



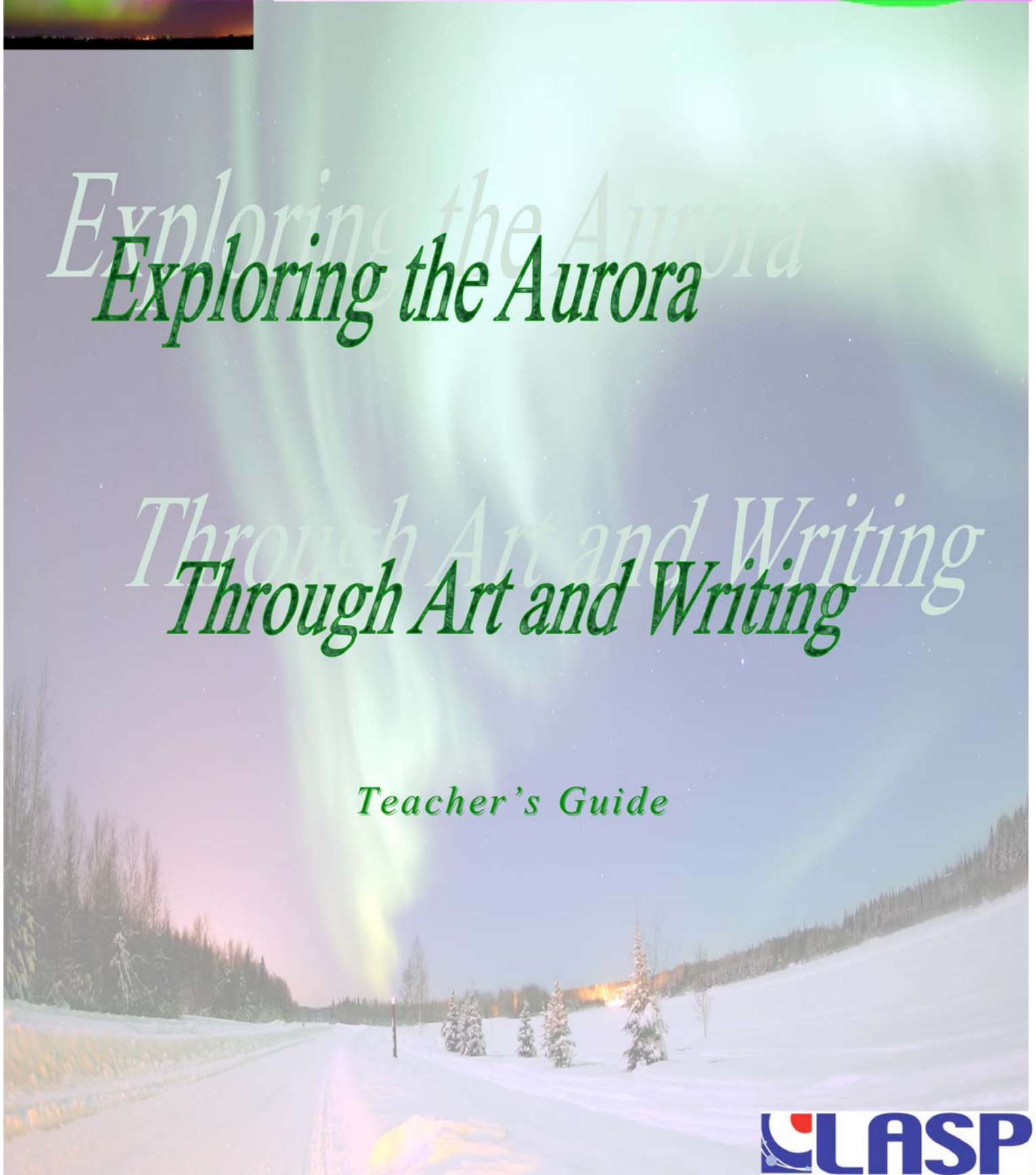
Dancing Lights



Exploring the Aurora
Exploring the Aurora

Through Art and Writing
Through Art and Writing

Teacher's Guide





Dancing Lights

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Dancing Lights

Welcome to Dancing Lights!

Over the last decade, it has become increasingly clear that science can be a wonderful way to excite kids about reading, writing and the arts. The natural beauty that science represents inspires students to both think about the world around them and strive to find the words and images that communicate their excitement.

Dancing Lights provides a set of five activities that allows students in Grades 3 through 5 to explore the beauty, science and mythology of the aurora creatively through art and writing. This standards-based, flexible 'plug-and-play' program is based on the latest research on bringing science into the literacy and art classroom. It can be used as a complete sequence of lessons or can be used as guidelines for teachers to develop their own activities.

Before teaching the first lesson, teachers might hand out manila folders that can serve as student portfolios. Students can decorate and personalize their folders with images and words about the aurora.

Visit the Dancing Lights website for more background information, references on science and literacy, and more education opportunities at <http://lasp.colorado.edu/education/dancinglights/>

We hope you enjoy **Dancing Lights**, and we look forward to your feedback!

Emily A. CoBabe-A

Office of Communication and Outreach
<http://lasp.colorado.edu/education>

Cover Image Courtesy of: Joshua Strang/USAF



Dancing Lights

Why is the Science-Literacy Connection so Important?

Science is all about inquiry in our natural world. Yet all of the observational skills at our fingertips are useless if we don't have the ability to communicate it effectively to our friends, family, and classmates. The development of language skills is critical for students to be able to codify their ideas, integrate observations from the outside, and synthesize both to create the next step in their educational journey. Whether we are focused on students that are still learning how to 'decode' the words and phrases before them or on students that are developing their skills as comprehensive readers, science is a topic that can be used to excite and engage students in order to improve literacy skills (Douglas et al., 2006).

The connections between science and literacy in the classroom have received increasing attention over the last two decades, as more and more evidence demonstrates that science provides an exciting vehicle in which to engage students on the path to literacy improvement. When students are actively participating in science activities, including making observations, formulating hypotheses, and explicating their findings, they are also learning to utilize language to express ideas. In addition, combining literacy with science allows students to creatively explore the world or universe (Palinscar and Magnusson, 2001). Combining science and literacy improves both reading and science scores, and increases students' interest in science (Romance and Vitale, 1992, Mechling and Oliver, 1983; Simon and Zimmerman, 1980).

Science and writing are not mutually exclusive. Scientists must read and write as a part of their daily routine and effective communication skills are crucial to the scientific process. Given this, the marriage of science and literacy in the classroom is not only a natural one; it is a critical one for students to effectively demonstrate understanding of scientific processes to themselves and others (Goldman and Bisanz, 2002). The same skills that make good scientists also make good readers: engaging prior knowledge, forming hypotheses, establishing plans, evaluating understanding, determining the relative importance of information, describing patterns, comparing and contrasting, making inferences, drawing conclusions,

generalizing, evaluating sources, and so on (Armbruster, 1993). Science and literacy share a set of intellectual processes (observing, classifying, inferring, predicting and communicating) and the same problem-solving processes are used (Padilla et al., 1991). By embedding authentic literacy within the scientific framework (and vice versa), students take advantage of this synergy (Cervetti and Pearson, 2006).

Finding ways to connect science with literacy development is a natural step in integrating curriculum across disciplines, particularly at the elementary school level. Storytelling is an important component of this effort. People are natural storytellers, hearing stories from birth, telling stories to others, and handing stories down through generations. Storytelling creates emotional ties, and studies of memory retention suggest emotion creates strong memories (Wolfe, 2001). Using emotion in the classroom is one way to facilitate retention of curriculum (Banikowski, 1999). Additionally, science, because it involves complex cognitive activity, may produce more articulate and expressive writing (Wolfe, 2001). Scientific exploration can lead students on vicarious journeys to, say, other planets or the bottom of the ocean (Palinscar and Magnusson, 2001), and the written word can be used to express those journeys and explicate knowledge gained in the process.

In the Dancing Lights program, students explore the aurora creatively as well through a scientific lens. The goal is to facilitate students' exploration of the aurora through reading, writing and art, thereby using several different media, catering to a diverse set of learning styles (Varelas et al., 2006). Students are encouraged to use several strategies during the program, including: Know-Want to Know-Learned (KWL), creating lists and organizing using webs, reading and writing myths, stories and poetry, and using description to communicate to others. These techniques are supported by current research, described here, as methods that clarify students' understanding and aid in retention of knowledge. Really, any science can be explored in this way; however, the aurora is a perfect topic for this application since it is a visually beautiful natural phenomenon, it has been used in storytelling for generations and among people that span remote regions of the globe, and can be used as a backdrop for studies of the Sun and its interactions with the Earth.



Dancing Lights

Lesson 1: What I Know About the Aurora

Description of Lesson: In this introductory lesson, students will learn the basics of the aurora. First, they will discuss the aurora in small groups. They will reflect on what they already know about aurora and what they hope to learn. Students will also read a poem with animations on the computer, which provides an overview of auroral activity. Next, they will read about auroras as a class, after which they will again break off into their small groups and discuss what they learned from this activity. If time allows, the answers can be discussed as a class.

National Science Education Standards

- **Earth and Space Science**
Changes in earth and sky (K-4)
Earth in the Solar System (5-8)

Benchmarks for Science Literacy, Project 2061 (3-5)

- **The Physical Setting**
The Earth
Forces of Nature

Lesson Time: 45 minutes

Materials:

- "What I Know" Worksheets
- Northern Lights Tutorial:
<http://ds9.ssl.berkeley.edu/auroras/story.html>
- An LCD projector (optional)
- Computer (s)
- *The Aurora: What is it, where do we see it, and how do we study it?*
Power Point (on *Dancing Lights* CD)

Procedure:

- Organize the class into small groups of three to five students. Distribute the "What I Know" worksheet to each group. Each student should have his/her own worksheet. The students will discuss what they know and what they would like to know about the aurora in small groups and record their responses.
- If it's possible, project the Northern Lights tutorial to the class. If a projector is not available, have the small groups of students read the tutorial from a computer, while the other students complete their group discussions.
- Next, show *The Aurora: What is it, where do we see it, and how do we study it?* Power Point presentation.
- Distribute the "What I Learned" worksheet to each group and allow them to talk about what they now know about aurora.
- If time allows, discuss the student responses with the entire class, allowing each group to share its answers. If there is not enough time, begin the next lesson with this class discussion. Teachers can make a list of the group responses on the board so students can compare their answers to those of the other groups.



Dancing Lights

Name _____

Date _____

Draw or write what you know and what you would like to know about the aurora.

What I Know About the Aurora:

**What I Would Like to Know About
the Aurora:**



Dancing Lights

Name _____

Date _____

What I Learned About the Aurora:



Dancing Lights

Lesson 2: Myth versus Fact

Description of Lesson: The purpose of this lesson is to introduce students to myths about the auroras in different cultures. In this lesson, the class will read a story relating to legends of the aurora and will have a chance to creatively share their reactions to the story. For homework, students will create their own myth regarding the aurora. This activity will help students understand why different cultures believe what they do about the Northern Lights, and will provide a creative way to demonstrate understanding.

Background: Many cultures have created legends about the creation of aurora, the bright flashes of colored light that appear in the sky over the northern latitudes. The Inuit, for example, believed the lights to be dancing spirits of animals, such as salmon, deer, and seals. This activity will focus primarily on the mythology of the aurora, while the next lessons will cover the science of these beautiful lights.

Benchmarks for Science Literacy, Project 2061 (3-5)

- **Human Society:** *Cultural effects on behavior*

National Standards for English Language Arts

- **Standard 1:** *Students read a wide range of print and non-print texts to build an understanding of texts, of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classic and contemporary works.*
- **Standard 5:** *Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes.*

Lesson Time: 45 minutes

Choose one or more of the following books for this lesson:

- Kinsey-Warnock, Natalie. The Fiddler of the Northern Lights. Dutton Juvenile, 1996.
- Kusugak, Michael Arvaarluk. Northern Lights and Soccer Trails. Annick Press, 1993.
- Sabuda, Robert. The Blizzard's Robe. Atheneum, 1999.
- Waboose, Jan Bourdeau. Sky Sisters. Kids Can Press, 2009.

Materials:

- One or more of the books listed above
- Plain white paper
- Chapter Two of Wonders of the World: Northern Lights
Or
Northern Lights 'Fascinating Facts' pp 45-46
Or
Auroras: Light Shows in the Night Sky pp 9-19
Or
Science Matters: Northern Lights p 7

Procedure:

- Read one or more of the books listed above to the class.
- In the time remaining, have the students think about the story and allow them to draw and/or write a response to it on the white paper. Their illustrations and written reactions should reflect how they feel about the story and can be as creative as they want.
- For homework, have the students read Chapter Two of Wonders of the World: Northern Lights and have them write their own myth with illustrations on the aurora. If time permits, have students begin writing their myth in class.
- Begin the next lesson by having students volunteer to share their myths with the class. If only a few students volunteer, teachers can initiate a class discussion using the example discussion questions provided at the end of this lesson.

Example Discussion Questions

- How/why are myths created?
- Do myths differ among cultures?

For Older Students:

- How can myths help a culture/people understand their environment?
- How do myths reflect the environment in which they were created?



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Lesson 3: Aurora Comparisons

Description of Lesson: This activity gives students the opportunity to imagine they are scientists. It will provide them with a basic understanding of aurora and help them to use creative methods in their observations. First, students will study the scientific aspect of the aurora. They will also look at images of the aurora (both pictures and illustrations) and describe what they think of when they see them. These descriptions can be stored in the student portfolios as they will be useful in future lessons.

Background: Scientists collect data for their investigations using observation as a tool. They must be creative when writing descriptions of what they observe. Before scientists studied things using spacecrafts and computers, the tool that they used the most was their eyes! Scientists today still use their eyes to carefully observe the phenomena they are studying. When looking at the aurora, scientists look for changes they see in color, shape, and size. They create descriptions so that they know if they are seeing the same effect over time, or if something looks entirely new. This is how great scientific discoveries are made, and the students will use analogies and metaphors today to describe what they see just as many scientists (and poets!) do.

National Science Education Standards

- **Physical Science**
 - Properties of objects and materials (K-4)*
 - Light, heat, electricity, and magnetism (K-4)*
 - Transfer of energy (5-8)*
- **Earth and Space Science:**
 - Objects in the sky (K-4)*
 - Changes in earth and sky (K-4)*
 - Structure of the earth system (5-8)*
 - Earth in the solar system (5-8)*

- **History and Nature of Science**
Science as a human endeavor (K-4)
Nature of science (5-8)

Benchmarks for Science Literacy, Project 2061 (3-5)

- **The Nature of Science**
The Scientific Enterprise
- **The Physical Setting**
The Earth
Energy Transformations

National Standards for English Language Arts

- **Standard 1**
Students read a wide range of print and non-print texts to build an understanding of texts, of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classic and contemporary works.
- **Standard 5**
Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes.

Lesson Time: 60 minutes

Books to choose from for this lesson:

- Kusugak, Michael Arvaarluk. Northern Lights and Soccer Trails. Annick Press, 1993.
- Sabuda, Robert. The Blizzard's Robe. Atheneum, 1999.

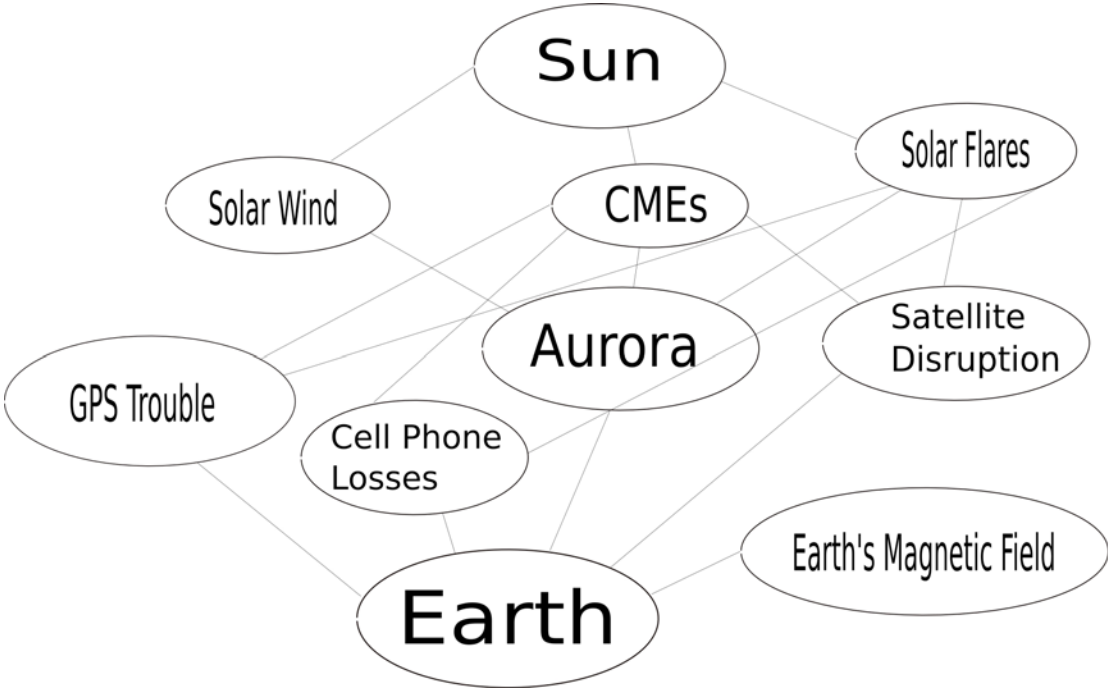
Materials:

- *The Northern Lights* movie (on Dancing Lights CD)
- "Space Weather: A Guide to the Sun-Earth Connection" handout
- "The Aurora Reminds Me Of..." worksheet
- "The Aurora Looks Like" worksheet
- Glossy pictures of auroras
- One or more of the books listed above
- Extension Activity (Optional): "Building a Sun-Earth Connection Web"

Procedure:

- After explaining how science involves observation and creativity, have students silently read the handout on the science of the aurora.
- Show the class "The Northern Lights" video, and distribute the glossy pictures to the students, allowing them to take a good look at the aurora. (Rather than distributing the photos, you could also put the pictures around the classroom and let students walk around and look at them).
- If they haven't already read all of the books listed in the first lesson, teachers can read one of the books listed above. These books have beautiful artwork of the Northern Lights, which may help students describe the aurora for their worksheets.
- Hand out the two worksheets listed above, and have the students write down anything that they think of while looking at the pictures. For example, "The Aurora Reminds Me Of...Christmas lights" or "The Aurora Looks Like...fire in the sky." Encourage students to be creative!
- If you plan on completing Lesson 4, for homework have students research a place in the world where auroras can be seen. Their research should include information on the lights, where they can be seen, and when they are best viewed.
- Extension Activity: Have students build a concept web on aurora. An example web is provided.

Example Concept Web from Extension Activity:





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SPACE WEATHER:

A Guide to the Sun-Earth Connection

Erin Wood, LASP Educational Consultant

The Sun

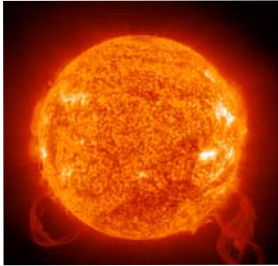
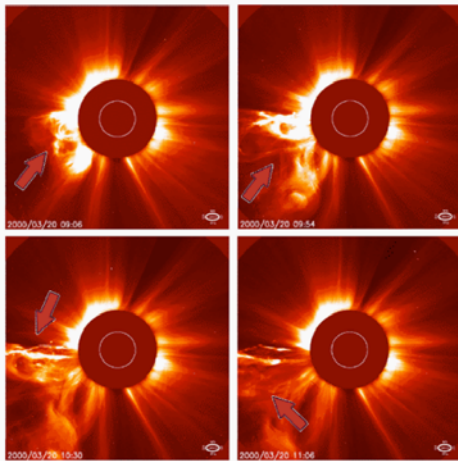


Photo Courtesy of SOHO/LASCO Consortium

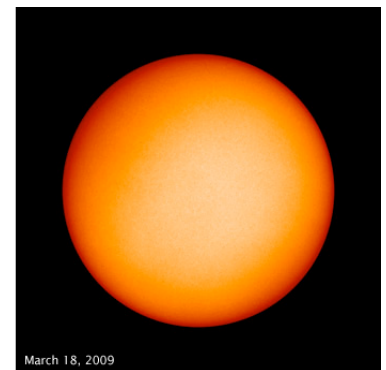
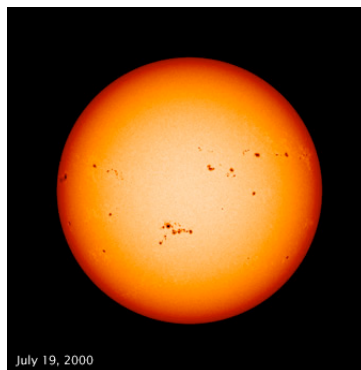
You might think that the Sun never changes, and that it's always a solid bright yellow disk in the sky. Actually, the Sun is a ball of hot gas that is very active. The Sun produces a solar wind that carries material into the Solar System. The Sun also has flares and Coronal Mass Ejections (CMEs): violent eruptions that fling solar material into space. Sometimes a flare or CME comes from the side of the Sun facing Earth. Flares send out radiation that can be dangerous to astronauts. CMEs carry solar material into space. Flares and CMEs can damage satellites, disrupt cell phone communication and can cause other problems for us here on Earth.



A large coronal mass ejection (CME) as observed by SOHO's LASCO C2 instrument over a two-hour period

The red arrows in this picture show a CME leaving the Sun. The center of the Sun is blocked out by an instrument on the SOHO spacecraft so the outside of the Sun can be seen (the center is too bright, making it difficult to see parts of the Sun). It's kind of like shielding your eyes with your hand when the Sun is out so you can see in front of you. Image courtesy of SOHO/LASCO Consortium

The Sun goes through an 11-year cycle called a sunspot cycle. Sunspots are dark spots that appear on the Sun. You can count the most number of sunspots during the solar maximum and the least number during the solar minimum. When the Sun is experiencing solar maximum there tend to be more flares and CMEs.

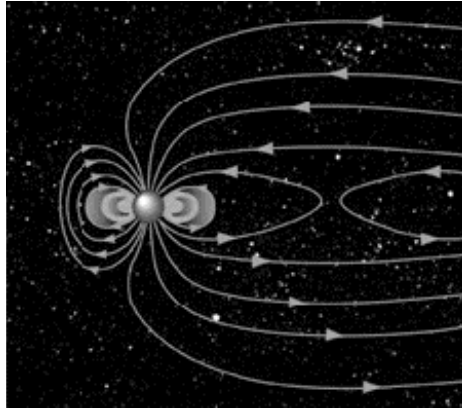
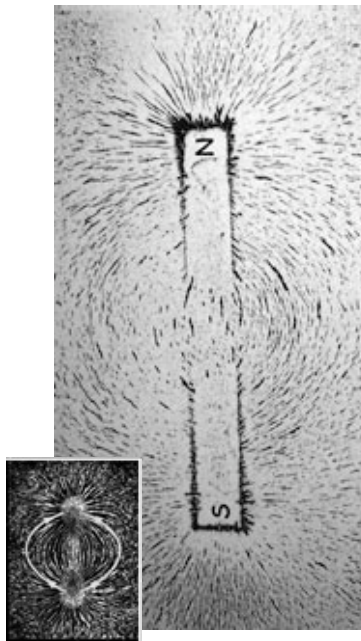


These pictures show the number of sunspots increasing over time. The year 2000 has many more sunspots than the year 2009. The full cycle lasts about 11 years. Image courtesy of SOHO/LASCO Consortium.

The Earth

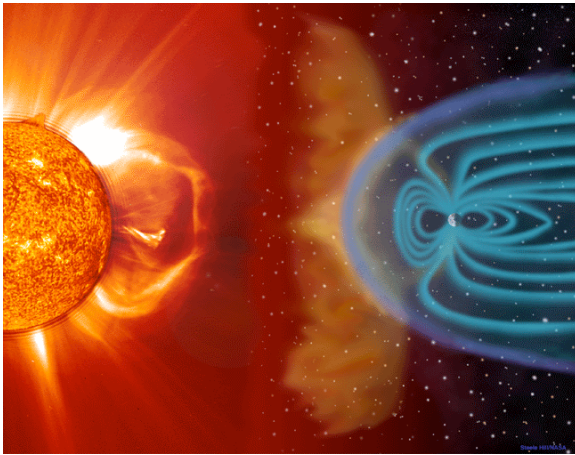
The Earth acts like a gigantic magnet because the center is made up of melted iron. The iron moves around as the Earth spins, creating a magnetic field. It's sort of like having a giant bar magnet inside of the Earth, and it's the reason we can use a compass--the dial in your compass lines up with the Earth's magnetic field telling you where north is located. If you lived on Mars, your compass wouldn't work because Mars doesn't have the same kind of magnetic field!

Have you ever poured iron filings over a bar magnet? The filings trace the lines of the magnetic field. The Earth's magnetic field looks really similar to this except that it is stretched out by the solar wind much the same way long hair blows back on a person walking into the wind.



The image on the left shows iron filings poured over a piece of paper with a magnet underneath. Notice how the magnetic field makes a circular pattern around the magnet. The image on the right shows how the magnetic field of the Earth is stretched out behind it because of the solar wind.

We're lucky to have our magnetic field, not just because compasses work, but also because the magnetic field protects us from the solar wind and other material that comes toward the Earth from space.



This picture shows how the solar wind and material from the Sun travels to Earth. The Earth is protected by its magnetic field (the picture was created by an artist, and the lines have been added). Image courtesy of SOHO/LASCO Consortium

Some material from the Sun gets trapped in the Earth's magnetic field. It travels along the magnetic field and enters the atmosphere close to the north and south poles. The Earth's atmosphere is really just a lot of gases around us. This material interacts with the gases in the atmosphere and creates the aurora.

Different gases in the atmosphere create different colors of auroral lights. The lights are created in a similar way a florescent or neon light bulb shines. These light bulbs are just full of gas that gives off light when it has a source of energy. In the case of the aurora, the solar material creates



energy when it collides with the atmosphere, and the gases have enough energy to give off light. Most of the atmosphere is made of Oxygen and Nitrogen. Oxygen gives off red or greenish light and Nitrogen gives off red or violet light.

The Aurora Borealis, or Northern Lights
Photo courtesy of Tom Eklund

Why Scientists Study Aurora

Scientists make measurements and observe the aurora from the ground and by using satellites in space. Scientists also study the Sun and make predictions about the aurora based on the solar wind and level of solar activity. If the Sun is very active, there will be more auroral activity, and the aurora may even be seen at lower latitudes than it is commonly seen.

The aurora may be beautiful but they can also act as a warning for us on Earth. When the aurora is particularly stunning it means there is a lot of material traveling to Earth near the poles. This is called a geomagnetic storm. The effects of a geomagnetic storm can cut off electricity and radio signals in some areas of the globe. At this time, it is dangerous to fly in an airplane going over the poles or be an astronaut in space because radio communication from the ground could be cut off. Before the material even reaches the Earth's atmosphere it can disrupt satellites, which spells trouble for people and companies that use them. A storm can also affect things like the Earth-orbiting Global Positioning System (GPS) satellites.



GPS satellites send signals to GPS devices. GPS devices tell people where they are on the globe and give directions. Many people carry GPS devices while camping, driving or in cell phones. Pilots, people in the military, and even farmers use GPS in their jobs. GPS might not work or give the wrong location during a geomagnetic storm, which is bad while driving if you don't know where you are going, but it could be dangerous for a pilot trying to locate the runway!

Many scientists work hard to predict when a geomagnetic storm might be dangerous for the Earth. It's like a weather forecast but it is in space, so we call it space weather. The Space Weather Prediction Center (SWPC) creates a forecast to predict solar storms using satellite measurements, so planes can re-route, satellites can turn off power to sensitive electronics, and electric companies can protect equipment.



SWPC also predicts **Solar Radiation Storms**. Radiation can harm astronauts and could be dangerous to people flying in airplanes over the poles. If this type of storm is headed our way, planes re-route, and astronauts stay inside the spacecraft. Astronauts onboard the International Space Station have a special room shielded from radiation where they can take shelter.

How Scientists Study Aurora

Scientists study the aurora because they do not fully understand how they are created, why they have certain shapes, why those shapes change, and how they interact with the atmosphere. They look for similarities between the Aurora Borealis (Northern Lights) and the Aurora Australis (Southern Lights) to test theories of formation. They compare their knowledge of solar activity and solar storms to what they observe.

Scientists make measurements. They make measurements of the Earth's magnetic field using satellites and see how it changes. They also make measurements of the magnetic field on the ground. They look at the atmosphere from space and from the ground to measure how it's affected during a solar storm and how the material that enters the atmosphere behaves.

All of these things help us understand what the aurora is, how our Earth interacts with the Sun, and how the Earth's magnetic field behaves. Scientists paint a clear picture of the Earth so we can better understand the planet on which we live.



The spacecraft, THEMIS, is launched by a Delta II rocket from Cape Canaveral, Florida. THEMIS is a mission to investigate what causes auroras in the Earth's atmosphere to dramatically change from slowly shimmering waves of light to wildly shifting streaks of color. Discovering what causes auroras to change will provide scientists with important details on how the planet's magnetic field works and the important Sun-Earth connection. Photo and text courtesy of NASA

Websites:

NASA Solar Missions and Programs:

THEMIS

http://www.nasa.gov/mission_pages/themis/main/index.html

SDO

<http://sdo.gsfc.nasa.gov/>

LWS

<http://lws.gsfc.nasa.gov/>

Aurora Pages:

The Auroral

<http://image.gsfc.nasa.gov/poetry/educator/Aurora79.html>

Space Weather at Windows to the Universe

<http://www.windows.ucar.edu>

Space Weather Tutorial

<http://sunearth.gsfc.nasa.gov/sehtml/tut.html>

Living in the Atmosphere of the Sun

<http://istp.gsfc.nasa.gov/exhibit/>

May 2003 Aurora Gallery

http://science.nasa.gov/spaceweather/aurora/gallery_01may03.html

August 2003 Aurora Gallery

http://science.nasa.gov/spaceweather/aurora/gallery_01aug03_page4.htm

Lights Below: The Aurora from Space

<http://www-istp.gsfc.nasa.gov/istp/outreach/afromspace.html>

Painted Sky: The Aurora from the Ground

<http://www-istp.gsfc.nasa.gov/istp/outreach/afromground.html>



Dancing Lights

Name _____

Date _____

The Aurora Borealis Reminds Me
Of...



Dancing Lights

Name _____
Date _____

The Aurora Borealis Looks Like...



Dancing Lights

Building a Sun-Earth Connection Web



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Lesson 4: Come See An Aurora!

Description of Lesson: In this activity, students will create their own travel brochure or poster inviting people to visit a place where they could see an aurora. It is recommended that the class complete Lesson 1 prior to this activity.

National Standards for English Language Arts

- **Standard 5**

Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes.

- **Standard 8**

Students use a variety of technological and information resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.

- **Standard 12**

Students use spoken, written, and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).

Lesson Time: 45 minutes/day (may take 2-3 days)

Materials:

- Markers, crayons, colored pencils, etc.
- Poster board
- Paper (construction, computer, or tagboard)

Procedure:

- Students should choose a location on the globe where auroras appear and research the area to complete this project
- Have the students create a travel brochure or poster encouraging travelers to visit a place in the world where they could see an aurora.

- The students can choose how they want to present it, but each project should include the following:
 1. Information on the location where the aurora can be seen
 2. Information about the aurora
 3. Illustrations
 4. Other things that visitors might want to see there



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Lesson 5: Aurora Poetry

Description of Lesson: The aurora has been described as poetry in motion. In this lesson, students will demonstrate their understanding of the aurora by writing their own poems. Teachers can decide which form(s) of poetry to use from their worksheets or allow students to create their own. Examples of styles include: Acrostic, List, Haiku, Like and As, and May and Could. To help students get inspired, the class will read a poem on the aurora, and they can also look through their portfolios to help form ideas.

National Science Education Standards

- **Physical Science**
Properties of objects and materials (K-4)

National Standards for English Language Arts

- **Standard 5**
Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes.
- **Standard 12**
Students use spoken, written, and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).

Lesson Time: 45 minutes

Book for this Lesson (Optional):

- Sandburg, Carl. Not Every Day an Aurora Borealis for Your Birthday: A Love Poem. Alfred A. Knopf, 1997.

Materials:

- Poetry Worksheets
- Glossy Pictures
- Aurora Portfolios (optional)

Links:

- <http://www.authorsden.com/visit/viewPoetry.asp?id=103441>
-

Procedure:

- First, read Not Every Day an Aurora Borealis for Your Birthday: A Love Poem as a class and/or the poems provided in the links above.
- Have students look at the pictures of aurora or go through their Aurora Portfolios to give them ideas.
- Distribute the poetry worksheet(s) and read examples of the form(s) of poetry you chose.
- Finally, have students write their poem(s).



Dancing Lights

Name _____

Date _____

Aurora Acrostic Poem

A _____

U _____

R _____

O _____

R _____

A _____



Dancing Lights

Name _____

Date _____

Aurora Like and As Poems

The aurora is like...

The aurora is as...



Dancing Lights

Name _____

Date _____

Aurora May and Could Poems

The aurora may...

The aurora could...



Dancing Lights

Name _____

Date _____

Aurora Haiku

(Five syllables)

(Seven syllables)

(Five syllables)



Dancing Lights

Name _____

Date _____

Aurora List Poem

When I see the aurora...

When I see the aurora...

When I see the aurora...

When I see the aurora...

When I see the aurora...

When I see the aurora...



Dancing Lights

Lesson 6: KWL Assessment

Description of Lesson: In this lesson, students will reflect on and discuss what they learned about the aurora. First, students will compare what they know now with what they knew at the beginning of the program, and discuss their answers with a partner using "Think, Pair, Share." The entire class will create a new KWL chart on the board before turning in their individual work.

Lesson Time:
45 minutes

Materials:

- Students' "What I Know, What I Want to Learn, and What I Learned" (KWL) worksheets from Lesson 1
- "What I Learned" worksheets

Procedure:

- Distribute the "What I Learned" worksheets to students and ask them to write down what they learned about the aurora.
- Once students are finished, hand out the student KWL sheets from Lesson 1 and allow them to compare their answers from the beginning of the program with the sheets they just completed.
- Using their sheets as a guide, have students do a "Think, Pair, Share" with their neighbors. As they discuss their responses, students can add more to their "What I Learned" sheet if they remember material that they did not list.
- Next, discuss student responses as a class using a large KWL chart on the board. Sample discussion questions are:
 - Compare what you thought you knew at the beginning of the program to what you know now.
 - Did you learn everything you wanted to learn? Is there more information you want to know?

- Address specific items with a class. If any items imply student miscomprehension, talk these items through and have students discuss. Highlight items with scientific accuracy as well.
- Students will hand back the "What I Learned" sheet and original KWL sheet for individual student assessment.

Assessment techniques

Using student KWL and end of lesson "What I Learned" sheets, assess the improvement of the student from the first lesson using the example rubric below.

Poor	Fair	Acceptable	Good	Outstanding
Student shows little to no improvement over initial KWL. Science/geography understanding is incomplete or poor. Student has few entries in list.	Student has some improvement over initial KWL. Science/geography understanding is moderate, but may be incomplete or inaccurate.	Student shows improvement over initial KWL. Student shows moderate understanding of science/geography. Student includes Sun-Earth interaction.	Student shows marked improvement over initial KWL. Student shows working knowledge of Sun-Earth interaction and geography. Student shows moderate understanding of connections between aurora, magnetism, atmosphere, and geography.	Student shows marked improvement over initial KWL. Student shows working knowledge of Sun-Earth interaction and geography. Student makes connections between Sun-Earth interaction, aurora, magnetism, atmosphere, and geography.

Example: *Good*

What I Learned About the Aurora

Science (make a list)

Forms an oval

Near the Earth's north and south poles

Can be seen from ground and space

Forms in the atmosphere

Is caused by the Sun's wind, material, and/or energy

Material around Earth can travel along the magnetic field and enter atmosphere

Atmospheric gases can glow with energy

Seen near the north pole (Alaska, Sweden, Finland, Canada)

Can mean there is a solar storm

Scientists use satellites to measure aurora and the magnetic field

Other things I learned (make a list)

This will vary by class; use your own judgment.



Dancing Lights

Name _____

Date _____

What I Learned About the Aurora:

Science (make a list)

Other things I learned (make a list)



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Recommended Reading

Bryson, George. Northern Lights: The Science, Myth, and Wonder of the Aurora Borealis. Seattle: Sasquatch Books, 2001.

-This book has incredible pictures, but the reading level will be challenging for students.

Sandburg, Carl. Not Every Day an Aurora Borealis for Your Birthday: A Love Poem. New York: Alfred A. Knopf, 1997.

Dwyer, Mindy. Aurora: A Tale of the Northern Lights. Anchorage: Alaska Northwest Books, 2001.

Esbensen, Barbara Juster. The Night Rainbow. New York: Orchard Books, 2000.

Kinsey-Warnock, Natalie. The Fiddler of the Northern Lights. New York: Cobblehill Books, 1996.

Kusugak, Michael Arvaarluk. Northern Lights and Soccer Trails. Toronto: Annick Press, 1993.

Lundebrek, Amy. Under the Night Sky. Maine: Tilbury House Publishers, 2008.

Sabuda, Robert. The Blizzard's Robe. New York: Atheneum, 1999.

Shepherd, Donna Walsh. Auroras: Light Shows in the Night Sky. New York: Franklin Watts, 1996.

Souza, Dorothy. Northern Lights. Minneapolis: Carolrhoda Books, 1994.

Underwood, Deborah. Wonders of the World - The Northern Lights. KidHaven Press, 2004.

Waboose, Jan Bourdeau. Sky Sisters. Kids Can Press, 2009.

Whitfield, David. Science Matters: Northern Lights. New York: Weigl Publishers, 2006.



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Teacher Resources on Aurora:

LASP Space Weather Page:

http://lasp.colorado.edu/education/space_weather/index.htm

Description of the Aurora:

<http://www.astronomy.com/asy/default.aspx?c=a&id=2088>

Fun student tutorial (used in Lesson 1):

<http://ds9.ssl.berkeley.edu/auroras/story.html>

Auroras are "mirror images":

http://eiger.physics.uiowa.edu/%7Evis/conjugate_aurora/

Animated video of Sun's solar activity:

http://www.nasa.gov/mpg/111836main_what_is_a_cme_NASA%20WebV_1.mpg

Info on Aurora:

<http://www-spof.gsfc.nasa.gov/Education/aurora.htm>

More pictures of Aurora:

<http://www-istp.gsfc.nasa.gov/istp/outreach/afromground.html>

Savage, Candace. Aurora: The Mysterious Northern Lights. San Francisco: Sierra Club Books, 1994.



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Teacher Resources on Science and Literacy:

Armbruster, B. 1993. Science and reading. *The Reading Teacher*. 46(4): 346-347.

Banikowski, A.K. 1999. Strategies to enhance memory based on brain research. *Focus on Exceptional Children* 32 (2): 1-16

Barton, Mary Lee, and Jordon, Deborah L. 2001. Teaching Reading in Science: A Supplement to Teaching Reading in the Content Areas Teacher's Manual (2nd edition). McREL, Aurora, Colorado.

Cervetti, G.N., P.D. Pearson, M.A. Bravo, and J. Barber. 2006. Reading and writing in the service of inquiry-based science. Making sense in science through words and pictures. In: *Linking science and literacy in the K-8 classroom*. R. Douglas, M.P. Klentschy, and K. Worth (eds.). Pp. 221-244. Arlington, VA: NSTA Press.

Douglas, R., M.P. Klentschy, and K. Worth (eds.). 2006. *Linking science and literacy in the K-8 classroom*. Arlington, VA: NSTA Press. 441p.

Goldman, S.R. and G.L. Bisanz. 2002. Toward a functional analysis of scientific genres: Implications for understanding and learning processes. In: *The psychology of science text comprehension*. J. Otero, J.A. Leon, and A.C. Graesser (eds.). Pp. 19-50. Mahwah, NJ: Lawrence Erlbaum.

Hapgood, Susanna, and Palincsar, Annemarie Sullivan. 2007. Where Literacy and Science Intersect. *Educational Leadership* 64(4): 56-60.

Hirsch, E.D., Jr. 2003. Reading Comprehension Requires Knowledge—of Words and the World. *American Educator*. Spring:10-29.

Jet Propulsion Laboratory. 2004. Reading, Writing, and Rings: Mission to Saturn Educator Guide. Jet Propulsion Laboratory, Pasadena, California. <http://saturn.jpl.nasa.gov>

Kinniburgh, Leah and Shaw, Edward. 2007. Building Reading Fluency in Elementary Science through Readers' Theatre. *Science Activities: Classroom Projects and Curriculum Ideas*, 44(1): 16-20.

Mechling, K.R. and D.L. Oliver, 1983. *Handbook I: Science teaches basic skills*. Washington, D.C.: National Science Teachers Association.

Padilla, M.J., K.D. Muth, and R.K. Padilla. 1991. Science and reading: Many process skills in common? In *Science learning: Processes and applications*. C.M. Santa and D.E. Alverman (eds.). Pp. 14-19. Newark, DR: International Reading Association.

Palinscar, A.S. and S.J. Magnusson. 2001. The interplay of firsthand and text-based investigations to model and support the development of scientific knowledge and reasoning. In: *Cognition and instruction: Twenty-five years of progress*. S. Carver and D. Klahr (eds.). Pp. 151-194. Mahwah, NJ: Lawrence Erlbaum.

Romance, Nancy and Vitale, Michael. 1992. "A Curriculum Strategy that Expands Time for In-Depth Elementary Science Instruction by Using Science-Based Reading Strategies: Effects of a Year-Long Study in Grade Four." *Journal of Research In Science Teaching* 29(6): 545-554.

Simon, M.S. and J.M. Zimmerman, 1980. Science and writing. *Science and Children* 18 (3): 7-9.

Varelas, M., C.C. Pappas, and the ISLE Team. 2006. Young children's own illustrated information books: Making sense in science through words and pictures. In: *Linking science and literacy in the K-8 classroom*. R. Douglas, M.P. Klentschy, and K. Worth (eds.). Pp. 95-116. Arlington, VA: NSTA Press.

Wolfe, P. 2001. *Brain Matters: Translating Research into Classroom Practice*. Association for Supervision & Curriculum Development. Alexandria, VA.

Yopp, Hallie Kay and Yopp, Ruth Helen. 2006. Primary Students and Informational Texts. *Science and Children*, 44(3): 22-25.



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Teacher Resources on Science and Art

- Chessin, Debby and Zander, Mary Jane. 2006. The Nature of Science and Art. *Science Scope*, 29(8): 42-46.
- Coy, Mary. 2007. Finding Art in the Science Room. *SchoolArts: The Art Education Magazine for Teachers*, 106(7): 29.
- Girod, Mark. 2007. Sublime Science. *Science and Children*, 44(6): 26-29.
- Tolley, Kimberley. 1994. The Art and Science Connection: Hands-on Activities for Intermediate Students. Innovative Learning, Menlo, California.
- Tolley, Kimberley. 1993. The Art and Science Connection: Hands-on Activities for Primary Students. Addison Wesley Publishing Company, Boston, Massachusetts.



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Additional Magnetism Activities

We placed these activities in the order we would recommend doing them in class.

Playing with Magnetism, NASA's Goddard Space Flight Center,
<http://www.gsfc.nasa.gov/>

In this introduction to magnetism, students explore magnets to better understand magnetic properties. They will discover which objects attract magnets, why they do so, and what it feels like when the poles of magnets repel or attract other magnetic objects. Students will record their findings and discuss their conclusions with their partners.

<http://image.gsfc.nasa.gov/poetry/activity/l6.pdf>

Magnetic Pick Ups, Science Net Links, <http://www.sciencenetlinks.com/>

This activity introduces the magnetism activity, How Strong is Your Magnet, below. Pairs of students will classify objects given to them by the teacher, and predict which objects are magnetic based on their classifications. Students will then test their predictions and record and discuss their results.

<http://www.sciencenetlinks.com/lessons.php?BenchmarkID=4&DocID=175>

How Strong is Your Magnet?, Science Net Links,

<http://www.sciencenetlinks.com/>

In this activity, students continue to study magnetic properties by testing the strength of magnets. They will see how distance to or placing barriers in front of magnets alters the strength. Students test the strength of their magnet using paperclips. Students will describe their observations and results and record their answers.

<http://www.sciencenetlinks.com/lessons.php?BenchmarkID=4&DocID=159>

Muscle Magnet, The National Science Center, <http://www.nscdiscovery.org/>

This lesson is a more advanced version of How Strong is Your Magnet?

Students divide a bar magnet into equal parts, and use paper clips to test the strength of each part of the magnet. Students use a spring scale to

measure force. Students discuss if different points of the magnet have stronger or weaker forces.

<http://www.nscdiscovery.org/TeacherTools/Adobe/MuscleMagnet.pdf>

Iron Filings and Magnetic Field Lines, Laboratory for Atmospheric and Space Physics, <http://lasp.colorado.edu/>

This activity could be used as a demo in front of the class. The teacher or the students create a 3-D magnetic field using iron filings and cow magnets. Students will record their predictions and observations before and after the activity, and discuss the reasons behind the magnetic interactions.

http://lasp.colorado.edu/education/space_weather/files/middle/P1-2_3D_field.pdf

Mystery Magnets, The National Science Center,

<http://www.nscdiscovery.org/>

This activity has four stations. In the first station, students experiment with magnets in vegetable oil to study magnetic field lines. In the second station, students work with iron filings to demonstrate magnetic field lines. In station three, they work with ceramic magnets in order to feel the magnetic forces. For the fourth station, students see and draw the magnets interacting.

<http://www.nscdiscovery.org/TeacherTools/Adobe/MysteryMagnets.pdf>

The Earth as a Magnet, NASA's Goddard Space Flight Center,

<http://www.gsfc.nasa.gov/>

This activity helps students understand the Earth's magnetosphere and how solar wind can affect it. Students will draw models of the magnetosphere and create their own representation of the Earth trapping solar particles in its magnetosphere. In the extension activity, students write stories or songs as a class or individually about particles traveling from the Sun to the Earth.

<http://image.gsfc.nasa.gov/poetry/activity/l10.pdf>

The Magnetometer, University Corporation for Atmospheric Research,

<http://www.ucar.edu/tools/education.jsp>

In this activity, appropriate for 4th and 5th graders, students build their own simple magnetometers to determine the direction and strength of magnetic fields. They can then use their magnetometers to find magnetic objects around the classroom or at home.

http://www.windows.ucar.edu/tour/link=/teacher_resources/magnetism/teach_magnetometer.html

Terra Bagga, University Corporation for Atmospheric Research,

<http://www.ucar.edu/tools/education.jsp>

Students should complete this activity after finishing The Magnetometer.

They will create their own planets using magnets and paper bags, and determine the orientation of their planet's magnetic field with their magnetometers. This activity helps students understand magnetic fields and the instruments scientists use to study them, as well as the geographic lines of longitude and latitude.

http://www.windows.ucar.edu/tour/link=/teacher_resources/magnetism/teach_terrabagga.html



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Additional Activities on the Sun

The Sun: An Introduction, Eye on the Sky, <http://eyeonthesky.org>

This lesson, as well as the rest of the Eye on the Sky series, would be best for younger students. In the introductory lesson, students complete a KWL chart (Know, What to Know, Learned) on the Sun and create a science word wall using solar vocabulary. Students compare works of art with scientific models and fiction with nonfiction writing about the Sun.

http://eyeonthesky.org/lessonplans/02sun_intro.html

Making a Homemade Sunspot Viewer, Laboratory for Atmospheric and Space Physics (LASP), <http://lasp.colorado.edu>

Students use a telescope to view the Sun without directly looking at it.

They project the image of the Sun onto poster board and trace the image, including the sunspots, onto tracing paper. Students can do this activity at the same time each day to follow the Sun's movement.

http://lasp.colorado.edu/education/space_weather/files/elem/sunspotviewer.pdf

Sunspot Flip Book Journal, Laboratory for Atmospheric and Space Physics (LASP), <http://lasp.colorado.edu>

In this activity, students use images of the Sun with sunspots to create a flipbook which shows the movement of the Sun. They discuss patterns they observed in the pictures, such as the movement, shape, and direction of the sunspots.

http://lasp.colorado.edu/education/space_weather/files/elem/sunspotflipbook.pdf

Sunspot Numbers, Laboratory for Atmospheric and Space Physics (LASP),
<http://lasp.colorado.edu>

For this activity, students graph the number of sunspots seen on the Sun for a ten year period. This activity can be used as an introduction to a lesson on the solar cycle, as students see that the number of sunspots changes every 11 years.

http://lasp.colorado.edu/education/space_weather/files/elem/sunspotnumbers.pdf

Features of the Sun, Laboratory for Atmospheric and Space Physics (LASP),
<http://lasp.colorado.edu>

This activity is traditionally for middle school students because of the reading level, however, may be appropriate for 4th and 5th grade students depending on the class. Students view images and identify features of the Sun after reading information about solar activity.

http://lasp.colorado.edu/education/space_weather/files/middle/featuresOfTheSun.pdf