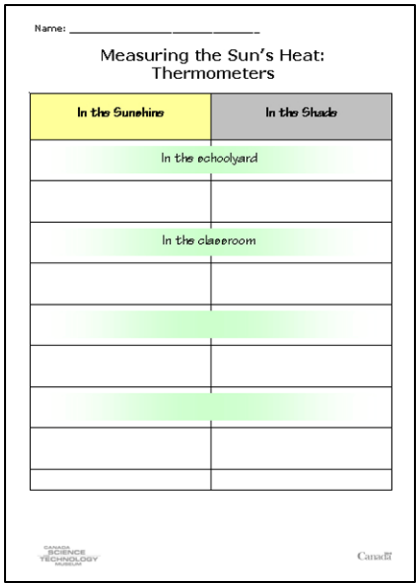
What I Know	What I Want to Know	What I Learned

Activity 3.1: Measuring the Sun's Heat: Thermometers

(Suitable for Kindergarten to Grade 3)

Possible KWL Prompts (see attached worksheet):

- What types of energy does the Sun provide for the Earth?
- How does the presence or absence of sunlight affect temperatures on Earth?


Name: _____

Measuring the Sun's Heat:
Thermometers

In the Sunshine	In the Shade
In the schoolyard	
In the classroom	

The thermometer is a fundamental scientific tool. In order to measure the amount of heat energy that the Sun provides, it is necessary to use a thermometer.

Conduct an experiment, using thermometers to measure the temperature at a variety of locations. Have students take thermometer readings in the sun and in the shade at various locations around the school (two examples are listed on the included worksheet). Using the worksheet, have students record their findings. You may wish to enlarge this worksheet, and post it within the classroom. Discuss the differences in temperature, explaining how the Sun provides heat (as well as light) for the Earth.

Extension Activity: *Have your students keep a "Sun Journal," recording daily temperatures in the morning, afternoon, evening, and at night. Students will realize that in general, temperatures are hottest when the Sun is highest in the sky. As well, they will see that the afternoon is the hottest time of day, while the overnight is the coolest. Collect this data as a class, charting and creating a graph.*

Activity 3.2: How Telescopes Work
(Suitable for Grades 4 to 6)

Possible KWL Prompts (see attached worksheet):

- What is a telescope?
- Are there different types of telescopes?
- What is the longest type of telescope?
- What do astronomers observe with a telescope?

To introduce the subject of telescopes, and explain how they work, have your class view **"Telescopes – the Astronomer's Tools"** on the Canada Science and Technology Museum's website at the following address:

http://www.sciencetech.technomuses.ca/english/schoolzone/Info_Astronomy.cfm

Part 1 – Build a Galilean Telescope

Have your students create a telescope, emulating Galileo's famous astronomical tool. Following the directions provided, students will be able to construct a telescope that improves on the viewing power of Galileo's historic creation!

Materials:

You may choose to have students bring some of the required supplies from home. Depending on the age of your students, it might also help to have students prepare some of the supplies in advance, with the help of their parents (cutting the end of the potato chip tube, and removing the handles from magnifying glasses).

Materials, cont'd:

- Two magnifying lenses, one measuring roughly 3" (7.5 cm) in diameter, the second measuring roughly 2" (5 cm) in diameter.
    Ideally, to ensure uniformity between students, you could purchase lenses from a science or education supply store or catalogue. Alternately, you or your students could purchase magnifying glasses at a hardware, office supply, or dollar store. In this case, the handles would need to be removed. This might require cutting through the handles.
- An empty cardboard potato chip tube, rinsed out and dried well
- A sheet of matte black Bristol board
- A serrated knife (such as a steak knife) – to be used with adult assistance, depending on the age of the students
- A stapler
- A low-temp glue gun and glue sticks
- Scissors
- Black electrical tape
- Metallic makers, glow-in-the-dark pens, and/or stickers.

Process:

Step 1 – Preparing the Tube: Using the serrated knife, remove the metal base from the potato chip tube. Cut as close as possible to the base. (Younger children will need an adult to do this – you may choose to have the tubes prepared by parents at home ahead of time).

Step 2 – Cut out the Bristol board Pieces: Cut a rectangle of Bristol board large enough to wrap around the outside of the tube (wrap the Bristol board around the tube first, and then mark a cutting line with a pencil). Cut the Bristol board slightly wider than required, to allow for a 1/2 to 1 inch (2.5 cm) overlap when wrapped around the tube. Using this piece of cardboard as a template, trace and cut out two more pieces of Bristol board.

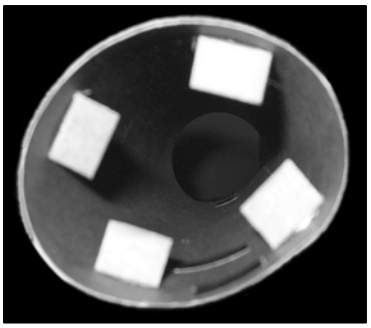
Step 3 – Cover the Outside of the Tube: Using the glue gun, glue a piece of Bristol board around the outside of the potato chip tube. Do this slowly, laying a bead of glue every couple of inches, smoothing the cardboard, and proceeding.

Step 4 – Cover the Inside of the Tube: Roll another cut piece of Bristol board into a tight cylinder, insert it into the tube, and let go. It will take the same size as the inside of the tube. Slide the inner cardboard halfway out of the tube. Secure the cylinder to itself with two staples. Repeat with the other end of the inner cardboard cylinder. Trim both ends of the cylinder so it sits neatly within the potato chip tube. Squirt hot glue between the inner cylinder and the inside surface of the potato chip tube. This will keep the inner cylinder in place.

Step 5 – Create the Sliding Focus Tube: Roll the third piece of Bristol board into a tight cylinder, and proceed as per Step 5 (stapling and trimming). Ensure that this inner cylinder slides freely within the tube. DO NOT glue this cylinder in place – remove it from the tube. Use electrical tape to cover the outside seam that runs the length of the sliding focus.

Step 6 – Secure the Larger Lens: If your lens only has one curved side, be sure that the curve is facing outwards**.** Using hot glue, secure the larger lens to one end of the covered potato chip tube. Reinforce this bond, using black electrical tape to secure the edge of the lens to the outside of the tube.

Step 7 – Cut out Bristol board "Brackets": Cut out 12 pieces of Bristol board, measuring 1/2" x 1" (roughly 1 x 2.5 cm). These pieces will serve as brackets to hold the lens and optional eyepiece in place. Fold each of these pieces in half widthwise.



Step 8 – Secure the Smaller Lens: Measure 2" (5 cm) down inside the sliding focus tube. Mark this measurement at four evenly-spaced spots inside the tube. Place a bead of hot glue on each of these marks. Glue a bracket at each spot, with the fold facing towards you **(see image, left)**. Place a bead of hot glue on the free end of each bracket, and glue the smaller lens in place. If the lens only has one curved side, be sure that the curve is facing away from you. Glue four more brackets in place, securing the front of the lens, and hiding the first set of brackets.

Step 9 (Optional) – Creating the Eyepiece: Trace the circumference of the sliding focus tube onto a scrap of Bristol board. Cut out this circle. Find the centre of this circle, and cut out a smaller circle no larger than 1/2" (or roughly 1 cm) in diameter.

Step 10 (Optional) – Installing the Eyepiece: Glue the 4 remaining brackets to the sliding focus tube, at the same end that the lens is located. Each bracket's fold should line up with the outer edge of the tube. Apply glue to the free end of each bracket, and secure the eyepiece in place. Reinforce this bond, securing the edge of the eyepiece to the tube using electrical tape.

Step 11 – Finishing and Decorating Your Telescope: Use electrical tape to cover any rough seams on the outside of your telescope. Slide the open end of the sliding focus tube into the heavier potato chip tube. Personalize the outside of the heavier tube, using metallic markers, glow-in-the-dark pens, and/or stickers.

You may wish to have your students draw various constellations on the outside of their telescope. This can later serve as a reference for them when they use their telescope to view the night sky. Constellation patterns can be obtained from the Star Charts or Planisphere located on the Canada Science and Technology Museum's website at the following address:

www.scientech.technomuses.ca/english/whatson/astronomy-resources.cfm

Using your Telescope:

Find an object in the distance that you would like to examine. Point your telescope in its direction, and look through the eyepiece (or open end of the sliding focus tube). Slide the sliding focus tube until the object appears in crisp focus. Note that the object will appear to be upside down – it is supposed to!

Extension Activity – Discover Refraction: *Refraction occurs when light bends as it passes from one medium to another medium. To give a concrete example, place a pencil in a glass half filled with water. What happens to the pencil? It appears bent because light is refracted. Light travelled from one medium, the air, and passed through another medium, water. Now try placing a test tube full of water in a beaker full of vegetable oil. Refraction is what allows you to see the water in the test tube. Now place a test tube full of vegetable oil in the beaker. Not only do you not see the oil – you don't even see the test tube. This is because the light passes through with very little refraction. Experiment, layering water and oil within the same test tube.*

Extension Activity – Discover Space Phenomena: *As a large group (using an LCD projector), discover breathtaking images that have been captured by the Canada France Hawaii Telescope. From* http://www.cfht.hawaii.edu/*, follow the "Images and Photos" link to the* ***Hawaiian Starlight*** *project. Here, you can view photographs and read brief factsheets regarding space phenomena such as nebula.*

Visual Art Assignment: *As a follow-up to the extension activity above, have students replicate the appearance of nebula by dripping thinned watercolour paint onto wet cold-pressed (thick, rough) paper. Let students experiment, layering colours, misting with clean water, and using coarse salt to absorb the paint (creating "stars"). Note that the most interesting works are often minimalist!*

Activity 3.3: Artifact Study
(Transitional – Grades 4 and up)

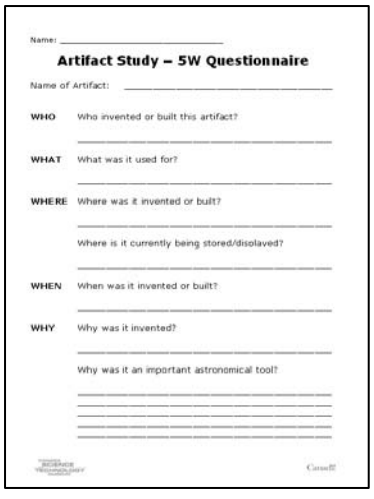
Possible KWL Prompts (see attached worksheet):

- What is an artifact?
- Where are artifacts stored and studied?
- Do astronomers use any tools other than telescopes? What kind?
- What types of astronomical artifacts might exist from the pioneer era? The early twentieth century? The late twentieth century? How would they differ?

There are many different ways of studying the past. Material History (or Material Culture) is an important element of this study. Material historians and researchers examine artifacts (or objects) and explore what they tell us about life, technology, and society, in the past. This is why it is important for societies to preserve, study, and share their important artifacts at museums.

Have your students visit the following website:

www.scientech.technomuses.ca/english/whatson/astronomy-resources.cfm



Name: _____

Artifact Study – 5W Questionnaire

Name of Artifact: _____

WHO Who invented or built this artifact?

_____

WHAT What was it used for?

_____

WHERE Where was it invented or built?

_____

Where is it currently being stored/displayed?

_____

WHEN When was it invented or built?

_____

WHY Why was it invented?

_____

Why was it an important astronomical tool?

_____

Here, they will find a selection film clips. In each of these clips, The Canada Science and Technology Museum presents the history and function of several of its astronomical artifacts.

Have your students select one (or all) of these film clips, and answer the questions on the corresponding worksheet.

Note that every question on the worksheet might not be answered in every film clip. This activity is intended to guide student learning, and for formative evaluation.

Alternate Activity:
Visit www.scientech.technomuses.ca/english/whatson/astronomy-resources.cfm to download the Museum's "ArtiFactsheet" posters. Each poster features an artifact presented in one of the films. These posters can be used to complete the worksheet featured above. This option is a good choice for hearing-impaired students, or classes that do not have access to a computer lab.

Video Assignment: *Working in pairs, have students conduct research and create their own short films, explaining the history and function of an astronomical instrument (such as a reflecting or refracting telescope, or a satellite).*

Extension Activities: *A series of extension activities have been written to accompany each of the Canada Science and Technology Museum's film clips. These activities mainly address students at the secondary level. Some are suited to classroom use, while others require students to observe the night sky. These activities are appended following the student activity sheets.*

Activity 3.4: Observatories Across Canada
(Suitable for Grades 7 and up)

Possible KWL Prompts (see attached worksheet):

- What is an observatory?
- What do researchers observe and study in an observatory? Only stars and planets?
- What sense(s) do astronomers use?
- Do astronomers use any tools other than optical telescopes? What kind?
- Has the focus of astronomical study shifted over time? Towards what technologies?

There are many ways to see the stars – not all of them involve using your eyes! Canadian observatories employ a variety of telescopes that rely on different frequencies of electromagnetic radiation to observe celestial bodies and events.

For more information about the many types of telescopes that exist, and how they work, you (or your students) may want to visit the National Research Council's website at the following address:
http://www.nrc-cnrc.gc.ca/eng/education/astronomy/topics/tools.html


Name: _____

Observatories Across Canada
Fast Facts At-a-Glance

Name of Observatory: _____
Location: _____
Year Founded: _____
Founding Organization: (if applicable) _____
Key People: (if applicable) _____
"Claim(s) to Fame": _____
Areas of Research/ Interesting Facts: _____
Types of Equipment: _____

Part 1: The following activity will help students to contextualize the many fields of study within the realm of astronomy. Students will note how research methods and tools have shifted over time — demonstrating the advancement of Canadian technology.

Have your students visit the following website:
http://astro-canada.ca/_en/a2100.html

Here, students will find a listing of Canadian observatories and observational partnerships, listed chronologically. Students can follow the links to discover specific information about each observatory.

Break you class into pairs, and assign each pair one of the following observatories:

- The Dominion Observatory (1905-1970)
- The Dominion Astrophysical Observatory (1917-)
- David Dunlap Observatory (1935-2008)
- Algonquin Radio Observatory (1961- 2006)
- University of British Columbia Liquid Mirror Observatory
- Dominion Radio Astrophysical Observatory
- Rothney Astrophysical Observatory
- Mont-Mégantic Observatory
- Sudbury Neutrino Observatory (1996-2007 – replaced by SNO Lab)

Have each pair complete a "Fast Facts At-a-Glance" worksheet. Encourage students to read the other sections once they complete the factsheet for their own. Take up the answers with the class, and collect the worksheets for formative evaluation.

Note that the reading level and complexity of this activity's texts are quite challenging. Students will not need to comprehend all content in order to find the answers to the worksheet's questions. Stress the importance of text skimming – passing over information that is irrelevant in order to find the facts that you actually need.

Part 2: Have the students find the location of each of the listed observatories. Have students indicate the location of each observatory on the "Mapping Canada's Observatories" worksheet.

Students can complete this activity using the same website as in Part 1, a mapping site (such as mapquest.ca), or they can work offline using atlases.

Additional Online Resources: For more information about Canada's observatories, please consult the following websites:

The Dominion Observatory
http://www.sciencetech.technomuses.ca/english/collection/dominion_observatory.cfm

Mont Mégantic Telescope
http://www.astro.umontreal.ca/omm/omm_eng.html

Dominion Astrophysical Observatory
http://www.hia-iha.nrc-cnrc.gc.ca/drao/index_e.html

Activity 3.5: International Observatories: Canadian Participation

(Suitable for Grades 7 and up)

Possible KWL Prompts (see attached worksheet):

- To what degree is Canada recognized in the field of Astronomy?
- Why would Canada choose to participate in international partnership programs?
- In what ways does Canada contribute to the world-wide field of Astronomy?
- How does Canada benefit from international partnerships?

Name: _____

International Observatories: Canadian Partnerships

Name of Observatory or Project: _____
Location: _____

Partnering Countries & Percentage of Observation Time (if stated):

Canada's Contributions:

Area of Research / Interesting Discoveries:

What do you believe would be the benefits of the partnership to Canada?

Have your students visit the following website:

http://astro-canada.ca/_en/a2100.html

Here, students will find a listing of Canadian observatories and observational partnerships, listed chronologically. Break you class into pairs, and have each pair read about the following partnership projects:

- The Canada-France-Hawaii Observatory
- The Gemini North and South Observatories
- The FUSE Space Telescope
- The Odin Space Observatory

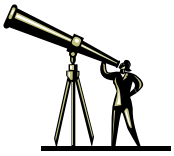
Provide each pair with four copies of the "International Observatories – Canadian Partnerships" worksheet, and have them complete a worksheet for each of the listed partnerships. Note that the questions on the worksheet only pertain to these four observatories/telescopes – this activity will not work with the other sites listed on the website.

Take up the answers with the class, and collect the worksheets for formative evaluation. Remember to link the knowledge gained through this activities with the questions posed in the KWL activity.

Note that the reading level and complexity of this activity's texts are quite challenging. Students will not need to comprehend all content in order to find the answers to the worksheet's questions. Stress the importance of text skimming – passing over information that is irrelevant in order to find the facts that you actually need.

Additional Online Resources: *For more information about Canada's most recognized observatory partnerships, please consult the following websites:*

Canada France Hawaii Telescope – http://www.cfht.hawaii.edu/
Gemini Observatory – http://www.gemini.edu/



Extension Activity: *As a large group (using an LCD projector), discover the breathtaking images that have been captured by the Canada France Hawaii Telescope. From* http://www.cfht.hawaii.edu/, follow the "Images and Photos" link to the ***Hawaiian Starlight*** project. Here, you can view photographs and read brief fact sheets regarding space phenomena such as nebulae.

Name: _____

The Tools of the Trade: The Technology of Astronomy

KWL Chart

What I Know	What I Want to Know	What I Learned

Name: _____

Measuring the Sun's Heat: Thermometers

In the Sunshine	In the Shade
In the schoolyard	
In the classroom	

Name: _____

Artifact Study – 5W Questionnaire

Name of Artifact: _____

WHO Who invented or built this artifact?

_____

WHAT What was it used for?

_____

WHERE Where was it invented or built?

_____

Where is it currently being stored/displayed?

_____

WHEN When was it invented or built?

_____

WHY Why was it invented?

_____

Why was it an important astronomical tool?

_____
_____
_____
_____

Name: _____

Observatories Across Canada

Fast Facts At-a-Glance

Name of Observatory: _____

Location: _____

Year Founded: _____

Founding Organization: _____
(if applicable)

Key People: _____
(if applicable) _____

"Claim(s) to Fame": _____
_____
_____
_____
_____

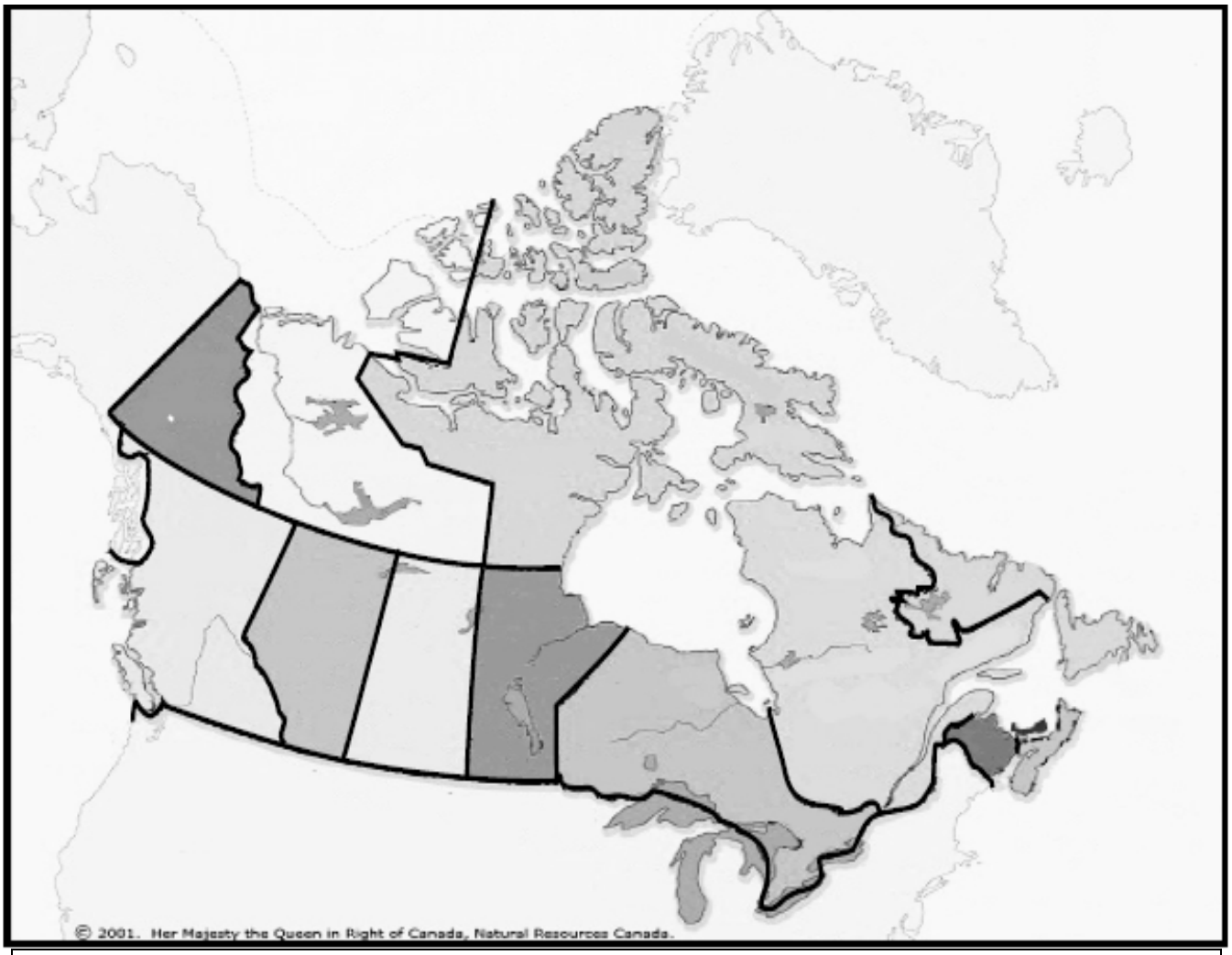
Areas of Research/
Interesting Facts: _____
_____
_____
_____
_____

Types of Equipment: _____
_____
_____
_____

Name: _____

Observatories Across Canada

Mapping Canada's Observatories



Legend:

1. The Dominion Observatory
2. The Dominion Astrophysical Observatory
3. David Dunlap Observatory
4. Algonquin Radio Observatory
5. Dominion Radio Astrophysical Observatory
6. Rothney Astrophysical Observatory
7. Mont-Mégantic Observatory
8. Sudbury Neutrino Observatory
9. University of British Columbia Liquid Mirror Observatory

Name: _____

International Observatories: Canadian Partnerships

Name of Observatory or Project: _____

Location: _____

Partnering Countries & Percentage of Observation Time (if stated):

_____

Canada's Contributions:

_____

_____

_____

_____

_____

Area of Research / Interesting Discoveries:

_____

_____

_____

_____

_____

What do you believe would be the benefits of this partnership to Canada?

_____

_____

_____

_____

_____

Astronomy Video Follow-up Activities

The following extension activities and discussion topics have been written to accompany the astronomy film clips presented on the Canada Science and Technology Museum's website. These activities mainly address older (secondary-level) students. Some are suited to classroom use, while others require students to observe the night sky.

Sundials

Younger students:

1. Over the next few days note what time the Sun rises or sets. How much does this time change each day? Will this amount of change be the same every day of the year? For a longer term project, make these same observations around the time of the winter or summer solstice, or the spring or autumn equinoxes (i.e. about Dec. 21st, March 21st, June 21st, and Sept. 21st).
2. Ancient civilizations divided the day time into 12 equal parts. This did not cause much of a problem at or near the equator. It would, however, be a problem for us in Canada today. Explain why this would be the case.

Older Students:

1. What is the equation of time? What is the shape of the Earth's annual orbit around the Sun? Can you figure out how the two are related? (Hint: Draw the distance that the Earth travels around the Sun when the Earth is close, and when it is further away).
2. Do you think you could make a moondial? What problems would you need to solve? What problems would not be solvable?

Optical Telescopes – Part I

1. Telescope optics (lenses and mirrors) have flaws that don't allow you to see all the detail you would like. For instance, Christian Huyghens, a 17th century Dutch astronomer, saw what he termed "ears" on Saturn. He could not see Saturn well enough to realize that the ears were actually rings. What other factors, beside optics, make it difficult for astronomers to observe objects clearly? Hint: have you noticed any difference between the appearance of stars close to the horizon compared to those high overhead?
2. Unlike the Moon and planets, most astronomical objects are very faint. Telescopes with larger lenses or mirrors are required for us to collect sufficient light to see these faint objects. For a period of a month, find a group of stars that is easy to find and recognize — preferably to the south or south-east, and about half way between the horizon and the highest point overhead (the zenith). Using a planisphere or star chart might be helpful to you in making your selection (both can be downloaded from the Canada Science and Technology Museum's website). Watch the sky each night and keep a diary of your observations. Keep track of how easy it is to observe the group of stars you chose. Also keep track of the position of the Moon — was it near or far away? Did it affect your observations of the star group? Besides clouds, did you notice any other factors that made your observations easy or difficult?

Optical Telescopes – Part II

For Students at the Secondary Level (or younger children, with adult assistance)

Equipment required: Binoculars (or a telescope)

One of the observations that shook the foundations of scientific and religious beliefs in 17th century was Galileo's discovery of Jupiter's moon. This discovery is easy to replicate with small optical instruments.

First, if you are using binoculars, take them outside during the day and become familiar with their use and adjustments (focusing, adjusting the spacing for your eyes, etc.). If you are using a small telescope, familiarize yourself with its mounting tripod. Looking at objects during the day, you will notice that they move through your field of view very quickly. What is the cause of this motion?

Next, check online to see when Jupiter is visible, and where it is located in the sky. Note that Jupiter is not always located in a spot that is convenient for viewing (for a few weeks each year, it is too close to the Sun to observe). Also check the position of Venus. If it is close to Jupiter, you might confuse the two planets (even though Venus is brighter) If Jupiter is visible, try to locate it in the night sky.

If you are using binoculars or a hand-held telescope, you should support the viewing device so you can look at one spot in the sky without the image moving. You can support your viewing device on a railing, on a car, or by leaning against a wall. If you have an "image stabilized" pair of binoculars or telescope, this step is not as necessary (though it is probably still a good approach).

Now look at Jupiter and see if you can identify any "star-like" objects near by — within about 10 to 15 times the diameter of Jupiter. Draw a chart showing Jupiter and these objects. Return three or four hours later and see if the objects' positions have changed. Check again the following evening, and as often as possible over the course of a month. Can you identify which of the "star-like" objects are Jupiter's moons; Io, Europa, Ganymede and Callisto?

Hint: Jupiter's moons, as listed above, are in order from the closest to Jupiter to the furthest. **Another Hint:** Ganymede is the largest (and the brightest) of Jupiter's moons. Io is only the 3rd largest, but it is second brightest. Why might this be the case?

NOTE: Remember that you are seeing the positions of Jupiter's moons as they are projected onto the sky. At times, they can be located behind or in front of Jupiter's disc. As well, you will sometimes see the shadow of one or more of the moons on Jupiter's disc. What astronomical events on the Earth are caused by the same type of alignment?

Radio Telescopes

Equipment required: Analogue television, “rabbit ears” or multi-element antenna

For Students at the Secondary Level (or younger children, with adult assistance)

First, if your TV is connected to a cable that provides your TV signal, have an adult remove the cable from the back of the TV. Note that most people in Canada receive “cable” service from a company such as Bell Expressvue, Cogeco, Rogers, Shaw or Skyview.

Attach the rabbit ears or multi-element antenna to the television. Turn on the TV, and select a station that has no signal. Most of the time you will see random “snow” continuously flashing on the screen. However, very occasionally you will see darker speckles that last from 1 to a few seconds. These speckles are caused by the radio emissions of a meteor as it enters the Earth’s upper atmosphere and burns up. The friction between the meteor and the air causes the air to become electrically charged or ionized in a “tube” along the meteor’s path. These charged particles generate a small radio pulse which is being picked up on your TV. On average, you might see one of these “flashes” on your TV every hour or two — so patience is definitely required. However, if you watch during one of the bright meteor showers, these will happen more frequently.

Here is a list of the strongest meteor showers. These are some of the best nights to try to detect radio signals:

Meteor Shower Name	Dates	Peak Dates
Quadrantids	Jan 1-Jan 5	Jan-03
Lyrids	Apr 15-Apr 28	Apr-22
Eta Aquarids	Apr 19-May 28	May-06
Arietids	May 22 Jul-2	Jun-07
South Delta Aquarids	Jul 12-Aug 19	Jul-28
Perseids	Jul 17-Aug 24	Aug-12
Orionids	Oct 2-Nov 7	Oct-21
Geminids	Dec 7-Dec 17	Dec-14
Ursids	Dec 17-Dec 26	Dec-22

The Canada Science and Technology Museum
presents:

Astronomy:
A Virtual Exploration Guide

Section 4

Astronomy, Canada, and Society

CANADA SCIENCE AND TECHNOLOGY MUSEUM

Canada

Introduction

There is more to Astronomy than scientific calculations and technological devices. Astronomy is also about people – how we have interpreted the night sky in the past, and how we continue to learn about our Universe. To fully appreciate Canada's role in Astronomy, we need to examine how different cultures have practiced astronomical observation. We also need to recognize the origins of modern astronomy in Canada, appreciating the work of noted Canadian astronomers, and examining the history of Canada's astronomical institutions.

Section 4 Content

The following is an outline of this section's structure, and intended activity grade levels. For a comprehensive overview of the whole Exploration Guide, please see Section 1.

Primary (K-3)

4.1 Daily Rituals: The Sun in our Lives

Transitional (Grade 4 and up)

4.2 Canadian Astronomers: A Biographical Study
4.3 Native Canadian Perspectives
4.4 Across Cultures and Time: Comparing Constellation Myths

Intermediate/Senior (Grade 7 and up)

4.5 Canada's Astronomical Institutions: A Research Activity

Distinctive icons throughout the Exploration Guide indicate its key features, helping you to find your way through the text quickly and efficiently.

 **Classroom Activity**	 **Discussion or Essay Topic**
 **Deeper Study**	 **Website to Visit**

Resources for the Activities

Many of the following activities require students to conduct research online. Worksheets for all activities are included at the end of this section. Teachers may request an answer package for the more detailed Activity Sheets by e-mailing virt_prog@technomuses.ca. Please allow about a week for us to reply.

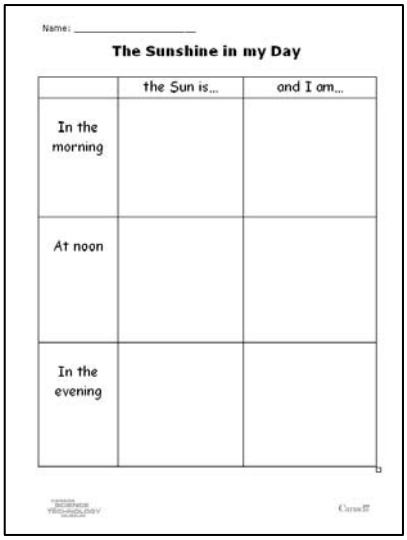
Note that, given the content of Section 4's activities,
there are no Section 4 Answer Sheets in the Answers Package.

Activities

Activity 4.1: Daily Rituals: The Sun in our Lives

(Suitable for Kindergarten to Grade 3)

Review with your students how the Earth's daily cycle results from its rotation on its own axis every 24 hours (as presented in Section 2 of this Exploration Guide). Further illustrate this principle using a revolving globe, a small (star) sticker, and a flashlight. Have your class find (or approximate the location of) your city, town, or village on the globe. Stick the sticker at this location. Point the flashlight at the sticker, and then spin the globe. Note how "day" and "night" pass as the sticker moves cyclically from the light into the shade.



Still using the globe and flashlight, engage your students in a discussion about the activities that they undertake over the course of a typical day. Encourage them to compare their daily rituals. For each phase of the day, note your community's location in relation to the Sun.

Sunrise:

- waking in the morning (who wakes them?)
- bathing or showering
- dressing and breakfast routines
- going to school, and morning school routines (calendar activity, "circle time," etc.)
- people (parents) going to work
- animals waking, birds starting to sing

Mid-day:

- lunchtime
- recess

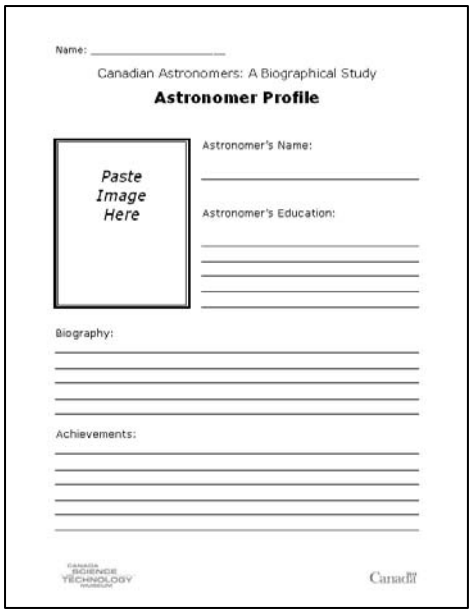
Sunset:

- dinner (supper) time
- starting to feel sleepy
- bathing, brushing teeth
- reading a bedtime story

Following this class discussion, have your students complete the associated worksheet (two pages), associating daily events with the Sun's location in the sky.

Activity 4.2: Canadian Astronomers: A Biographical Study
(Transitional – Grades 4 and up)

Have your students discover more about Canadian's contributions of the field of astronomy. Have students select an astronomer to study, and complete an "Astronomer Profile" sheet. Several suggestions are listed below to help you tailor this activity to the skill set and interests of your students:


Name: _____

Canadian Astronomers: A Biographical Study

Astronomer Profile

Paste Image Here

Astronomer's Name:

Astronomer's Education:

Biography:

Achievements:

Historical Focus (All Ages): Discover how notable Canadian astronomers have contributed to the study of astronomy in the past.

Select one of the following historic Astronomers:

- Carlyle S. Beals
- Clarence Chant
- Andrew McKellar
- Peter Millman
- John Plaskett
- Helen Sawyer Hogg

Contemporary Focus (Best for Older Students): When we examine how astronomy has been studied in Canada, it is easy to loose sight of the fact that astronomy is an innovative, fast-paced sector of the sciences and technologies. Discover present-day astronomers who work in Canada.

Select one of the following contemporary Canadian Astronomers:

- Arif Babul
- Joanne Brown
- Peter Brown
- Jayanne English
- Doug Johnstone
- Jaymie Matthews
- Jim Peebles
- John Percy
- Ian Short

These websites are a good starting point:

Canadian Astronomical Society http://www.cascaeducation.ca

Virtual Museum of Canada – "Canada Under the Stars: Astronomers" http://astro-canada.ca/_en/a2203.html

Process for Younger Students: Have students select an astronomer, and complete an "Astronomer Profile" factsheet. Sheets can be compiled in such a way that your class authors a "Big Book of Astronomers." This "book" can be proudly placed in your class's reading area as a resource.

Process for Older Students: The "Astronomer Profile" can serve as the first page of a larger research paper regarding that particular astronomer's area of research.

Activity 4.3: Native Canadian Perspectives
(Transitional – Grades 4 and up)

Canada's Native peoples have unique interpretations of the night sky in each of its phases. Their understandings of the Earth, its origins, and its cycles, were informed by what they witnessed, year after year, in the sky above. According to Native beliefs, the Earth is seen to be flat. The Sun, stars, and other celestial bodies are believed to be moving overhead across a solid canopy. In many Native cultures, each star was believed to be a unique and powerful spirit. A selection of Native Canadian astronomy-related legends is available on the Virtual Museum of Canada's "Canada Under the Stars" website at: http://astro-canada.ca/_en/a4101.html.

Depending on the age and abilities of your students, you could approach this material in a variety of ways:

- Break your class into small groups, and assign a legend to each group. Have each group pantomime their legend to the rest of the class, while one student reads the story aloud.

- Break your class into jigsaw groups. Have each group memorize one of the legends, and practice sharing it in a dramatic, storytelling style. Then reorganize the groups, such that one child in each group knows each story. Have students tell their stories in a sharing circle. You may choose to pass a stick between storytellers, as is customary in some Aboriginal groups.

Possibilities for Summative Evaluation Projects:

- Have students select one of the featured legends, and rewrite it in the form of a children's book. You may wish to review the conventions of various writing styles, particularly effective children's literature (repetition, etc.). Don't forget to have students illustrate their work! Students may wish to share their storybooks with younger classes in the school.

- Have your students read each of the legends, and write their own astronomy-related legend. Be sure to review the conventions of story writing, particularly legends.

- Discuss the use of symbolism and iconography in Native legends, comparing Native symbolism to European Judeo-Christian literary symbolism. Examine examples of Native Canadian artwork, discussing how art can tell a story. Have students create their own artwork, in a traditional Native style, to represent one of the legends that they read.

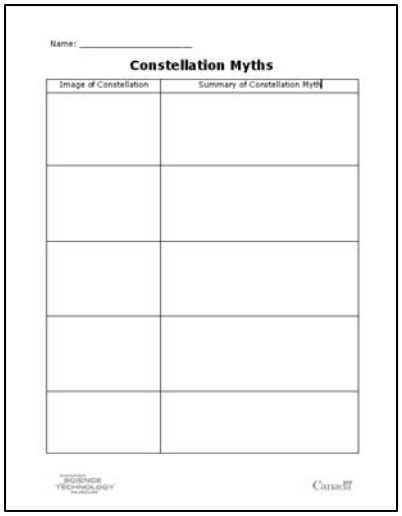
Activity 4.4:
Across Time & Cultures: Comparing Constellation Myths
(Transitional – Grades 4 and up)

A constellation is a grouping of stars in which people have "seen" a picture. Over time, different cultures have attached unique mythical and spiritual meaning to the constellations. For a brief introduction to constellations, and their cultural significance, read Ken Tapping's article titled "That? A Crow?" on the National Research Council's website:

http://www.nrc-cnrc.gc.ca/eng/education/astronomy/tapping/2005/2005-05-11.html

Part 1: Ask your students if they can name any constellations. Make reference to popular culture. With some prompting, students might recognize that each of the Zodiac signs shares its name with a constellation. Have your students learn about the constellations, and how they move across the night sky. Visit the National Research Council's Interactive Planisphere at:

http://www.nrc-cnrc.gc.ca/eng/education/astronomy/constellations/planisphere.html


Name: _____

Constellation Myths

Image of Constellation	Summary of Constellation Myth

With this interactive tool, students can view the night sky as it appears on any given night of the calendar year. Using the included worksheet, have students select five constellations, draw them, and provide a summary of their associated myth. Note that most of the referenced myths derive from Greek and Roman mythology.

Encourage students to look up significant dates (such as their birthdays) and read about the stars that appear in the sky at that time. As they read more about each of the constellations, older students might realize that they have heard references to these names in other places (on television, in literature, etc.).

Extension Activity: *Have your students create their own planispheres (or star wheels). Planisphere plans are available on the Canada Science and Technology Museum's website at*:

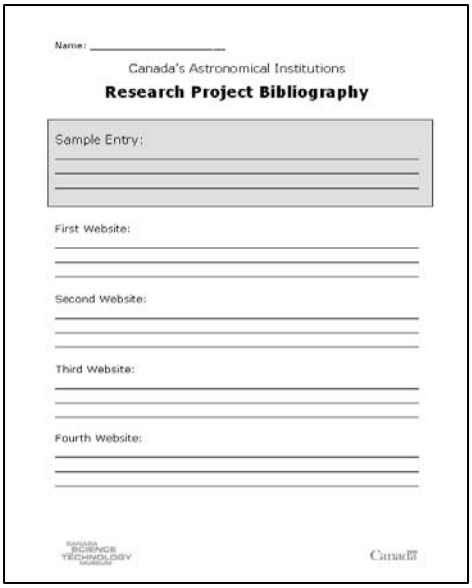
www.scientech.technomuses.ca/english/whatson/astronomy-resources.cfm

Students can use these planispheres to examine the night sky at home. Younger students will enjoy this opportunity to "be an expert" by pointing out the constellations for their families.

Possible Project: There are many cultural myths and legends related to each of the constellations. Have your students conduct an online research project to discover stories related to the Ursa Major (or "Big Bear") constellation.

Activity 4.5: Canada's Astronomical Institutions: A Research Activity

(Suitable for Grades 7 and up)



Name: _____

Canada's Astronomical Institutions

Research Project Bibliography

Sample Entry:

First Website:

Second Website:

Third Website:

Fourth Website:

Astronomy-related innovation in Canada is largely due to the work of a number of science and technology institutions. These departments and organizations encourage innovation by operating and funding a varitey of important programs.

Break your class into small groups, and have each group prepare a presentation about one of the following organizations. Each group will need to conduct research online, prepare a written draft of their presentation, and compile a bibliography of their online resources (on the provided template sheet). A space for a sample bibliographical entry is provided on the worksheet – complete this example together as a class. Be sure to stress the importance of using reputable online sources.

Provide students with the following questions to guide their online research:

- What does your organization do (what is its mandate)?
- What type of organization is it? (A government department? A not-for-profit organization?)
- When was the organization founded? By whom? Why?
- Why is this organization important to the study of astronomy in Canada?

If it is feasible, encourage students to use computer technologies (such as PowerPoint) to present their finding.

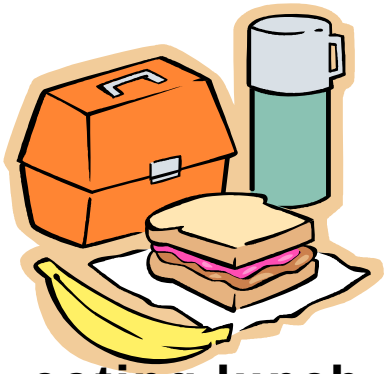
Optional: You may wish to have students format their presentations using the model of a five-paragraph essay. In this case, students would need to form a thesis (i.e. "The Hertzberg Institute is an important Canadian institution"), and support this thesis with three arguments based on their online research.

Possible Astronomy Organizations & Institutions *Do not provide these addresses to your students right away –* *allow them to use their research skills to find the sites themselves!*	
National Research Council (NRC)	www.nrc-cnrc.gc.ca
Canada Space Agency	www.asc-csa.gc.ca
Canadian Astronomical Society (CASCA)	www.casca.ca
Royal Astronomical Society of Canada	www.rasc.ca
Hertzberg Institute of Astrophysics	www.hia-iha.nrc-cnrc.gc.ca

The Sunshine in my Day

Cut out each of these pictures, and paste it to the chart.

rising



eating lunch

high in the sky

reading a bedtime story

going to school

setting

Name: _____

The Sunshine in my Day

	the Sun is…	and I am…
In the morning		
At noon		
In the evening		

Name: _____

Canadian Astronomers: A Biographical Study

Astronomer Profile

Paste Image Here

Astronomer's Name:

Astronomer's Education:

Biography:

Achievements:

Name: _____

Constellation Myths

Image of Constellation	Summary of Constellation Myth

Name: _____

Canada's Astronomical Institutions

Research Project Bibliography

Sample Entry:

_____
_____
_____

First Website:

_____
_____
_____

Second Website:

_____
_____
_____

Third Website:

_____
_____
_____

Fourth Website:

_____
_____
_____

The Canada Science and Technology Museum
presents:

Astronomy:
A Virtual Exploration Guide

Section 5

Astronomy and our Environment

CANADA SCIENCE AND TECHNOLOGY MUSEUM

Canada

Introduction

As we study the stars and planets, there is a tendency to view Astronomy as being 'distant' — without practical implications in our world. This is far from being the truth. By studying celestial phenomena, we learn more about many aspects of our environment, from why we have to dress differently for each season, to why the tides change. Through the course of this section, your students will investigate how events in space impact the environment on Earth. Older students will also examine how space research has led to technological innovations that can teach us more about our environment.

Section 5 Content

The following is an outline of this section's structure and intended activity grade levels. For a comprehensive overview of the whole Exploration Guide, please see Section 1.

Primary (K-3)

5.1 Canada's Seasonal Cycles: Dressing for the Weather

Junior (Grade 4 to 6)

5.2 The Seasonal Behaviour of Canada's Animals

Transitional (Grade 4 and up)

5.3 All About Tides

Intermediate/Senior (Grade 7 and up)

5.4 Solar Winds and the Aurora Borealis

5.5 Satellites and their Environmental Applications

Distinctive icons throughout the Exploration Guide indicate its key features, helping you to find your way through the text quickly and efficiently.

 **Classroom Activity**	 **Discussion or Essay Topic**
 **Deeper Study**	 **Website to Visit**

Resources for the Activities

Many of the following activities require students to conduct research online. Worksheets for all activities are included at the end of this section. Teachers may request an answer package for the more detailed Activity Sheets by e-mailing virt_prog@technomuses.ca. Please allow about a week for us to reply.

Activities

Activity 5.1: Canada's Seasonal Cycles: Dressing for the Weather

(Suitable for Kindergarten to Grade 3)

This activity reinforces the idea that Canada's four seasons result from the changing angles at which sunlight reaches the Earth over the course of the year. Before you begin this activity, review the relationship between the tilt of the Earth's axis, and the temperature on Earth. This relationship is explained in Activity 2.2 of the Exploration Guide (Tracing the Sun's Heat).

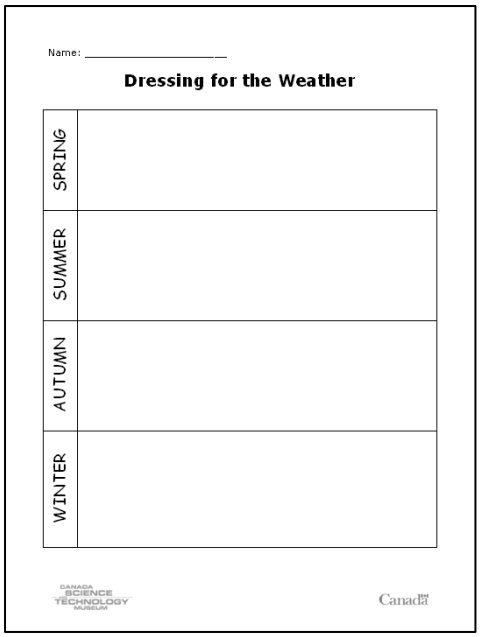
For this activity, you will need a suitcase filled with examples of seasonal outerwear, a wall-mounted map of Canada, a flashlight, old magazines and catalogues, safety scissors, glue, and the activity worksheet.

Part 1: Packing a Suitcase – Tell your students to imagine that you are going on a trip across Canada. This trip will take 365 days, so you have packed all of the clothes that you will need for a whole year. Take the articles of outerwear out of the suitcase one-by-one. As a class, have students identify each article of clothing, which season it should we worn in, and why. Have students use the flashlight to illustrate on the map the angle at which sunlight hits the earth during each season (as per Activity 2.2). For ideas about possible seasonal clothing items to include, see the chart below:

TYPES OF CLOTHING			
Fall cool, getting colder	**Winter** cold, freezing	**Spring** cool, getting warmer	**Summer** warm, getting hotter
windbreaker jacket rain coat rubber boots light mittens toque wool or polar fleece sweater	parka scarf heavy socks winter boots wool or polar fleece toque mittens	windbreaker jacket rain coat rubber boots light mittens toque wool or polar fleece sweater	t-shirt shorts running shoes sandals sun hat sunglasses

Part 2: Qualities of Seasonal Clothing – As a large group, brainstorm qualities that make articles of clothing suitable for a specific season. Organize your students' thoughts into a chart on the blackboard, as per the following example:

SOME CHARACTERISTICS OF CLOTHING			
Fall Fabrics need to:	**Winter** Fabrics need to:	**Spring** Fabrics need to:	**Summer** Fabrics need to:
cover most of the body be windproof be waterproof be breathable be warm	cover the whole body be heavy to keep you warm insulate be windproof be waterproof be thick have many layers	cover most of the body be windproof be waterproof be breathable be warm	keep you cool be light be thin be breathable protect from the Sun



Name: _____

Dressing for the Weather

SPRING	
SUMMER	
AUTUMN	
WINTER	

Part 3: "Dressing for the Weather" Chart – Distribute magazines and catalogues, scissors, glue, and the attached worksheet. Ask students to imagine that they are now going on a year-long trip across Canada. Have them plan what clothing they would need to pack, cutting out examples of seasonal clothing, and pasting them in the appropriate row on the worksheet.

You may wish to enlarge the worksheet, printing on tabloid-sized paper. This will allow students more area to paste their gathered images.

A variation of this activity would be to have students work in groups, pasting images onto a Bristol board.

Activity 5.2: The Seasonal Behaviour of Canada's Animals

(Suitable for Grades 4 to 6)

One effect of Canada's changing seasons is animal migration and hibernation. Many factors trigger migration and hibernation, including temperature changes and fluctuations in daylight hours. These factors are a direct result of the Earth's revolution around the Sun. Indeed, it is thought that some animals are even guided by the position of the Sun and stars. Certainly, we can see that astronomy has a direct correlation with the actions of animals on Earth.

For more information about animal migration, visit the *Hinterland Who's Who* website at www.hww.ca/hww2.asp?id=126

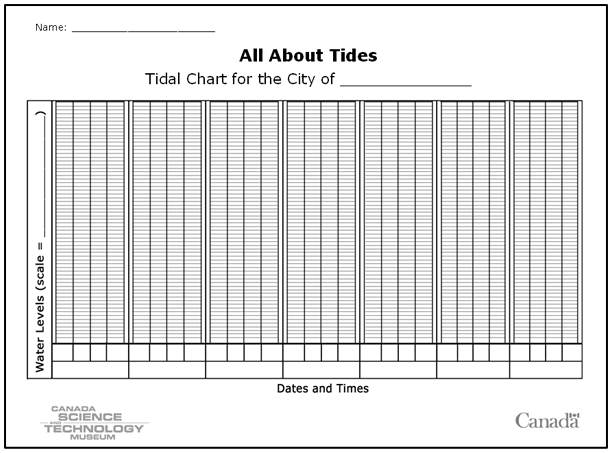
Have your students visit the *Hinterland Who's Who* online media centre at www.hww.ca/media.asp. They will find a variety of video clips and factsheets pertaining to Canadian wildlife. Younger students can follow the 'youth' link to access video clips and factsheets that better suit their level of understanding and interest.

Working individually or in pairs, have students view a selection of the video clips. Ask students to select one of the featured animals, ensuring that they select an animal that migrates (most of the featured animals do). Using this resource, have students compile a small project explaining why the seasons change (as presented in earlier activities), and how seasonal changes affect the animal that they have selected. This project could take the form of a poster and/or an oral presentation.

Activity 5.3: All About Tides
(Transitional – Grades 4 and up)

It is very important for people to be able to predict the tide. Ships need to know when they can pass through bodies of water without hitting bottom. People also need to know when it is safe to access certain coastal areas. Interestingly, the rising and lowering of the tide is actually caused by the gravitational pull of the moon! That, and the centrifugal force of the Earth's rotation, cause there to be two high tides, and two low tides, everyday.

For a detailed explanation of why we have tides, visit the Canadian Space Agency's website at http://www.asc-csa.gc.ca/eng/educators/resources/astronomy/module3/content.asp#8. From Section 8 of this webpage, you can also access a "Tides and tidal interaction" applet. This interactive animation illustrates how the tides raise and lower due to the rotation of the Earth and the location of the Moon.


Name: _____

All About Tides

Tidal Chart for the City of _____

Water Levels (scale = _____)

Dates and Times

CANADA SCIENCE AND TECHNOLOGY MUSEUM

Canada

Working alone or in pairs, have your students visit Fisheries and Oceans Canada's website at www.waterlevels.gc.ca/english/Canada.shtml. From here, they can access tidal readings for a variety of coastal towns and cities on Canada's coastlines. Have students follow the prompts on the map to select a city. Note that tidal readings are presented differently for different regions of Canada. Have students access water level readings or predictions raging over a period of seven days.

Using the attached worksheet, have students chart the water levels, as read at high and low tides (if this is not broken down in chart form on the webpage, have students find the hours of high and low tide, looking at the fluctuating water level readings. There should be four readings per day charted on the graph.

Grades 4 to 6: Given that this is a challenging website to navigate, gather the information yourself from the website, and provide your students with paper copies of the required data. Have all students read the tide for the same city – perhaps your own.

Grades 7 and up: You may wish to have older students present their findings to the class. This charting could be one element of a larger project, whereby students conduct online research to examine the importance of waterways and water levels in their chosen city (their impact on wildlife, tourism, shipping, etc.).

Extension Activity: *Have your students research where the highest tides in Canada are located (Bay of Fundy and Ungava Bay). What special characteristics do these bays have?*

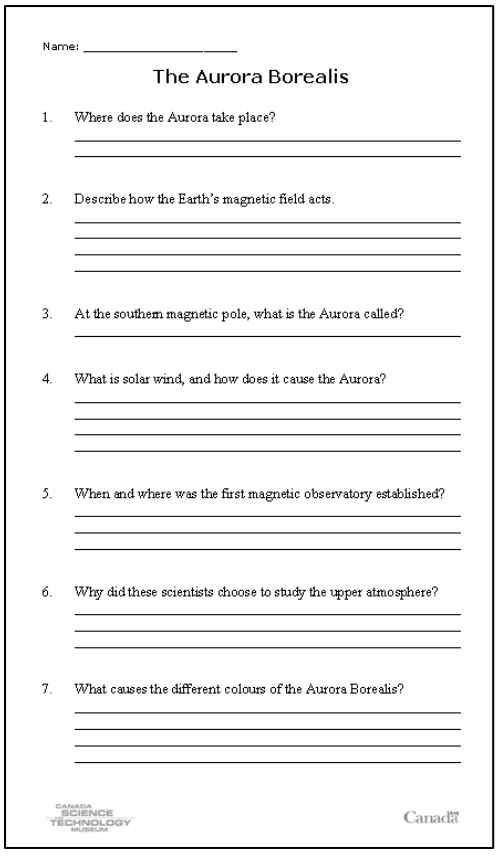
Activity 5.4: Solar Winds and the Aurora Borealis
(Suitable for Grades 7 and up)

If your students have ever witnessed the Northern Lights (or Aurora Borealis), they were likely captivated by their mystery and beauty. How better to engage your students' interest in Astronomy than by relating it to such a fascinating phenomenon!

The Aurora Borealis (in the Northern hemisphere) and the Aurora Australis (in the Southern hemisphere) are caused by electrically charged particles that are ejected from the surface of the Sun. This phenomenon is called "solar wind." This solar wind is attracted to the Earth's two magnetic poles. When it enters the Earth's atmosphere at these locations, it creates a dazzling spectacle in the night sky.

For a brief technical description of what causes the Aurora Borealis, visit the National Research Council's website at:
www.nrc-cnrc.gc.ca/eng/education/astronomy/topics/solar_phenomenon.html.

For a more in-depth explanation, visit Natural Resources Canada's website at:
www.nrcan-rncan.gc.ca/com/elements/issues/13/auror-eng.php.



Name: _____

The Aurora Borealis

1. Where does the Aurora take place?

2. Describe how the Earth's magnetic field acts.

3. At the southern magnetic pole, what is the Aurora called?

4. What is solar wind, and how does it cause the Aurora?

5. When and where was the first magnetic observatory established?

6. Why did these scientists choose to study the upper atmosphere?

7. What causes the different colours of the Aurora Borealis?

CANADA SCIENCE TECHNOLOGY MUSEUM

Canada

Have your students visit the Canada Space Agency's website at:

www.asc-csa.gc.ca/eng/missions/sts-097/kid_aurora.asp.

Working individually or in pairs, have students read the Aurora Borealis factsheet online, finding answers to the included worksheet. **Please note that this worksheet must be printed on legal-sized paper**. The online factsheet explains why the Aurora Borealis exists. It also provides background information about how Canadian researchers have studied the Aurora, culminating with Canada's entry into the space age.

The online factsheet is also available in pdf format. You may wish to print the worksheet and have your students complete the activity offline.

Extension Activity: *Based on what they learned in this activity, have older students conduct research to identify how the Aurora Borealis impacts our lives today. What current technologies are affected by solar winds? What do these technologies have in common?*

Activity 5.5: Satellites and their Environmental Applications

(Suitable for Grades 7 and up)

Satellites have come a long way since Sputnik in 1957, and Canada's Alouette project in 1962. Today, people use satellites for many applications. One major function of satellites is to monitor conditions as the Sun's electromagnetic particles travel towards the earth. A variety of geomagnetic phenomena as associated with the journey of these particles, the study of which has been termed "space weather."

To learn more about space weather and geomagnetic phenomena, visit the Space Weather Canada's website at http://www.spaceweather.gc.ca/index_e.php.

Oral Presentation: Have your students visit the section of the website explaining the effects of space weather on consumer technologies (http://www.spaceweather.gc.ca/effects_e.php). Several technologies are discussed — power systems, satellite services, GPS positioning, pipelines, communication cables, etc. In pairs or small groups, have students learn about one way that space weather affects our everyday lives, and what hazards space weather can pose. Have students present their findings to the rest of the class.

Topics for Group Discussion: Encourage your students to make connections between astronomy and its relevance to their lives. The following topics are meant to help guide large and small-group discussions within your classroom:

- How many consumer technologies are reliant of satellite technologies?
- In what ways might our reliance on satellites make us vulnerable?
- Debate the merits and the problems surrounding satellite imaging.

Extension Activity: *Using a computer and a projector, view NASA's Earth Observatory page at* http://earthobservatory.nasa.gov. *Browse through a selection of images from NASA's "Image of the Day" archive. Each image includes a detailed description of what you are seeing. Many images illustrate contemporary issues in Environmental Studies, such as coastal soil erosion, or rainforest deforestation.*

Name: _____

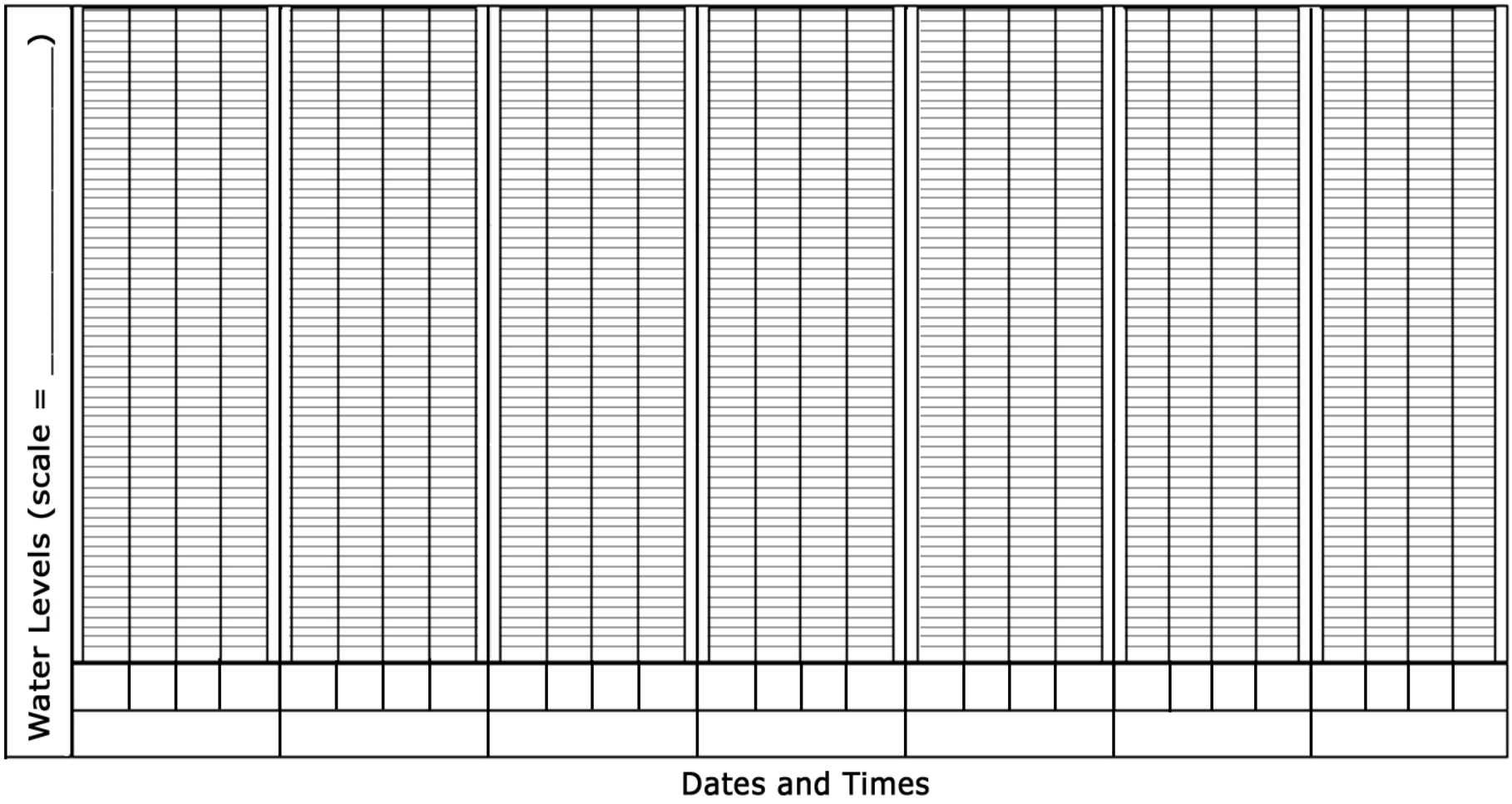
Dressing for the Weather

SPRING	
SUMMER	
AUTUMN	
WINTER	

Name: _____

All About Tides

Tidal Chart for the City of _____



CANADA SCIENCE AND TECHNOLOGY MUSEUM

Canada

Name: _____

The Aurora Borealis

1. Where does the Aurora take place?

_____
_____

2. Describe how the Earth's magnetic field acts.

_____
_____
_____
_____

3. At the southern magnetic pole, what is the Aurora called?

_____

4. What is solar wind, and how does it cause the Aurora?

_____
_____
_____
_____

5. When and where was the first magnetic observatory established?

_____
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6. Why did these scientists choose to study the upper atmosphere?

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7. What causes the different colours of the Aurora Borealis?

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8. Is the Aurora always there? _____

9. What shape is it? _____

10. Where exactly is the Aurora Borealis located?

_____
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11. When is there the greatest chance of seeing the Aurora Borealis in southern Canada?

_____
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12. In the 1950s, what did the Aurora Borealis frequently interrupt?

_____
_____

13. How is the Aurora Borealis responsible for Canada entering the space age?

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