Grades 9-12 Science in Ontario: Meeting Expectations with Astronomy Activities

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Summary

Astronomy is one of those areas of science that has wide-spread interest but low enrolment. Teachers can pull all of the sciences together in an engaging and universal study by bringing more astronomy activities into the classroom, and making relevant connections with the world.

This collection of astronomy-related activities has been selectively tailored to the Revised 2008 Ontario Science Curriculums for Grades 9–12 and spans all four categories: Biology, Chemistry, Physics, and Earth Sciences.

Teachers may use the activities as they are listed or make changes to them to suit their own classrooms and needs.

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Fundamental Objectives

There are benefits to integrating astronomy and space into the high school Science curriculum. Astronomy engages and motivates students, and, as an integrative science, helps to address basic concepts which are relevant to all the sciences.

Currently, there are only three science courses out of 18 in the Ontario curriculum that have strong astronomy connections: the two Grade 9 science courses (Applied and Academic) in a unit which composes one-fifth of each course, and a third Grade 12 Earth and Space Science course which is two-fifths astronomy, three-fifths earth science, and often is not even available in schools due to low enrolment.

Students are leaving high school with limited knowledge of the connections many sciences have with the rest of the universe and with each other. The science of astronomy has many societal applications including connections to industries, technologies, environments, and trends. Bringing astronomy into the classroom encourages a different approach by the students to develop the same curriculum skills expected at that level and helps them build a greater awareness of useful and interesting science connections and concepts outside the classroom.

Looking at astronomy helps you realize how closely related all the sciences are.

This document is aimed at teachers who wish to integrate more astronomy and science activities into their science classes but have not had the time or resources to make the connections. Each of these activities either provide access to a complete lesson plan or suggest a comprehensive route a teacher may take to develop his or her own. There is also some emphasis on the general misconceptions that often arise with the concepts addressed.

These activities have been carefully chosen and paired to meet *specific expectations* across the four main Science divisions: ***Biology***, ***Chemistry***, ***Physics***, and ***Earth and Space Sciences***. The following tables outline how the reader may find suitable activities, first by pairing them with the specific expectations of courses, second by pairing them with curriculum skills developed.

Finding the Right Activity for Your Class

Activities are listed by science department heading only. To avoid searching through each part, use this reference chart to see which activities may be coordinated with your specific class unit. Multiple units are denoted with an “M”. The greyed courses have units in Astronomy already.

Astronomy Activities Paired With Science Course Strands	SCIENCE						ES	ENVIRO		BIOLOGY			CHEMISTRY			PHYSICS		
	SNC1D	SNC1P	SNC2D	SNC2P	SNC4M	SNC4E	SES4U	SVN3M	SVN3E	SBI3U	SBI3C	SBI4U	SCH3U	SCH4U	SCH4C	SPH3U	SPH4U	SPH4C
[BIOLOGY]																		
1 Astrobiology in the Classroom	B	B	B	B														
2 Searching for Life	B	B	B	B														
3 Virtual Field Trip	B	B								M	M	C						
4 Investigating Plants in Space	B	B								M	M	C				D		
5 Hunt for Alien Earths										B	C	C						
6 Stem Cell Research in Space			B							D	D	M						
7 Lunar Land Use	B	B								M	F	F						
8 Creature Feature Images	A	A	B	B														
9 Size and Shape Matter			B								C							
[CHEMISTRY]																		
1 Star Spectra													B	C	B	E	M	
2 The Message of Light	M	D	E	E													E	
3 Origins: Earth is Born	D	D												C				
4 Origins: Elemental Puzzler	C	C											B	C				
5 Rays: Sun or Supernova?			C										B	C				
[PHYSICS]																		
1 Building a Galilean Telescope			E	E													E	
2 Impact Cratering																D	C	E
3 Your Weight On Other Worlds																C		
4 Exploring Solar Activities																	D	
5 Figure Eight in the Sky																B		
[EARTH AND SPACE SCIENCE]																		
1 Venus & the Greenhouse Effect			D	D											F			
2 Martian Polar Caps			D															
3 Sun’s Impact on Earth’s Temp.			D	D														
4 Is There Water On Mars?			D															
5 The Very Simple Climate Model			D	D														
6 Graphing Stratospheric Ozone			D	D														

Pairing Activities with Curriculum Skills

Use this reference chart to see which activities may be coordinated with the curriculum skills you would like your class to develop.

Astronomy Activities Paired With Curriculum Skills	Analysis/Investigation	Communication	Computer	Concentration	Critical Thinking	Goal Setting	Motivation	Observation	Organization	Perspective	Prediction	Preview/Survey	Questioning/Problem Solving	Reading Comprehension	Summarization	Teamwork/Interpersonal	Time Management/Scheduling	Writing
[BIOLOGY]																		
1 Astrobiology in the Classroom	X	X			X		X	X		X	X	X	X		X	X		
2 Searching for Life	X			X	X			X		X	X	X	X		X			X
3 Virtual Field Trip	X		X		X			X		X			X					
4 Investigating Plants in Space	X				X	X	X	X	X		X		X	X	X	X	X	X
5 Hunt for Alien Earths		X	X	X	X		X	X		X			X					
6 Stem Cell Research in Space	X	X			X	X			X	X		X	X	X	X	X	X	X
7 Lunar Land Use	X	X			X	X	X			X	X	X	X		X	X	X	X
8 Creature Feature Images		X		X	X		X	X	X	X		X			X	X		X
9 Size and Shape Matter	X			X	X			X		X		X	X			X		
[CHEMISTRY]																		
1 Star Spectra	X		X	X	X			X	X		X	X	X	X	X			
2 The Message of Light	X	X		X	X		X	X	X	X	X		X	X	X	X		X
3 Origins: Earth is Born	X	X			X	X	X	X	X		X	X	X		X	X	X	X
4 Origins: Elemental Puzzler	X	X	X	X	X		X	X					X	X		X		X
5 Rays: Sun or Supernova?	X		X	X	X			X				X	X	X	X			
[PHYSICS]																		
1 Building a Galilean Telescope	X	X		X	X	X	X	X	X	X	X	X	X			X	X	
2 Impact Cratering	X	X	X		X			X			X		X		X	X		
3 Your Weight On Other Worlds	X	X	X		X					X	X	X	X	X	X			X
4 Exploring Solar Activities	X	X		X	X	X	X	X			X	X	X	X	X			X
5 Figure Eight in the Sky	X				X	X	X	X		X	X	X	X		X	X	X	
[EARTH AND SPACE SCIENCE]																		
1 Venus & the Greenhouse Effect	X	X			X	X	X	X	X		X	X	X		X	X	X	X
2 Martian Polar Caps	X		X		X			X		X	X	X	X	X				X
3 Sun's Impact on Earth's Temp.	X	X	X	X	X			X		X	X	X	X	X	X			
4 Is There Water On Mars?	X	X			X	X	X	X	X	X	X	X	X		X	X		X
5 The Very Simple Climate Model	X	X	X	X	X			X	X		X	X	X	X	X			
6 Graphing Stratospheric Ozone	X	X	X		X			X	X	X	X	X	X	X	X	X		X

Online Resources

Ontario Curriculum

The Ontario Science Curriculum Grades 9 and 10, 2008
http://www.edu.gov.on.ca/eng/curriculum/secondary/science910_2008.pdf

The Ontario Science Curriculum Grades 11 and 12, 2009
http://www.edu.gov.on.ca/eng/curriculum/secondary/2009science11_12.pdf

Other Canadian Provincial Curricula

All recent Canadian provincial astronomy curriculum guides
http://www.cascaeducation.ca/files/teachers_curriculum.html

Elementary Level Teacher Resources

Teaching links, articles, tips, and resources for Grade 1, 6, and other astronomy-related units, including summative assessments and complete unit plans.
http://www.cascaeducation.ca/files/teachers_secondary.html

Secondary Level Teacher Resources

Teaching links, articles, tips, and resources for Grade 9, 11, and 12 Earth and Space Science courses, including summative assessments and complete unit plans.
http://www.cascaeducation.ca/files/teachers_secondary.html

Post-Secondary Level Teacher Resources

Teaching links, articles, tips, and resources for post-secondary endeavours.
http://www.cascaeducation.ca/files/teachers_post.html

Summative Assessment Ideas for Teachers

There is a great opportunity to be creative with astronomy projects, as shown by this list.
http://www.cascaeducation.ca/files/teachers_summative.html

Biology

Astrobiology in the Classroom: Life on Earth... And Elsewhere?

Motivation to Use in the Classroom
Astrobiology looks at the origin, evolution, distribution, and future of life in the Universe. Bringing it into the classroom is not only relevant but also keeps current with new research and technology. This set of detailed lesson plans, labs, and teacher resources poses five questions that are directly related to potential impacts on society when certain variables change within a biological system.

Course	Specific Expectations Addressed	
SNC1D	B3.5	Identify various factors related to human activity that have an impact on ecosystems.
SNC1P	B3.5	Identify some factors related to human activity that have an impact on ecosystems.
SNC2D	B1.3	Describe public health strategies related to systems biology, and assess their impact on society. [AI, C]
SNC2P	B1.2	Evaluate the effects that use of or exposure to a technology, substance, or environmental factor may have on the function of human tissues, organs, or systems. [AI, C]

Synopsis
In these lab activities, the students investigate the answers to these five questions: What is life? What does life need to live? What makes a world habitable? What can life tolerate? and Is there life on other worlds? Habitability of planets is of particular interest for this expectation.

Teacher Strategy
1) Visit this website to gain an overview of all five lesson plans and activities available for students. *Educator's Resource*: http://nai.arc.nasa.gov/library/downloads/ERG.pdf
2) Blackline masters of any required print material are found at the end of each activity.
3) "Think About It" sections reflect on what is being learned, either for homework, assessment or discussion.

Learner Outcomes – By completing these activities, the learner will:
a) understand the requirements for life.
b) broaden his or her knowledge of the planets and six large moons in terms of habitability for life.
c) discuss the question, "what is the chance that we are the only life in the universe?"
d) connect these activities to math-related concepts.

Searching for Life

Motivation to Use in the Classroom
Astrobiology looks at the origin, evolution, distribution, and future of life in the Universe. Bringing it into the classroom is not only relevant but also keeps current with new research and technology. This set of detailed lesson plans, labs, and teacher resources looks at the definition and characteristics of life and about the possibility of looking for life on Mars and the impact this would have on society.

Course	Specific Expectations Addressed	
SNC1D	B3.5	Identify various factors related to human activity that have an impact on ecosystems.
SNC1P	B3.5	Identify some factors related to human activity that have an impact on ecosystems.
SNC2D	B1.3	Describe public health strategies related to systems biology, and assess their impact on society. [AI, C]
SNC2P	B1.2	Evaluate the effects that use of or exposure to a technology, substance, or environmental factor may have on the function of human tissues, organs, or systems. [AI, C]

Synopsis
Students start to develop criteria for recognizing life with basic activities: Imaginary Martians, Looking for Life, and Mars Critters. They then study possible tests for sensing life in advanced activities: Wolf Trap, Stopped Dead in its Tracks, Connecting the Dots, and The Nose Knows.

Teacher Strategy

1) Visit this website to access each of the seven labs as separate lesson plans and activity sheets.
   Main Page: http://ares.jsc.nasa.gov/Education/Websites/AstrobiologyEducation/lookforlife.htm
2) A separate advanced package entitled “Destination: Mars” is also provided which gives six lesson plans, a Mars fact sheet, related process skills, and discusses Science and Math standards. These may be used with the activities previously described or separately for more Mars impacts.
   Packet: http://ares.jsc.nasa.gov/Education/Websites/AstrobiologyEducation/Data/destmars.pdf

Learner Outcomes – By completing these activities, the learner will:

a) understand the requirements for life.
b) practice using chemistry concepts, including the difference between physical/chemical changes.
c) discover the relevance of biomarkers from living organisms.
d) observe characteristics of substances.

Related Resources:
http://archive.seti.org/pdfs/Life.pdf

The SETI Institute produced a similar set of 10 “missions” for Grades 7-8 discovering the same sort of findings as above. It has a forward by Carl Sagan and is 285 pages long. A complementary PowerPoint set is also available for download here: http://archive.seti.org/ppts/LifeHTE_Slides.ppt. Keep an eye on the SETI website for updates to the curriculum files: http://www.seti.org/Page.aspx?pid=364.

Virtual Field Trip

Motivation to Use in the Classroom
This downloadable program explores various geological regions on Earth that share traits with those on Mars. Using interactive virtual reality placement, detailed photos, and video clips, students can learn how these terrains and the objects found in them might help solve scientists' questions about habitable lands elsewhere in the Universe. Emphasis is on the interactive and engaging nature of the program, as well as the current technologies in use to create such environments.

Course	Specific Expectations Addressed	
SNC1D	B3.1	Compare and contrast biotic and abiotic characteristics of sustainable and unsustainable terrestrial and aquatic ecosystems.
SNC1P	B3.4	Identify the major limiting factors of ecosystems and explain how these factors are related to the carrying capacity of an ecosystem.
SBI3U	B1.2	Analyse the impact that climate change might have on the diversity of living things. [AI, C]
	F3.4	Describe the various factors that affect plant growth.
SBI3C	C2.5	Investigate and analyse the conditions needed by microorganisms for growth. [PR, AI]
	F2.3	Investigate how chemical compounds and physical factors affect plant growth. [PR, AI]
SBI4U	C1.2	Assess the relevance, to their personal lives and to the community, of an understanding of cell biology and related technologies. [AI, C]

Synopsis
This multimedia application immerses the user into Earth areas that have been identified as analog sites to regions on Mars. Students navigate virtual reality from global to surface views, can select objects, and listen to video clips from scientists to answer their questions of interest.

Teacher Strategy

1) Go to this site to get the latest program files to save to the students' computers.
   Program files: http://quest.arc.nasa.gov/vft/
2) While there is no current lesson plan for the site, these questions may help get you started.
   Alien Earths Q&A: http://www.pbs.org/wgbh/nova/space/marcy-extrasolar.html

Learner Outcomes – By completing these activities, the learner will:

a) investigate the requirements for life from physical, chemical, and biological environments.
b) use investigative techniques to explore questions posed about the terrains.

Investigating Plants in Space

Motivation to Use in the Classroom
These activities help relate science and technology in a real-world set of space-related experiments. Students explore the impacts of environmental variables on the growth and development of plants, focusing on quantitative biology and mathematics. Other science process skill sets include observing, measuring, hypothesizing, communicating, interpreting data, and controlling variables.

Course	Specific Expectations Addressed	
SNC1D	B2.2	Interpret qualitative and quantitative data from undisturbed and disturbed ecosystems, communicate the results graphically, and, extrapolating from the data, explain the importance of biodiversity for all sustainable ecosystems. [PR, AI, C]
	B3.1	Compare and contrast biotic and abiotic characteristics of sustainable and unsustainable terrestrial and aquatic ecosystems.
SNC1P	B2.5	Analyse the effect of factors related to human activity on terrestrial or aquatic ecosystems by interpreting data and generating graphs. [AI, C]
	B3.4	Identify the major limiting factors of ecosystems and explain how these factors are related to the carrying capacity of an ecosystem.
SBI3U	B1.2	Analyse the impact that climate change might have on the diversity of living things. [AI, C]
	C1.2	Evaluate the possible impact of an environmental change on natural selection and on the vulnerability of species. [AI, C]
	F2.2	Design and conduct an inquiry to determine the factors that affect plant growth. [IP, PR, AI]
	F3.4	Describe the various factors that affect plant growth.
SBI3C	C2.5	Investigate and analyse the conditions needed by microorganisms for growth. [PR, AI]
	F2.3	Investigate how chemical compounds and physical factors affect plant growth. [PR, AI]
	F2.4	Investigate plant tropism by growing and observing plants in a variety of natural and human-made environments. [PR]
	F3.6	Explain the role of plant tropism in a plant's survival.
SBI4U	C1.2	Assess the relevance, to their personal lives and to the community, of an understanding of cell biology and related technologies. [AI, C]
SPH4U	D1.2	Assess the impact on society and the environment of technologies that use gravitational, electric, or magnetic fields. [AI, C]

Synopsis
In these five areas of activities, students first look at the growth and development of plants, their pollination and fertilization, and finally at germination and orientation. Students may use AstroPlants or other similar seeds (such as turnip, lettuce, or alfalfa) and will ultimately investigate the environmental factors affecting plant growth. Full data sheets are provided.

Teacher Strategy

1) Save this 112 page PDF document to refer to for Teacher Resources and Activities for Students.

Main PDF: http://virtualastronaut.tietronix.com/teacherportal/pdfs/InvestigatingPlantsinSpace.pdf

2) Overview of the Document: Sections to look at other than the activities include The Importance of Plants in Space (p.6), which emphasizes the close and interdependent relationship between humans and plants, Understanding the Environment (p.13), which emphasizes the factors of physical, chemical, and biological environments in life processes and systems, and the Science and Technology exploration section (p.18). These will help with understanding the overall progress.
3) Overview of Activities. Activity 1 (p.32) starts students off with Constructing the Plant Growth Chambers (PGCs). Activity 2 (p.35) looks at Planting AstroPlants in the PGCs. Activity 3 (p.38) tracks the Variation within the Normal Growth and Development of plants. Activity 4 (p.46) diverges a little in looking at the importance of pollination by Making Beesticks, as does Activity 5 (p.54) in Measuring Time on the Floral Clock, and Activity 6 (p.59) with Embryogenesis. Activity 7 (p.67) progresses to germination and Getting Acquainted With a Seed. Activity 8 (p.74) is about Launching the Seed, observing the interaction between germination and orientation. Activity 9 (p.79) looks at Gravitropism and How Do Plants "Know" Which Way to Grow? Activities 10 (p.86) and 11 (p.88) finally look at the effects of Phototropism in terms of colour and amount of light.
   Note: It may be possible to skip Activities 4–6 under certain conditions.

Learner Outcomes – By completing these activities, the learner will:

a) investigate the requirements for life from physical, chemical, and biological environments.
b) understand the role of environment in regulating plant growth, including the absence or presence of: gravity, light, particular light wavelengths, water, and other possible factors.
c) use various scientific instruments to take accurate measurements and make observations.
d) use drawing skills on scale diagrams, emphasizing accuracy and precision.
e) understand the roles of pollination and fertilization in the growth of plants.
f) use various graphing techniques to record and interpret observational results.
g) apply simple geometry and other mathematical functions to create experimental variables.
h) learn to set up simple experiments, make predictions, and observe results.

Related Resources:

http://www.pbs.org/wgbh/nova/teachers/activities/3112_origins.html

This NOVA developed classroom activity has students learn about the characteristics that define organisms. Activity sheets and answers are provided with the procedures, along with further reading links.

Hunt for Alien Earths

Motivation to Use in the Classroom
Many questions that are raised by students often do not get answered because they are far beyond the understanding of the teacher, often not an astronomy expert. This website, video, and question & answer interview with an astrophysicist helps answer some of the tough questions you might not expect to get about life in the Universe. The activity is interactive, eye-opening, and inspirational.

Course	Specific Expectations Addressed	
SBI3U	B1.2	Analyse the impact that climate change might have on the diversity of living things. [AI, C]
SBI3C	C2.5	Investigate and analyse the conditions needed by microorganisms for growth. [PR, AI]
SBI4U	C1.2	Assess the relevance, to their personal lives and to the community, of an understanding of cell biology and related technologies. [AI, C]

Synopsis
This 12-minute video and accompanying Q&A with an astrophysicist helps capture the attention of students and answer their questions about life in the Universe. An online quiz is available.

Teacher Strategy

1) Download the 12-minute video file or entire episode from ScienceNow at this main website.
   Download Video File: http://www.pbs.org/wgbh/nova/sciencenow/0402/01.html
2) Look over the two Teacher's Resources for this activity, developed by NOVA Teachers. The latter is quite rich in questions and ideas to bring to the students, including further links to videos and sites.
   Program Overview: http://www.pbs.org/wgbh/nova/teachers/programs/0402_01_nsn.html
   Viewing Ideas: http://www.pbs.org/wgbh/nova/teachers/viewing/0402_01_nsn.html
3) While there is no current lesson plan for the site, these extras may help get you started.
   Alien Earths Interview: http://www.pbs.org/wgbh/nova/space/marcy-extrasolar.html
   Online Video & Quiz: http://www.pbs.org/wgbh/nova/sciencenow/0402/01-life-flash.html
   Related Science News: http://www.pbs.org/wgbh/nova/sciencenow/0402/01-related.html
4) This 2005 video segment has planet-hunters discuss the search for extra-solar planets.
   Planet-hunting video: http://www.pbs.org/wgbh/nova/teachers/space/strange-new-planet.html
5) This 2009 video segment discusses the methods of detecting life on other planets.
   Detecting life video: http://www.pbs.org/wgbh/nova/teachers/evolution/detecting-life.html

Learner Outcomes – By completing these activities, the learner will:

a) investigate the requirements for life from physical, chemical, and biological environments.
b) use investigative techniques to explore questions posed about life requirements.
c) have the resources to continue exploring recent discoveries in related science news.

Stem Cell Research in Space

Motivation to Use in the Classroom

Astrobiology looks at the future of life in the Universe. Stem cell research looks at the building blocks of life itself; It is a relatively young, emergent field and raises many ethical issues when it involves the manipulation of human embryonic stem cells. Combining these related fields and making students aware of current research technologies and where they might lead is of key interest in this segment.

Course	Specific Expectations Addressed	
SNC2D	B1.1	Analyse, on the basis of research, ethical issues related to a technological development in the field of systems biology. [IP, PR, AI, C]
	B3.2	Explain the importance of cell division and cell specialization in generating new tissues and organs.
SBI3U	D1.2	Evaluate, on the basis of research, the importance of some recent contributions to knowledge, techniques, and technologies related to genetic processes. [IP, PR, AI, C]
SBI3C	D1.2	Evaluate, on the basis of research, some of the effects of genetic research and biotechnology on the environment. [IP, PR, AI, C]
SBI4U	C1.2	Assess the relevance, to their personal lives and to the community, of an understanding of cell biology and related technologies. [AI, C]
	D1.1	Analyse, on the basis of research, some of the social, ethical, and legal implications of biotechnology. [IP, PR, AI, C]
	D1.2	Analyse, on the basis of research, some key aspects of Canadian regulations pertaining to biotechnology, and compare them to regulations from another jurisdiction. [IP, PR, AI, C]
	D3.5	Describe some examples of genetic modification, and explain how it is applied in industry and agriculture.

Classroom Ideas

1) Introduction. Discuss the topics of astrobiology (the origin, evolution, distribution, and future of life in the Universe) and the study of stem cell research (in humans, mice, and other animals).
2) Think-Pair-Share. Print articles (see below) and others of a similar nature to distribute amongst groups in class. Have them discover and discuss the ethical issues, analyse the benefits and costs for such research, and hypothesize where it might lead future astrobiologists if successful (or not).
3) Debate. Have the students create an argument for the debate. (Topic ideas: “Stem cell research should be used to help find out how life begins and evolves” or “Stem cell research should be studied under all environments and circumstances”.) Distribute material amongst the teams: For, Against, Judges, Journalists. At the end of the second day, the Judges must come to a decision. All will hand in related research, evidence of arguments, and hand in a report from their perspective.

Web Articles

http://www.mercurynews.com/search/ci_14910612?IADID=Search-www.mercurynews.com-www.mercurynews.com&nclick_check=1

“Stem cells back from outer space may solve mysterious illnesses of astronauts”

http://spacebiosciences.arc.nasa.gov/MouseImmunology&TissueLossRelease.pdf

“NASA sends cells into space to understand growth and infection”

http://www.nasa.gov/centers/ames/news/releases/2010/10-11AR.html

“NASA to Study Seeds in Space to Better Understand Plant Growth”

Further Notes

- 50% of the astronauts who flew in the 1960s and 70s Apollo missions came down with infections. A recent flight into space with the stem cells of mice onboard may help figure out why.
- These cells may help fight weakened bones and muscles, compromised immune systems, health problems on Earth as well as for astronauts aiming to travel to Mars or further.
- Previous studies have found malfunctioning cells in space.
- Scientists look at cells growth during the flight, specifically the genes and biochemical pathways that were active and compare them to those on Earth. Analysis expected to take a year.
- Third article provides contrast for stem cell research with regular plant cell research.

Lunar Land Use

Motivation to Use in the Classroom
Students often miss the connection that humans have on ecological footprints. Bringing the activity away from Earth to the Moon and then concluding by relating the concepts back to Earthly ones emphasizes this connection in an engaging and thought-provoking approach. Students will work in groups and further develop their communication and teamwork skills while researching related topics.

Course	Specific Expectations Addressed	
SNC1D	B1.1	Analyse, on the basis of research, the impact of a factor related to human activity that threatens the sustainability of a terrestrial or aquatic ecosystem. [IP, PR, AI, C]
	B3.5	Identify various factors related to human activity that have an impact on ecosystems.
SNC1P	B1.1	Analyse, on the basis of research, how a human activity threatens the sustainability of a terrestrial or aquatic ecosystem. [IP, PR, AI, C]
	B3.5	Identify some factors related to human activity that have an impact on ecosystems.
SBI3U	B1.1	Analyse some of the risks and benefits of human intervention to the biodiversity of aquatic or terrestrial ecosystems. [AI, C]
	F1.1	Evaluate, on the basis of research, the importance of plants to the growth and development of Canadian society. [IP, PR, AI, C]
SBI3C	F1.2	Assess the positive and negative impact of human activities on the natural balance of plants. [AI, C]
SBI4U	F1.1	Analyse the effects of human population growth, personal consumption, and technological development on our ecological footprint. [AI, C]

Synopsis
Students present proposals for developments on the Moon, relating the effects of human impact on the Earth to its lunar neighbour. The given running class time of 8 days could be condensed.

Teacher Strategy

1) The general overview and student activity sheets may be found in one online PDF document. *Teacher Resource*: http://ares.jsc.nasa.gov/Education/activities/ExpMoon/LandUse.pdf
2) Class projects on the Moon are given in the following categories (but more may be brainstormed): mining communities, scientific bases, telescopic outposts, government headquarters, recreational bases, tourist sites, residential communities, etc.
3) The purpose of this activity is to get the students thinking of the impact these projects would have on the Moon and then relate them to similar impacts on Earth. The point is to relate the ecological footprints with human intervention and the ethical and social implications that arise because of it.

Learner Outcomes – By completing these activities, the learner will:

a) understand the importance of interpretive skills and communication.
b) practice viable brainstorming techniques in a team setting.
c) relate the effects of human population and technology to our ecological footprint.

Creature Feature Images

Motivation to Use in the Classroom
Observation skills are required in any science lab or experiment. This may arguably be a simple task suitable for younger grades, but the exercises are quick and engaging for the students, and emphasize the underlying significance of scientific measuring instruments and writing skills.

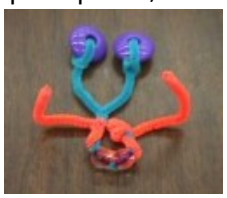
Course	Specific Expectations Addressed	
SNC1D	A1.6	Gather data from laboratory and other sources, and organize and record the data using appropriate formats, including tables, flow charts, graphs, and/or diagrams.
SNC1P	A1.6	Gather data from laboratory and other sources, and organize and record the data using appropriate formats, including tables, flow charts, graphs, and/or diagrams.
SNC2D	B2.1	Use appropriate terminology related to cells, tissues, organs, and systems of living things, including but not limited to: absorption, anaphase, capillaries, concentration, differentiation, diffusion, meristematic, mesophyll, phloem, prophase, red blood cells, stomate, and xylem. [C]
SNC2P	B2.1	Use appropriate terminology related to cells, tissues, organs, and systems, including but not limited to: absorption, anaphase, capillaries, concentration, differentiation, diffusion, interphase, metaphase, osmosis, prophase, red blood cells, regeneration, and telophase. [C]

Synopsis
Students learn the importance of observation and measurement in three mock experiments aboard a spaceship. While suitable for younger grades, this simple exercise is quick, engaging, and emphasizes the significance of scientific measuring instruments and writing skills.

Teacher Strategy

1) The teacher overview and individual student activities may be found together in this document: http://ares.jsc.nasa.gov/Education/Websites/AstrobiologyEducation/Data/creaturefeatureactivity.pdf
2) Some preparation by the teacher is required before the activity in order to create a set of alien creatures and place them in boxes. **Examples** of creatures are shown below (note the use of colour, size, shape, and orientation of pipe cleaners, beads, pom-poms, and other materials):



Learner Outcomes – By completing these activities, the learner will:

a) understand the importance of good observation skills and communication.
b) practice the use of terminology associated with recording observations.
c) practice safety in using scientific equipment in the classroom.

Size and Shape Matter

Motivation to Use in the Classroom
The link to astronomy is a little vague in this activity but keep in mind it opens up the idea that, even on far away planets and in distant galaxies, there may exist microscopic interests to humans. How we view and classify them would be based on existing methods. Relating the possible implications if life were found would be an interesting discussion following these activities of observation and analysis.

Course	Specific Expectations Addressed	
SNC2D	B1.3	Describe public health strategies related to systems biology, and assess their impact on society. [AI, C]
	B2.4	Investigate, using a microscope or similar instrument, specialized cells in the human body or in plants, focusing on different types of cells, and draw labelled biological diagrams to show the cells' structure differences. [PR, C]
SBI3C	C1.1	Assess some of the effects, both beneficial and harmful, of microorganisms in the environment. [AI, C]
	C2.5	Investigate and analyse the conditions needed by microorganisms for growth. [PR, AI]

Synopsis
Students observe the importance of relative size and morphology in identifying microscopic structures, including some recent Mars meteorite images. An emphasis is present throughout the lab on making valid observations and drawing conclusions.

Teacher Strategy

1) Visit this website to access the different sections of this activity: (a) Matter and (b) Imaged.
   Main Page Links: http://ares.jsc.nasa.gov/Education/Websites/AstrobiologyEducation/eyespyI.htm
1) The PDF link "Size and Shape Matter Activity" contains the lesson plan and activity sheets for the students and an overview for the teacher, including background information.
2) The PDF link "Size and Shape Matter Activity Images" contain the 12 images students will study (from an SEM). Corresponding answers are found in the Answer Key link, a direct PPS download.
3) The PDF link "Size and Shape Imaged Script" contains the teacher script for discussing the Imaged Slideshow found in the next link, a direct PPS download.

Learner Outcomes – By completing these activities, the learner will:

a) understand morphology and scale.
b) make valid observations from scanning electron microscope (SEM) research images.
c) discover the range of geological and microbiological samples by viewing more SEM images.

Related Resources

Motivation to Use in the Classroom
This is simply a good resource base for further reading. The sites are user-friendly, vast in knowledge, related to Biology and Astronomy, and would engage students (and teachers) to want to learn more.

http://astroventure.arc.nasa.gov/

Students can earn their online badges as they progress through learning modules on the habitability conditions for life in a Solar System. Astronomy, atmospheric science, geology, and biology are all discussed with strong connections to the careers that these areas offer.

http://starcentral.mbl.edu/microscope/portal.php?pagetitle=habitatnav

The micro*scope project, motivated to provide the resources for the next generation of microbiologists, this particular link branches off into Geography, Habitat, and other collections. Students have access to an enormous amount of information regarding different conditions for life to exist on Earth and may extrapolate these to Space.

http://www.eol.org/

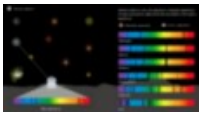
The Encyclopedia of Life: “Imagine an electronic page for each species of organism on Earth.” (Edward O. Wilson.) Check out the FAQ page for topics to bring up with students, such as the impact of this technology being available to society and to science at large (catalyzing new discoveries?), how students may use the site, and more.

Chemistry

Star Spectra

Motivation to Use in the Classroom
Many students wonder how astronomers can understand the chemical makeup of objects in the night sky simply by interpreting the light that we receive from them. This activity lets students explore the light spectra of different elements (spectroscopy) and infer the properties of a variety of stars.

Course	Specific Expectations Addressed	
SCH3U	B2.2	Analyse data related to the properties of elements within a period to identify general trends in the periodic table. [AI]
SCH4U	C1.1	Assess the benefits to society of technologies that are based on principles of atomic and molecular structures. [AI, C]
SCH4C	B1.2	Analyse, on the basis of research, applications of qualitative analysis of matter in various fields of endeavour. [IP, PR, AI, C]
SPH3U	E2.5	Analyse the relationship between a moving source of sound and the change in frequency perceived by a stationary observer. [AI]
SPH4U	E3.3	Use the concepts of refraction, diffraction, polarization, and wave interference to explain the separation of light into colours in various situations.
	F2.4	Conduct a laboratory inquiry or computer simulation to analyse data that support a scientific theory related to relativity or quantum mechanics. [PR, AI]



Synopsis
In this online applet/Gizmo, students explore the light spectra of a variety of stars to determine the elements that are represented in each spectrum. With the worksheets provided, students then classify the stars based on temperature and other features.

Teacher Strategy

1) Assuming the teacher is a member of the ExploreLearning.com community, visit the website and add the Gizmo entitled "Star Spectra" to a class tab to make it available to students.
   Main Page: http://www.explorelearning.com/
2) Several resources are available for use with this Gizmo that explain the activity in more details.
   Teacher Guide: http://cs.explorelearning.com/materials/StarSpectraTG.doc
   Student Exploration Guide: http://cs.explorelearning.com/materials/StarSpectraSE.doc
   Answer Key: http://cs.explorelearning.com/materials/StarSpectraSE_Key.doc
   Vocabulary Sheet: http://cs.explorelearning.com/materials/StarSpectraVocab.doc
3) Some assessment questions are available below the Gizmo itself and may be used for evaluation of the student's progress or understanding.

Learner Outcomes – By completing these activities, the learner will:

a) distinguish the relative speed of wavelengths of colours along the light spectrum.
b) interpret the absorption spectrum from a star and identify general trends from the elements.
c) differentiate between an emission spectrum and an absorption spectrum.
d) observe the Doppler Effect using light waves from a distant star (blueshifting).
e) observe that the universe is expanding (redshifting).

Related Resources:

http://www.ExploreLearning.com/

Using the H-R Diagram Gizmo on this site allows students to explore the foundations of the Hertzprung-Russell diagram (HRD), an interactive graph relating star colour with its magnitude. When first discovered, astronomers thought it might graphically show the evolution of star formation and thus led to a discrepancy in the age of the universe in the first quarter of the 1900s.

Related websites on this topic:

CASCA lab activity: http://www.cascaeducation.ca/files/pdf/cascaed_HRdiagram.pdf
Interactive diagram: http://aspire.cosmic-ray.org/labs/star_life/hr_interactive.html
Wikipedia resource: http://en.wikipedia.org/wiki/Hertzsprung%E2%80%93Russell_diagram
Overview: http://outreach.atnf.csiro.au/education/senior/astrophysics/stellarevolution_hrintro.html

http://www.pbs.org/wgbh/nova/teachers/physics/stellar-velocity-doppler-effect.html

This interactive activity from NOVA allows students to learn how scientists use the Doppler effect to study distant galaxies by gauging their speed and direction of motion in relation to Earth.

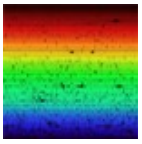
http://www.pbs.org/wgbh/nova/teachers/activities/3113_origins.html

This fully-developed classroom activity from NOVA Teachers leads the students through various readings before pairing off into groups to further research planetary spectral analysis. The end result is a report that is supported with evidence they have researched and a presentation to the class. Handouts and question sheets are supplied.

The Message of Light

Motivation to Use in the Classroom
Astronomers use electromagnetic radiation from the universe to discover unique information about the celestial objects. For example, the age, mass, composition, temperature, luminosity, and even evolutionary history of a star may be determined by interpreting the radiation it emits. In this two-part activity, students first look at the nature of light and then apply it to discover the life of a star.

Course	Specific Expectations Addressed	
SNC1D	C2.1	Conduct an inquiry to identify the physical and chemical properties of common elements and compounds. [PR]
	C3.7	Compare and contrast the physical properties of elements within a group and betweens groups in the periodic table.
	C3.8	Identify and use the symbols for common elements and the formulae for common compounds.
	D2.5	Compare and contrast properties of celestial objects visible in the night sky, drawing on information gathered through research and using an appropriate format. [PR, AI, C]
SNC1P	D2.3	Use a research process to compile and analyse information on the characteristics of various objects in the universe. [PR, AI]
SNC2D	E3.2	Identify and label the visible and invisible regions of the electromagnetic spectrum.
SNC2P	E3.2	Identify and label the visible and invisible regions of the electromagnetic spectrum, and identify the colours that make up visible white light.
SPH4U	E1.2	Assess the impact on society and the environment of technologies that use the wave nature of life. [AI, C]
	E3.3	Use the concepts of refraction, diffraction, polarization, and wave interference to explain the separation of light into colours in various situations.



Synopsis
In these activities, students will study how astronomers learn about the universe: the basic physics of light and the rest of the electromagnetic spectrum. Students learn about the square inverse law and are introduced to the misconceptions of astrology. Core activities, poster pages, and investigations along with answers to questions are provided.

Teacher Strategy

1) Teachers can get an overview of the activities and outcomes by reading these online documents.
   Educator's Overview 1: http://www.aavso.org/sites/default/files/teacher_Chapter8.pdf
   Educator's Overview 2: http://www.aavso.org/sites/default/files/teacher_Chapter9.pdf
2) Teachers may wish to reorganize the data on the website into a handout for the students but these activities are laid out in full in the following documents.
   Student Resource 1: http://www.aavso.org/sites/default/files/Chapter8.pdf
   Student Resource 2: http://www.aavso.org/sites/default/files/Chapter9.pdf
3) A comprehensive glossary of new terms and acronyms is also provided on this website.
   Glossary: http://www.aavso.org/sites/default/files/Glossary.pdf

Learner Outcomes – By completing these activities, the learner will:

a) learn the segments of the electromagnetic spectrum.
b) gain an understanding of spectroscopy and the life of a star.
c) use interpretative skills to read information from a database.
d) discover the science that asks questions that require more sophisticated instruments.
e) observe that time and distance are factors that drive the effectiveness of such technology.
f) collect and analyse data and plot properties in graphical form.

Related Resources:

http://www.aavso.org/education/vsa

The previous activity is part four of a series of five units in 13 chapters that look at Variable Star Astronomy. It provides multiple links and resources for the teacher and students, including an online variable star activity and related PowerPoint slides. This activity strongly links to the previous one, “Star Spectra”.

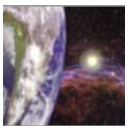
http://www.citizensky.org/

This website encourages users to get more involved with astronomy by taking part in solving riddles and sending in observations. For example, on the front page asks you to help solve a 175-year-old mystery regarding epsilon Aurigae, and they give you all the tools to help do it. This is similar to the MoonZoo.org project but for celestial objects in the night sky other than the Moon. Teachers could introduce these websites to students and submit observations as a class or through a school club.

Origins: Earth is Born

Motivation to Use in the Classroom
Getting an interactive lab activity ready for students is sometimes difficult with astronomy due to the need for night-time observations. With this activity, students may work in groups to collect samples over the course of 48 hours and determine if they have "caught" any micrometeorites in the process. Teachers may wish to introduce a competition for the class, either with the activity or through the interactive game students can play and learn more about the origins of Earth online.

Course	Specific Expectations Addressed	
SNC1D	D2.5	Compare and contrast properties of celestial objects visible in the night sky, drawing on information gathered through research and using an appropriate format. [PR, AI, C]
SNC1P	D2.3	Use a research process to compile and analyse information on the characteristics of various objects in the universe. [PR, AI]
SCH4U	C2.6	Conduct an inquiry to observe and analyse the physical properties of various substances and to determine the type of chemical bonding in each substance. [PR, AI]



Synopsis
In these activities, students will get a hands-on introduction to micrometeorites by collecting samples and preparing them for observation with a microscope. The online, interactive Origins game allows further insight into various sites on Earth that origins researchers are studying.

Teacher Strategy
1) Teachers can get an overview of the activity and outcomes by reading this 8-page document.
   Teacher's Guide: http://www.pbs.org/wgbh/nova/teachers/activities/pdf/3111_origins.pdf
2) Option: You can purchase the video "Origins: Earth is Born" from NOVA, originally broadcasted in September 2004, and follow these viewing ideas for the classroom.
   Viewing Suggestions: http://www.pbs.org/wgbh/nova/teachers/viewing/3111_origins.html
3) While outlined in the Teacher's Guide, the Hunt for Micrometeorites activity is fully described here.
   Classroom Activity: http://www.pbs.org/wgbh/nova/teachers/viewing/3111_origins.html
4) Related websites are provided by NOVA for students wishing to further explore this topic.
   Related links: http://www.pbs.org/wgbh/nova/teachers/overviews/3111_origins.html
5) An interactive game may be found here for students to play with, either in class or at home.
   Origins game: http://www.pbs.org/wgbh/nova/origins/earth.html

Learner Outcomes – By completing these activities, the learner will:
a) learn important data collection and slide preparation techniques for microscopes.
b) develop team skills and coordination while following written instructions.
c) use interpretative skills to read information from collected samples.
d) develop sketching techniques to recreate what they see through the microscopes.
e) become aware of the meticulous nature of science in making observations and recording data.
f) distinguish between asteroids and meteorites.
g) learn how these scientific discoveries may reveal information about the universe.

Origins: Elemental Puzzler

Motivation to Use in the Classroom

Puzzles are fun and interactive ways to get students involved in a new subject. This activity uses a crossword and extended questions to help students learn about the elements that play a role in the cosmos, as well as addressing common misconceptions that often arise. Students may then choose a specific element from the periodic table to create a poster on its properties and role in the universe.

Course	Specific Expectations Addressed	
SNC1D	C1.1	Assess the usefulness of and/or the hazards associated with common elements or compounds in terms of their physical and chemical properties. [AI, C]
	C3.2	Describe the characteristics of neutrons, protons, and electrons, including charge, location, and relative mass.
	C3.4	Describe the characteristic physical and chemical properties of common elements and compounds.
	C3.7	Compare and contrast the physical properties of elements within a group and between groups in the periodic table.
SNC1P	C3.2	Indentify the characteristics of neutrons, protons, and electrons, including charge, location, and relative mass.
	C3.4	Explain the relationships between the properties of elements and their position in the periodic table.
SCH3U	B2.2	Analyse data related to the properties of elements within a period to identify general trends in the periodic table. [AI]
	B3.3	State the periodic law, and explain how patterns in the electron arrangement and forces in atoms result in periodic trends in the periodic table.
SCH4U	C2.6	Conduct an inquiry to observe and analyse the physical properties of various substances and to determine the type of chemical bonding in each substance. [PR, AI]

Synopsis

In this activity, students use researching techniques to further develop their knowledge of the elements in the Periodic Table, first by completing a crossword puzzle then by creating a poster for a specific element of their choice. Teachers may also choose to assign class presentations.

Teacher Strategy

1) Teachers can get an overview of the activity and outcomes by reading this 5-page document. *Teacher's Guide*: http://www.pbs.org/wgbh/nova/teachers/activities/pdf/3114_origins.pdf
2) Option: You can purchase the video "Origins: Back to the Beginning" from NOVA, originally broadcasted in September 2004, and follow these viewing ideas for the classroom. *Viewing Suggestions*: http://www.pbs.org/wgbh/nova/teachers/viewing/3114_origins.html
3) While outlined in the Teacher's Guide, the Elemental Puzzler activity is fully described here. *Classroom Activity*: http://www.pbs.org/wgbh/nova/teachers/activities/3114_origins.html
4) Related websites are provided by NOVA for students wishing to further explore this topic. *Related links*: http://www.pbs.org/wgbh/nova/teachers/overviews/3114_origins.html
5) An interactive game may be found here for students to play with, either in class or at home. *Universe History game*: http://www.pbs.org/wgbh/nova/origins/universe.html

Learner Outcomes – By completing these activities, the learner will:

a) develop reading skills and coordination while following written instructions.
b) develop an awareness of spectroscopy and its use to astronomers.
c) use the periodic table to conduct further research.

Related Resources:

http://www.amnh.org/education/resources/programs/origins/beginning.php

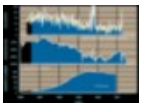
The American Museum of Natural History has collected a series of activities that specifically relate to the Origins: Back to the Beginning activity described above. These articles vary between grades but are aimed mostly at students in high school.

Where Do Cosmic Rays Come From: The Sun or Supernova?

Motivation to Use in the Classroom

Earth is constantly bombarded with particles not only from the Sun but also from other interstellar and galactic sources. Studying the cosmic ray isotopes in terms of their element fluxes may help scientists understand the formation and evolution of the universe. Aimed at an academic crowd, this activity is useful for interpreting unfamiliar graphical data and drawing conclusions on these findings.

Course	Specific Expectations Addressed	
SNC2D	C1.2	Analyse how an understanding of the properties of chemical substances and their reactions can be applied to solve environmental challenges. [AI, C]
SCH3U	B2.2	Analyse data related to the properties of elements within a period to identify general trends in the periodic table. [AI]
	B3.2	Explain the relationship between isotropic abundance of an element's isotopes and the relative atomic mass of the element.
SCH4U	C1.1	Assess the benefits of technologies that are based on the principles of atomic and molecular structures. [AI, C]



Synopsis

In this activity, students will study logarithmic graphs and interpret patterns and anomalies corresponding to fluxes of cosmic ray isotopes for different elements. Students can interpret the data for certain days and draw conclusions why those events may have occurred.

Teacher Strategy

1) Teachers can get an overview of the activity and its outcomes at this website.
   Educator's Overview: http://helios.gsfc.nasa.gov/supernova_abstract.html
2) Teachers may wish to reorganize the data on the website into a handout for the students but as it stands, there is just a website giving the Background, Procedures, and Questions for this activity.
   Procedure & Questions: http://helios.gsfc.nasa.gov/supernova.html#procedure
3) There are two additional resources for this activity to help: Composition of Matter and Cosmology.
   Composition of Matter and Atomic Structure: http://helios.gsfc.nasa.gov/ace2.html
   Cosmology and Stellar Evolution: http://helios.gsfc.nasa.gov/ed-acecosmo.html

Learner Outcomes – By completing these activities, the learner will:

a) use graphing skills to find patterns and correlations between data sets.
b) understand lower and higher cosmic ray isotopes of carbon, nitrogen, and oxygen.
c) read logarithmic plots from scientific data collections.
d) contemplate the formation and evolution of the universe.

Related Resources

Motivation to Use in the Classroom
This is a list of further good resources. The sites are user-friendly, vast in knowledge, related to Chemistry and Astronomy, and would engage students (and teachers) to want to learn more.

http://www.seasky.org/celestial-objects/stars.html

This website explains various cosmic wonders about the Stars. Of particular interest to chemistry is the second section entitled "A Nuclear Furnace" which looks at how deuterium and tritium atoms combine to form helium, a neutron, and a massive amount of energy – in other words, how nuclear fusion works. Engaging activities could be derived from this website, especially if used with the WebQuest link listed under the Related Resources portion of the Earth and Space Science section later in this document.

Physics

Building an Inexpensive Galilean-Style Telescope

Motivation to Use in the Classroom
This engaging, hands-on activity allows students to explore the physics behind telescopes and study the different types that have been built. Specifically building a replica of Galileo's model, they can rediscover history and see what he saw in the night sky. Focuses on teamwork, problem-solving skills, and tactile exercises, as well as building appropriate vocabulary in this area.

Course	Specific Expectations Addressed	
SNC2D	E1.2	Analyse a technological device that uses the properties of light and explain how it has enhanced society. [AI, C]
	E2.2	Use an inquiry process to investigate the laws of reflection, using plane and curved mirrors, and draw ray diagrams to summarize their findings. [PR, C]
SNC2P	E2.7	Construct an optical device that uses a variety of mirrors. [PR]
	E3.8	Explain how the properties of light or colour are applied in the operation of an optical device.
SPH4U	E1.1	Analyse, with reference to the principles related to the wave nature of light, a technology that uses these principles. [AI, C]
	E2.3	Conduct inquiries involving the diffraction, refraction, polarization, and interference of light waves. [PR]

Synopsis
In this lab activity, the students create an accurate replica of Galileo's telescope and can recreate his difficulties and successes in observing light from the Moon, Venus, Jupiter's satellites, and other planets.

Teacher Strategy

1) Find a complete list of materials and step-by-step building guide on this website.
   Educator's Resource: http://galileo.rice.edu/lib/student_work/astronomy95/telescope_design.html
2) Look at the findings that a previous university class did in Texas.
   Previous findings: http://galileo.rice.edu/lib/student_work/astronomy95/astrogroup.html
3) Starting this project at the beginning of the term would allow students to make observations throughout the semester/year. Depending on school policies, you might consider making a class set once or making one set per class so that students may keep their projects to use at home.
4) Galileo looked at many celestial objects in the night sky, some of which were essential in proving Copernicus' theory that the Earth revolved around the Sun. Click on these links to help generate detailed lesson plans:
   Mars, the Red Planet: http://galileo.rice.edu/lib/student_work/astronomy95/mars.html
   Earth's Moon: http://galileo.rice.edu/lib/student_work/astronomy95/moon.html
   Venus: http://galileo.rice.edu/lib/student_work/astronomy95/venus.html
   Jupiter's Moons: http://galileo.rice.edu/lib/student_work/astronomy95/jupiter.html
   Saturn's Rings: http://galileo.rice.edu/lib/student_work/astronomy95/saturn.html

Learner Outcomes – By completing these activities, the learner will:

a) build and use an instrument to demonstrate the properties of light from space.
b) broaden their knowledge of the planets by directly observing them.

c) discuss the history of the model of the Solar System.

Related Resources:

http://www.nmm.ac.uk/explore/astronomy-and-time/astronomy-facts/instruments/astronomical-spectroscopy

The telescope activity would pair well with this website, which looks at astronomical instruments and how light and other electromagnetic waves may be filtered into its constituent colours to study the spectra that it creates and what may be learned from it.

http://science.howstuffworks.com/telescope.htm

This website would also pair well with the telescope activity in that it thoroughly describes the different types of telescopes that have been built, how light is manipulated in each type, and provides interesting videos and links. Guidelines on how to build your own are also suggested.

https://www.galileoscope.org/gs/

This website has all the information you need to order and build Galileoscope kits. Priced under $30 a unit, this high quality 50mm F/10 refractor kit emphasizes more on enabling “more people in more places to personally experience the wonders of the universe” than the physics inside the scope. Discounts are available for bulk purchases, ideal for school settings, and come with useful educational activities that you can read about and download here: https://www.galileoscope.org/gs/content/galileos-classroom.

http://www.phys.hawaii.edu/~teb/java/ntnujava/Lens/lens_e.html

This applet allows users to manipulate the size of the mirror or lens and watch as the rays update accordingly. This is a good aid in showing how the angles of light rays change as the factors change.

http://hubblesite.org/the_telescope/hand-held_hubble/

This website allows users to choose between three levels of difficulty in creating a scale model of arguably the world’s most famous scope. Model is non-working but is an engaging demonstrational tool.

Impact Cratering

Motivation to Use in the Classroom

Finding engaging activities for students can often be a difficult task. In this slingshot activity, students are interactively creating their own craters and interpreting the data into useful kinetic energy values. Care must be given to ensure students wear goggles. This lab activity is memorable and relevant to many observable celestial objects, such as the Moon, for which we can see impact craters.

Course	Specific Expectations Addressed	
SPH3U	D2.4	Plan and conduct inquiries involving transformations between gravitational potential energy and kinetic energy to test the law of conservation of energy. [IP, PR]
SPH4U	C2.5	Analyse, in qualitative and quantitative terms, the relationship between mass, velocity, kinetic energy, momentum, and impulse for a system of objects moving in one and two dimensions, and solve problems involving these concepts. [PR, AI]
SPH4C	E2.3	Construct a simple device that makes use of energy transformations, and use it to investigate transformations between gravitational potential energy and kinetic energy. [PR]

Synopsis

In this lab activity, students use a calibrated slingshot to fire projectiles and create craters to observe the effects of mass and velocity on the kinetic energy of the activity, determined by the size of the impact crater. All necessary equations and calculations are provided.

Teacher Strategy

1) Save the 11-page PDF document, which contains both the teacher's notes and the student activity. *Educator's Resource*: http://teacherlink.ed.usu.edu/tlnasa/units/PlanetaryGeology/7.pdf
2) The activity sheets (pp.5-11) lead the students through the lab activity, using a calibrated slingshot to create recordable findings that the students then interpret and calculate into kinetic energy. This lab could be a good summative activity for the end of the kinetic energy portion of the unit.
3) A further online activity for the students would be to take a look at high resolution images of the surface of the moon and use their new skills to determine the information about the craters found. Additional instructions for participating in an online study happen to be provided on the website. *Moon Zoo Images*: http://www.moonzoo.org/

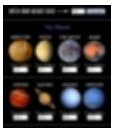
Learner Outcomes – By completing these activities, the learner will:

a) understand the relationship between mass and velocity of a projectile.
b) be able to deduce the direction of incoming projectiles, in certain cases.
c) demonstrate the mechanics of the energy of motion, kinetic energy.

Your Weight On Other Worlds

Motivation to Use in the Classroom
Students often have misconceptions in distinguishing between mass and weight. This activity looks at these properties from a perspective outside Earth in order to show the significance of the differences. Drawing free-body diagrams, problem solving, and communication are key skills utilized here.

Course	Specific Expectations Addressed	
SPH3U	C2.2	Conduct an inquiry that applies Newton's laws to analyse, in qualitative and quantitative terms, the forces acting on an object, and use free-body diagrams to determine the net force and acceleration of the object. [PR, AI, C]



Synopsis
Using this website as an aid, students can discover their weight on other planets and moons in our solar system. From this they can determine the gravitational acceleration constants. The importance of free-body diagrams and distinguishing between mass and weight is noted.

Teacher Strategy

1) Direct the students to this website in order to find their respective weights on different worlds. *Interactive Website*: http://www.exploratorium.edu/ronh/weight/
2) Report: Using the text at the bottom of the website as a guide, students will be asked to create a free-body diagram and calculate the gravitational constant for each planet and moon listed on the site, and tabulate their results in a report. The report should note the significance of mass in these calculations and the variance of weight between different places in the Solar System.

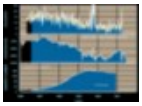
Learner Outcomes – By completing these activities, the learner will:

a) distinguish between weight and mass of an object.
b) use free-body diagrams to show the net force and acceleration of an object on different worlds.
c) use Newton's laws to quantitatively and qualitatively analyse these forces.

Exploring Human Impacts of Solar Activities

Motivation to Use in the Classroom
While this expectation has the inclination to look at man-made objects that emit these fields, it can be beneficial to look at naturally occurring field disruptions that affect our electronics. In this activity, students interpret data, graph it, and deduce if solar flares affect the electronic fields of satellites orbiting the Earth. This activity also provides an excellent opportunity to use a graphing calculator.

Course	Specific Expectations Addressed	
SPH4U	D1.2	Assess the impact on society and the environment of technologies that use gravitational, electric, or magnetic fields. [AI, C]



Synopsis
In this lab, students will make a graph from a data table and look at patterns and possible correlations between the frequency of cosmic disturbances and glitches. Students also get the chance to debunk old folklore/pseudoscience by scientifically hypothesizing future events.

Teacher Strategy

1) Save the 57-page PDF document, which contains both the teacher's notes and student activities. *Educator's Resource*: http://teacherlink.ed.usu.edu/tlnasa/units/PlanetaryGeology/7.pdf
2) Read the Teacher's Guide on this lab (pp.25-27), "Satellite Glitches and Cosmic Rays", to gain an understanding of the lab components.
3) The student lab starts on page 28 as four data tables followed by two empty pages, one with an empty graph, one with a large box. (This activity is not spelled out to the students so the teacher could make a separate document giving better instructions.)
4) Since the data is over 20 years old, students may wish to find how the data has changed over time – and it has. In an article posted in September 2009 in *Universe Today*, NASA discovered that the "cosmic ray intensities have increased 19% beyond anything we've seen in the past 50 years". Students could introduce this increase into their graphs and extrapolate to future years. *Article*: http://www.universetoday.com/2009/09/29/cosmic-ray-intensity-hits-50-year-high/
5) Many people think 2012 will be the end of the world, partly because the Mayan calendar prophecied the "end of the world" in 2012, partly because of the implied risk of a massive solar flare that would wipe out all electronics on the planet. Students could investigate this 2012 theory and make their own scientific conclusions based on real data and other articles such as this one. Article: http://www.universetoday.com/2008/06/21/2012-no-killer-solar-flare/
6) There are other activities in this set that may be of use to the teacher. These include: Solar Storms and Satellites (p.9), Cosmic Radiation Creates Unfriendly Skies (p.22), Planning a Trip to Mars (p.31), and Cosmic Rays and Sunspot Numbers (p.38).

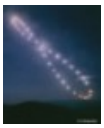
Learner Outcomes – By completing these activities, the learner will:

a) understand the magnetic effects of solar flares on the Earth and orbiting electronic satellites.
b) use scientific reasoning to make observations on collected data.
c) use graphing skills to find patterns and correlations between data sets.
d) discuss the differences between pseudoscience and science.

Figure Eight in the Sky

Motivation to Use in the Classroom
The analemma concept is antiquated but still may serve simple graphing purposes in the classroom. Teachers may also encourage the students in a year-long class exercise to create their own records and photographs for a class compilation or competition.

Course	Specific Expectations Addressed	
SPH3U	B2.2	Analyse and interpret position-time, velocity-time, and acceleration-time graphs of motion in one dimension. [AI, C]



Synopsis
In this activity, students become acquainted with the motion of the Sun relative to the Earth's perspective over time, and can graph the resulting analemma or unique figure-eight shape.

Teacher Strategy – Follow these steps to figure out where to start and what the activities involve:

1) Find a complete list of materials and sample lesson on this website. Includes questions and assessment and reasons why the analemma is important in annual predictions and festivals:
   Lesson 1 Resource: http://www.urbanedpartnership.org/target/SMART/sunrise/4-7les1.html
   Lesson 2 Resource: http://www.urbanedpartnership.org/target/SMART/sunrise/4-7les2.html
2) Starting this project at the beginning of the term would allow students to make observations throughout the semester/year. Encourage picking a site that includes the school in the background.
3) For ideas on how to create the analemma as a class photo activity, visit this site for examples:
   Analemma over Ukraine: http://apod.nasa.gov/apod/ap070617.html
4) Halfway down this book review are techniques roofers use to maximize the Sun's angle.
   Solar Energy Applications: http://www.solarnet.org/IndHome/ch0610.htm
5) Familiarize yourself with how to observe an analemma and install a gnomon on school property. Other planets take analemma paths, and there is much math to relate to with this phenomenon.
   General Resource: http://www.analemma.com
   Book Resource: Astronomy for All Ages, by P. Harrington & E. Pascuzzi, Chapter 26

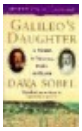
Learner Outcomes – By completing these activities, the learner will:

a) build and use an instrument to demonstrate the analemma path of the Sun.
b) understand how the tilt of the Earth affects the position of the Sun in the sky.
c) use graphing techniques to create and interpret position-time graphs.

Related Resources

Motivation to Use in the Classroom
This is simply a good resource base for further reading. The sites are user-friendly, vast in knowledge, related to Physics and Astronomy, and would engage students (and teachers) to want to learn more.

Book: **Galileo's Daughter**: An Historical Memoir of Science, Faith, and Love. ***
By: Sobel, Dava. | Year of publication: 1999. | Publisher: Viking. | Pages: 420 p.



On the Back: "Galileo's Daughter is a moving account of the relationship between father and daughter, and the tension between belief and scientific conviction at the origins of modern science. Sobel demonstrates the fruitful potential of studying science and religion from [an] historical point of view; but her story is also intriguing from a social perspective: a haunting glimpse into the mind of a highly intelligent and sensitive young woman at the dawn of the Renaissance."

How can I use this in a classroom? Read segments from it to the class. Have students read from it aloud. Create one-page book review pages for students to answer questions at the end of a segment.

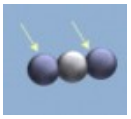
http://hubblesite.org/explore_astronomy/black_holes/
An fully interactive and visually appealing website for students to learn more about one of their favourite question topics: the Black Hole. Use a Hubble's viewfinder to explore different types of nightsky objects and "See the sky in different ways" using different wavelengths of the electromagnetic spectra. Use it as an aid or let students explore it on their own.

Earth and Space Science

Venus and the Greenhouse Effect

Motivation to Use in the Classroom
This activity uses household items to mimic the effects of a greenhouse on a smaller scale. Students can build it themselves or in groups and take observations throughout the course of the activity, fostering laboratory and communication skills in the process.

Course	Specific Expectations Addressed	
SNC2D	D2.2	Design and build a model to illustrate the natural greenhouse effect, and use the model to explain the anthropogenic greenhouse effect. [IP, PR, C]
SNC2P	D2.2	Investigate the principles of the natural greenhouse effect, using simulations, diagrams, and/or models, and compare these principles to those of an actual greenhouse. [PR, AI]
SCH4C	F3.2	Identify gases and particulates that are commonly found in the atmosphere, and explain how they affect air quality.



Synopsis
In these two lab activities, students investigate the effects of Earth's greenhouse effect using pop bottles to simulate the Earth and its atmosphere on a smaller scale. The teacher may then relate the concepts studied with the runaway greenhouse effect on Venus.

Teacher Strategy

1) Visit these two websites to gain an understanding of the two activities available for students.
   Activity 12: http://www.ucar.edu/learn/1_3_2_12t.htm "What is a Greenhouse?"
   Activity 13: http://www.ucar.edu/learn/1_3_2_13t.htm "What Factors Impact a Greenhouse?"
   Note: Assessment strategies are found on these pages too, along with possible modifications.
2) Students may visit the following printable versions and work from them in class.
   Student Activity 12: http://www.ucar.edu/learn/1_3_2_12s.htm
   Student Activity 13: http://www.ucar.edu/learn/1_3_2_13s.htm
3) Both activities have the students create their own greenhouse effects in large pop bottles in a classroom lab or experiment setting. However, these ideas could also make for an interesting science fair project base.
4) Overall lesson strategies for delivering the activities along with relevant facts may be found here.
   Background Material: http://www.ucar.edu/learn/1_3_1.htm
5) The relation to astronomy is not through these sites but by introducing the concept of a runaway greenhouse effect. Use Venus as the real-life example. A short background is described following the *Learner Outcomes* section with useful facts and internet links.

Learner Outcomes – By completing these activities, the learner will:

a) understand how greenhouses work to retain heat.
b) be able to identify at least 3 factors affecting the heat-trapping ability of a greenhouse (eg. transparency of greenhouse cover, color of surfaces inside greenhouse, type of surfaces inside).
c) be able to explain the factors important in the atmosphere's heat trapping ability.
d) understand the influence of albedo on earth's temperature.

Runaway Greenhouse Effect on Venus

Venus is the hottest planet in the Solar System, with a global temperature of 462°C (735 K) – it has the same temperature all over the planet, regardless of location or time of day. Carbon dioxide (CO_2) is a greenhouse gas: it is effective in trapping heat. When the Sun heats up the surface of Venus, the CO_2 atmosphere traps this heat and raises the surface temperature. Water vapour acts like CO_2 as a greenhouse gas but is even more effective at trapping heat. Scientists think Venus started heated up billions of years ago and the water that was present soon became water vapour, trapping a lot of heat and raising the planet's temperature. This temperature increase probably caused carbon trapped in rocks to sublimate into the atmosphere and mix with oxygen, creating even more CO_2. The CO_2 atmosphere on Venus is 92 times denser than that of Earth's (if you were to dive down 1km below the surface of the ocean, you would experience a similar kind of pressure). This greenhouse effect *could* happen on Earth, raising the temperature and density of the atmosphere to those similar on Venus now.

[Reference: http://www.universetoday.com/guide-to-space/venus/venus-greenhouse-effect/]

"Even though conditions on the ground are horrendous, once you get to an altitude of about 50 km to 65 km above the planet, the atmospheric pressure and temperature become very similar to Earth. In fact, this is the most Earthlike place in the Solar System – even more than Mars." (Applications for floating cities above Venus surface.)

[Reference: http://www.universetoday.com/guide-to-space/venus/atmosphere-of-venus/]

Related Resources:

http://ircamera.as.arizona.edu/NatSci102/lectures/venus.htm

Comparison of Earth and Venus greenhouse effects. Includes photographs showing surface properties on the planet.

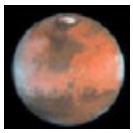
http://burro.astr.cwru.edu/stu/advanced/venus.html

Atmospheric study of Venus and timeline of spacecraft visits to it.

Investigating the Dynamic Martian Polar Caps

Motivation to Use in the Classroom
Relating Earth to other planets in the Solar System is beneficial for putting large ideas into context and taking a greater look at the effects of the Sun. This activity works to dispel the misconceptions that arise in this area due to lack of knowledge regarding the origin of planetary seasons.

Course	Specific Expectations Addressed	
SNC2D	D2.4	Investigate a popular hypothesis on a cause-and-effect relationship having to do with climate change using simulations and/or time-trend data that model climate profiles. [PR, AI, C]
	D2.6	Investigate, through laboratory inquiry or simulations, how water in its various states influences climate patterns. [PR, AI]



Synopsis
In these three computer-assisted activities, students investigate the changing polar ice cap on the planet Mars and compare it to Earth's. Some time is spent on the reason for seasons (planet's tilt) and length of a season (determined by one orbit around the Sun).

Teacher Strategy

1) Direct the students to this website to print it out and follow the instructions.
   Online student activity sheet: http://btc.montana.edu/ceres/html/Polar/polarstudentact.htm
2) For teacher assessment strategies, these are holistic suggestions on how to score the work:
   Assessment strategies: http://btc.montana.edu/ceres/html/Polar/polarassessment.htm
3) The overview and lesson strategies for the teacher may also be found at this website:
   Learner Plans: http://btc.montana.edu/ceres/html/Polar/polar1.htm

Learner Outcomes – By completing this activity, the learner will:

a) Understand that the sizes of the polar ice caps on Earth and Mars depend on the lengths of the seasons. (The fact the planet has a season depends on the tilt of the axis of rotation. The length of the season on each planet depends on the time it takes the planet to make one orbit around the sun.)
b) Measure the sizes of the polar ice caps on Earth and Mars using image processing techniques.
c) Compare the changing sizes of ice caps on Earth and Mars using the tilt of the axis of rotation, the time to complete an orbit (one year), and the time for one rotation about the axis (one day).

Related Resources
http://www.ExploreLearning.com has a useful Gizmo that interactively shows the changing seasons on Earth, called "Seasons: Earth, Moon, and Sun". Play around with the settings to change the tilt or other factors and observe the impact on daylight and seasons. Use this with a solar energy unit to calculate how much sunlight is required to meet requirements for one year that the class sets. Set up a real stick outside with your class and make compass measurements every day at the same time and record class results.

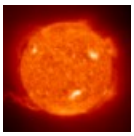
Teacher Guide: http://cs.explorelearning.com/materials/SeasonsEarthMoonSunTG.doc
Student Exploration sheet: http://cs.explorelearning.com/materials/SeasonsEarthMoonSunSE.doc

http://www.urbanedpartnership.org/target/SMART/sunrise/4-7les4.html
This online lesson plan provides students with a simple hands-on experiment to mimic the seasons using construction paper and a flashlight. This application could be useful in explaining housing locations.

Sun's Impact on Earth's Temperature

Motivation to Use in the Classroom
Deducing weather patterns and modelling climate profiles with online resources is of key interest with these activities. Students build their deductive reasoning skills as they analyse various data and models of Earth's closest neighbours and their respective relationships with the Sun.

Course	Specific Expectations Addressed	
SNC2D	D1.1	Analyse current and/or potential effects, both positive and negative, of climate change on human activity and natural systems. [AI, C]
	D2.4	Investigate a popular hypothesis on a cause-and-effect relationship having to do with climate change using simulations and/or time-trend data that model climate profiles. [PR, AI, C]
SNC2P	D1.1	Analyse, on the basis of research, various ways in which living things and natural systems have been affected by climate change, and communicate their findings. [IP, PR, AI, C]
	D2.4	Conduct an inquiry to determine how different factors affect global warming and climate change. [PR]
	D2.7	Compare different perspectives and/or biases evident in discussions of climate change in scientific and non-scientific media. [PR, AI]



Synopsis
In these five computer-assisted activities, the students view NASA images and movies of Venus, Earth, and Mars to deduce weather patterns and manipulate computer models to test competing hypotheses.

Teacher Strategy – Follow these steps to figure out where to start and what the activities involve:

1) Direct the students to this website to print it out and follow the instructions.
   Online student activity sheet: http://btc.montana.edu/ceres/html/Suns/sunsstudentactivity.htm
2) The overview and lesson strategies for the teacher may also be found at this website:
   Learner Plans: http://btc.montana.edu/ceres/html/Suns/suns1.html

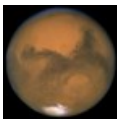
Learner Outcomes – By completing this activity, the learner will:

a) Compare weather patterns observed on Venus, Earth, and Mars.
b) Manipulate computer models to investigate the influence of solar distance and atmosphere.
c) Evaluate various solar system hypotheses using a computer model.

Mars Exploration: Is There Water On Mars?

Motivation to Use in the Classroom
Mars looks to have been carved with water channels and rivers, but there is little evidence to suggest there is still water on the surface... or is there? Students take this opportunity to use lab skills and deductive reasoning to explore the physics concepts that may explain the water-like features on Mars.

Course	Specific Expectations Addressed	
SNC2D	D2.4	Investigate a popular hypothesis on a cause-and-effect relationship having to do with climate change using simulations and/or time-trend data that model climate profiles. [PR, AI, C]
	D2.6	Investigate, through laboratory inquiry or simulations, how water in its various states influence climate patterns. [PR, AI]



Synopsis
In these seven comprehensive activities, students navigate through one or several specific lab activities by looking at the relationship between pressure and water's boiling pressure. The labs lead the students through a series of findings to ultimately hypothesize about Martian features.

Teacher Strategy

1) Save the following 105 page document to your computer.
   Water on Mars Guide: http://www.nasa.gov/pdf/58223main_Is.There.Water.on.Mars.pdf
2) An excellent module overview is provided on pages 8-9 for all seven activities:
   1 & 2: Students discover two plateaus as water changes state and explore contributing factors.
   3: Students increase the boiling point of water by increasing pressure in the container.
   4: Students discover Earth's atmosphere exerts considerable pressure at the surface.
   5: Students explore ways to reduce the boiling temperature of water using only pressure.
   6: Students analyze Mars features and graphs, concluding about the past existence of water.
   7: Students extrapolate module conclusions with data they want to see in upcoming missions.
3) The order of the labs is excellent but the third activity could be used in isolation if there are time constraints. The labs could then be condensed after to meet the specific expectation of this activity. *To do this:* Go to page 25 (p.13 using the doc's page numbers) for "Activity 3 – At a Glance". This is the overview of the activity, which follows on pages 26-31 (pp.14-19 of the doc).

Learner Outcomes – By completing this activity, the learner will:

a) discover the two plateaus as water changes state.
b) explore how water states affect life on Earth.
c) test the boiling temperature of water if pressure is increased in the container.
d) relate these findings to the influence of water on climate patterns, both on Mars and on Earth.

Related Resources:
http://exoplanet.eu/index.php

This website is the Extrasolar Planet Encyclopedia which contains tutorials, searching for extrasolar planets, and an interactive catalog of all the extrasolar planets that have been found to date. Students can do further research on the Ecozone, or the orbit range that allows water to exist in its liquid state.

The Very, Very Simple Climate Model

Motivation to Use in the Classroom
This activity engages students to think about the future repercussions of current trends in the concentration levels of carbon dioxide in the atmosphere and temperature changes. Interpreting graphical data is a useful skill for students to practice.

Course	Specific Expectations Addressed	
SNC2D	D2.3	Analyse different sources of scientific data for evidence of natural climate change and climate change influenced by human activity. [PR, AI, C]
	D2.4	Investigate a popular hypothesis on a cause-and-effect relationship having to do with climate change. [PR, AI, C]
	D3.6	Describe how different carbon and nitrogen compounds influence the trapping of heat in the atmosphere and hydrosphere.
SNC2P	D2.4	Conduct an inquiry to determine how different factors affect global warming and climate change. [PR]

Synopsis
This is an interactive graph showing the concentration levels of CO_2 vs. a projected year in the future. The student can alter the concentration levels and produce a simulated graph of the effects this would cause in terms of temperature and CO_2 change.

Teacher Strategy

1) Direct the students to this website to follow the instructions and fill in their projected variables.
   Online student activity: http://www.windows2universe.org/earth/climate/cli_model.html
2) For teacher assessment strategies, teachers could create a list of questions (other than found on the website) to explore different scenarios. For example, "How does the graph change for 13 GtC as you timestep over the next 90 years by 5 year intervals? Compare this to 6 GtC or 0 emissions."
   Note: to reset the graph, it looks like the student will have to reload the page (CTRL-R).
3) Get the students to look at the temperature changes to further discuss the trapping of heat. Students could integrate this online activity with a report on the differences between carbon and nitrogen compound influences, per the specific expectation requirements.
4) Teachers can lead a discussion on the biases within this model: ignoring changing winds, precipitation patterns, location of the CO_2, and ignoring other greenhouse gases and the ocean and albedo factors. Some notes may be found here:
   http://www.windows2universe.org/earth/climate/cli_model_notes.html

Learner Outcomes – By completing this activity, the learner will:

a) explore the changes in temperature and CO_2 change with an interactive online graph.
b) interpret data results from graphs.

Related Resources:

http://www.windows2universe.org/earth/climate/greenhouse_gases_scott_denning_movie.html

Movie explaining how greenhouse gases in the Earth's atmosphere warms our planet. Students can fill out a sheet to answer questions that Prof. Scott Denning proposes. Link to download movie is available on the same page.

http://windows2universe.org/earth/climate/carbon_cycle.html

Aimed at the Grade 5-8 level, this a game that allows you to travel the path of a carbon atom through the Carbon Cycle. Your objective is to get to all the places that carbon is stored along the map and answer

questions based on your readings. Good, interactive review. Complete lesson plan and suggested assessment strategies can be found here:
http://www.windows2universe.org/teacher_resources/teach_carbongame.html

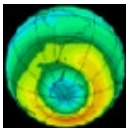
http://www.windows2universe.org/earth/Life/nitrogen_cycle.html&edu=mid

Aimed at three levels of learners (beginners, intermediate, and advanced), this a series of webpages where the reader can learn more about the Nitrogen Cycle. Also available in Spanish.

Graphing Stratospheric Ozone

Motivation to Use in the Classroom
Students are often unaware of the impact the ozone layer has on Earth's climate and sustainability of life. This activity leads them through a series of images to compare over time what has been happening to this layer and hypothesize what might continue from the effects of increased human impact. Emphasis in this activity is on interpreting and graphing data into useful tools.

Course	Specific Expectations Addressed	
SNC2D	D3.7	Describe, in general terms, the causes and effects of the anthropogenic greenhouse effect, the depletion of stratospheric and tropospheric ozone, and the formation of ground-level ozone and smog.
SNC2P	D2.6	Compare different tools or systems used by scientists to make informed decisions on global climate change. [PR, AI]



Synopsis
In this activity, students take data and NASA images from the internet and graph the ozone concentrations of a chosen location. Ozone chemistry study is encouraged with more resources.

Note: While the site is outdated, the activity could easily be updated with newer images that the students can research, or the students could look to other planets for graphing similar data sets.

Teacher Strategy

1) Direct the students to this website to practice graphing a sample set of ozone concentration levels:
   Making a simple graph: http://www.exploratorium.edu/learning_studio/ozone/graphing1.html
2) An introduction to the lesson plan is succinctly provided here:
   How-to use these 3 hours: http://www.exploratorium.edu/learning_studio/ozone/introduction.html
3) Other links to websites here provide good starting points for finding images and articles:
   Next Steps: http://www.exploratorium.edu/learning_studio/ozone/chemistry.html

Learner Outcomes – By completing this activity, the learner will:

a) compare total ozone concentrations taken over the course of several years.
b) manipulate computer graphs to investigate any correlations in data.
c) evaluate similar graphs with alternate data axes, such as pressure, altitude, and time.

Related Resources

Motivation to Use in the Classroom
This is simply a good resource base for further reading. The sites are user-friendly, vast in knowledge, related to Earth and Space Sciences and Astronomy, and would engage students (and teachers) to want to learn more.

http://www.cascaeducation.ca/files/teachers_gr12unit.html

A comprehensive website with links to many useful Grade 11 and 12 Astronomy-related activities for the Pan-Canadian Science Curriculum. Specific learning outcomes, curriculum objectives, and summative assessment activities are also available.

http://ex.susd.org/elearning/attachments/Science/The%20Life%20Cycle%20of%20Stars.htm

This WebQuest contains ten tasks that student work through online and hand in components of over the course of several days. Suitable for a Grade 9 or 10 class looking at the life cycle of the stars, with ties to Einstein's $E = mc^2$ equation, magnitudes of light, nuclear fusion models, and other concepts.

Podcast: **SkyWatch Weekly Audio Broadcast** http://hubblesite.org/explore_astronomy/skywatch/

SkyWatch with HubbleWatch – It's a big sky, someone has to watch it. Available in MP3 format (5MB per show), about 5 minutes in length. Teachers could let this run at the beginning of a class to get students thinking about the latest finds from Hubble, helping them settle and focus when they come in and take their seats.

Book & CD: **Astronomy**: The Solar System and Beyond. *****
By: Seeds, Michael A. | Year of publication: 2005. | Publisher: Brooks/Cole. | Pages: 506 p.

On the Back: "Prepare to be astonished! Astronomy is about more than planets, stars, and galaxies. It is also about us. This fascinating science will take you on a journey of discovery that will help you understand the meaning of our own existence... Stunning images and fascinating discoveries will take you to the very frontiers of human knowledge, from the discovery of buried water on Mars to the new view of the Milky Way as a cannibal of small galaxies."

How can I use this in a classroom? Reads like a colour textbook, makes an excellent resource for any class library. Assign students chapter review problems or start a lesson with one to get students thinking and on task. Run the CD with a projector and explore objects with TheSky, run in-class labs with Virtual Astronomy Laboratories, or explore the various activities, helpful tutorials, and potential lesson plans.