Educator Resources for Understanding Connections Between the Sun and Earth
Living With A Star is available in electronic format through NASA Spacelink—one of NASA’s electronic resources specifically for the educational community. This publication and other educational products may be accessed at the following address:

http://spacelink.nasa.gov/products
Living With A Star
An Educator Guide with Activities in Sun-Earth Sciences

National Aeronautics and Space Administration
Living With a Star

What is SEC?
Fundamental and applied research in the Sun-Earth Connection (SEC) will lay the groundwork for the future:

• To advance space science, we will continue to investigate the basic processes that cause solar variations, as well as their consequences for the solar system.

• To ensure the safety of humans traveling from Earth, we will seek to understand and forecast the space environments with which they must cope.

• To take the first steps toward voyaging to nearby stars, we will carry out robotic exploration of interstellar space beyond the heliosphere.

To meet these objectives, the SEC theme is dedicated to understanding the physical processes that power the Sun and link the Sun and Earth. The basic physics concerns the behavior of primarily electrified material and its interaction with magnetic fields on the Sun, in interplanetary space, at the Earth and planets, and in the local galactic environment.

What is SECEF?
The Sun-Earth Connection Education Forum (SECEF) is part of NASA’s Space Science Education and Public Outreach Program, a partnership between NASA’s Goddard Space Flight Center and the University of California, Berkeley’s Space Science Laboratory. Our two primary goals are to disseminate educational resources related to the Sun and its connection to Earth and to facilitate the involvement of space scientists in education.

Contact the Sun-Earth Connection Education Forum

UNIVERSITY OF CALIFORNIA, BERKELEY
Isabel Hawkins Forum Co-Director
Karen Meyer Forum Co-Manager
karenr@ssl.berkeley.edu
(510) 642-4185

NASA GODDARD SPACE FLIGHT CENTER
Rich Vondrak Forum Co-Director
Jim Thieman Forum Co-Manager
thieman@nssdc.gsfc.nasa.gov
(301) 286-9790

http://sunearth.ssl.berkeley.edu
http://sunearth.gsfc.nasa.gov
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Common Questions and Answers

Links to answer the most frequently asked questions.

Where can I find classroom activities about solar storms and the Sun?
http://istp.gsfc.nasa.gov/istp/outreach
http://sohowww.nascom.nasa.gov/explore/
http://sunearth.ssl.berkeley.edu/

Would you like to hear interviews with Sun-Earth Connection scientists?
http://www.exploratorium.edu/sunspots

What does the Sun look like today?

How can I tour the Sun and learn about our nearest star from the inside?
http://solar.physics.montana.edu/YPOP

Where can I find out about solar events that my class can participate in?
http://www.solarevents.org

How much do you know about the Sun?
http://solar-center.stanford.edu

Would you like to hear interviews with Sun-Earth Connection scientists?
http://www.exploratorium.edu/sunspots

What is the latest news on Space weather?
http://www.spaceweather.com

Experience a total solar eclipse!
http://www.exploratorium.edu/eclipse

How can I “hear” the Earth’s magnetosphere?
http://www.pw.physics.uiowa.edu/mcgreevy/

Where can I find out about solar flares?
http://cse.ssl.berkeley.edu/hessi_epo/

What are auroras?
http://www.auroras2000.com

How much do you know about the Sun?
http://solar-center.stanford.edu

Where can I “hear” the Earth’s magnetosphere?
http://www.pw.physics.uiowa.edu/mcgreevy/

How can I participate in a weekly live chat with a space scientist?
http://quest.arc.nasa.gov/ssb/chats/sched.html

Ask a Scientist
http://image.gsfc.nasa.gov/poetry/ask/askmag.html
http://sohowww.nascom.nasa.gov/explore/dsoho.html

New Launches
http://spasecience.nasa.gov

What is Solar Maximum?
http://www.solarmax2000.com

How do solar storms affect our electric power systems?
http://www.mpelectric.com/storms/

How does radiation affect astronauts?
http://flick.gsfc.nasa.gov
http://see.msfc.nasa.gov

Images:
(left) Earth’s Magnetosphere Illustration
courtesy of NASA’s Sun-Earth Connection.

http://sunearth.gsfc.nasa.gov/eclipse/eclipse.html

(bottom) Solar prominence image from Big Bear Solar Observatory.
http://www.bbso.njit.edu/

(bottom) Earth’s Magnetosphere illustration courtesy of NASA’s Sun-Earth Connection.
Images:
(top) Earth’s Magnetosphere Illustration courtesy of NASA’s Sun-Earth Connection.
# Sun-Earth Connection Missions

http://sunearth.ssl.berkeley.edu/educators/missions.html

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<tr>
<td>ACE Advanced Composition Explorer</td>
<td>(1997 – )</td>
<td>ACE Learning Center</td>
<td>Study of the physics and chemistry of the solar corona, the solar wind, and the interstellar medium.</td>
</tr>
<tr>
<td>CRRES Combined Release and Radiation Effects Satellite</td>
<td>(1990 – 1991)</td>
<td>No Education Page</td>
<td>To Find out how Earth’s radiation environment affects microelectronic circuitry; the composition of the Earth’s radiation belts; the magnetosphere interacts with the ionosphere.</td>
</tr>
<tr>
<td>Geospace Electrodynamic Connections (GEC)</td>
<td>(2008 – )</td>
<td><a href="http://istp.gsfc.nasa.gov/educ_out/educ_out.htm">http://istp.gsfc.nasa.gov/educ_out/educ_out.htm</a></td>
<td>GEC will determine how the ionopause-thermosphere (I-T) system responds to magnetosphere forcing and how the I-T system is dynamically coupled to the magnetosphere.</td>
</tr>
<tr>
<td>NASA SEC Mission</td>
<td>(Launch Date)</td>
<td>Mission Education Page</td>
<td>Science Objective</td>
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<tr>
<td>IMAGE</td>
<td>(2000 – )</td>
<td><a href="http://image.gsfc.nasa.gov/">http://image.gsfc.nasa.gov/</a></td>
<td>Study of how the magnetosphere is changed by its interaction with the solar wind; how plasmas are transported from place to place within the magnetosphere; the loss of magnetospheric plasmas from the system during storms.</td>
</tr>
<tr>
<td>Imager for Magnetopause-to-Aurora Global Exploration</td>
<td></td>
<td>poetry/</td>
<td></td>
</tr>
<tr>
<td>IMEX</td>
<td>(2001 – )</td>
<td>No Education Page</td>
<td>To provide global imaging of the aurora, ring current, and plasmaspheric populations. IMEX will provide in situ measurements, particularly of electric fields and ring current populations, and cross-calibration, while TWINS and IMAGE will provide a context for interpreting the IMEX measurements.</td>
</tr>
<tr>
<td>Inner Magnetosphere Explorer</td>
<td></td>
<td><a href="http://ham.space.umn.edu/spacephys/">http://ham.space.umn.edu/spacephys/</a></td>
<td></td>
</tr>
<tr>
<td>IMEX</td>
<td>(2009 – )</td>
<td><a href="http://lws.gsfc.nasa.gov/lws_education.htm">http://lws.gsfc.nasa.gov/lws_education.htm</a></td>
<td>A global network of satellites that will gather knowledge of how the ionosphere behaves as a system, linking solar energy with Earth’s atmosphere.</td>
</tr>
<tr>
<td>Ionospheric Mappers</td>
<td>(2009 – )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IMP-8</td>
<td>(1973 – )</td>
<td>No Education Page</td>
<td>IMP-8 measures the magnetic fields, plasmas, and energetic charged particles (e.g., cosmic rays) of Earth’s magnetotail and magnetosheath and of the near-Earth solar wind. IMP-8 is one of the longest running solar-terrestrial spacecrafts. The year 2001 marks this spacecraft’s 28th year.</td>
</tr>
<tr>
<td>INTERBALL</td>
<td>(1995 – )</td>
<td>No Education Page</td>
<td>Study of the relationship between processes in the geotail and the particle acceleration above the auroral oval; how solar flares and X-ray bursts affect the magnetotail and cusp regions.</td>
</tr>
<tr>
<td><a href="http://www.iki.rssi.ru/interball.html">http://www.iki.rssi.ru/interball.html</a></td>
<td></td>
<td></td>
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<tr>
<td>ISTP</td>
<td>(multiple missions)</td>
<td><a href="http://istp.gsfc.nasa.gov/istp/outreach/">http://istp.gsfc.nasa.gov/istp/outreach/</a></td>
<td>Participating Missions: • CLUSTER II • POLAR • WIND • GEOTAIL • SOHO (Find these listed alphabetically)</td>
</tr>
<tr>
<td>International Solar-Terrestrial Physics Program</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LWS</td>
<td>(multiple missions)</td>
<td><a href="http://lws.gsfc.nasa.gov/lws_education.htm">http://lws.gsfc.nasa.gov/lws_education.htm</a></td>
<td>Participating Missions: • IM • SDO • RBM • Solar Sentinels (Find these listed alphabetically)</td>
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<td>Living With a Star Program</td>
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# Sun-Earth Connection Missions

http://sunearth.ssl.berkeley.edu/educators/missions.html
http://sunearth.gsfc.nasa.gov/educators/missions.html

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<th>NASA SEC Mission</th>
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<tr>
<td><strong>MC</strong> Magnetospheric Constellation</td>
<td>(2010 – )</td>
<td><a href="http://stp.gsfc.nasa.gov/educ_out/educ_out.htm">http://stp.gsfc.nasa.gov/educ_out/educ_out.htm</a></td>
<td>This group of nano-satellites, will enable us to determine the dynamics of the magnetotail, understand its responses to the solar wind, and reveal the linkages between local and global processes.</td>
</tr>
<tr>
<td><strong>MMS</strong> Magnetospheric MultiScale</td>
<td>(2006 – )</td>
<td><a href="http://stp.gsfc.nasa.gov/educ_out/educ_out.htm">http://stp.gsfc.nasa.gov/educ_out/educ_out.htm</a></td>
<td>MMS will quantitatively determine the geoeffectiveness of solar processes on the geospace system by exploring the fundamental physics underlying the plasma processes that control magnetospheric dynamics.</td>
</tr>
<tr>
<td><strong>Polar</strong></td>
<td>(1996 – )</td>
<td><a href="http://istp.gsfc.nasa.gov/istp/polar/">http://istp.gsfc.nasa.gov/istp/polar/</a></td>
<td>Study of the role of the ionosphere in geomagnetic storms; the properties of the particles and fields near the Earth's polar regions and how is energy from the magnetosphere is deposited into the upper atmosphere and auroral regions.</td>
</tr>
<tr>
<td><strong>SAMPEX</strong> Solar Anomalous and Magnetospheric Particle Explorer</td>
<td>(1992 – )</td>
<td><a href="http://surya.umd.edu/www/sampex.html">http://surya.umd.edu/www/sampex.html</a></td>
<td>Study of how high-energy particles entering the magnetosphere affect Earth’s upper atmosphere, the isotopic composition of solar flares, and how cosmic rays are affected by the solar activity cycle.</td>
</tr>
<tr>
<td><strong>SDO</strong> Solar Dynamics Observatory</td>
<td>(2006 – )</td>
<td><a href="http://lws.gsfc.nasa.gov/lws_education.htm">http://lws.gsfc.nasa.gov/lws_education.htm</a></td>
<td>To observe the Sun’s dynamics and understand the nature and source of variations, from the stellar core to the turbulent solar atmosphere.</td>
</tr>
<tr>
<td><strong>Sentinels</strong></td>
<td>(2009 – )</td>
<td><a href="http://lws.gsfc.nasa.gov/lws_missions_sdo.htm">http://lws.gsfc.nasa.gov/lws_missions_sdo.htm</a></td>
<td>The Sentinels will observe the global structure of the inner heliosphere, follow the propagation of solar eruptive events to Earth, and trace geomagnetic disturbances back to their solar sources.</td>
</tr>
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### Sun-Earth Connection Missions

**NASA SEC Mission** | **Launch Date** | **Mission Education Page** | **Science Objective**
--- | --- | --- | ---
SNOE | (1998 – ) | [No Education Page](http://lasp.colorado.edu/snoe) | To measure nitric oxide density in the terrestrial lower thermosphere (100-200 km altitude) and analyze the energy inputs to that region from the Sun and magnetosphere that create it and cause its abundance to vary dramatically.

SOHO | (1995 – ) | ![Explore](http://sohowww.nascom.nasa.gov/explore/) | Study of how the solar corona is heated, the internal structure of the Sun, and what causes the activity seen on the surface of the Sun.


Solar Probe | (2007 – ) | ![Explore](http://www.jpl.nasa.gov/ice_fire//outreach/index.htm) | To find the source regions of the fast and slow solar wind at maximum and minimum solar activity, locate the source and trace the flow of energy that heats the corona; determine the structure of the polar magnetic field and its relationship with the overlying corona; and determine the role of plasma turbulence in the production of solar wind and energetic particles.

Spartan 201-05 | (1993, 1994, 1995) | [No Education Page](http://umbra.gsfc.nasa.gov/spartan) | Study of how the solar corona expands to become the solar wind, what the velocities and temperatures at the base of the solar wind are and how the solar wind is accelerated.

STEREO | (2004 – ) | ![Explore](http://stp.gsfc.nasa.gov/missions/stereo/stereo.htm) | STEREO will determine how coronal mass ejections (CMEs) are produced, how they evolve in the solar corona and how CME particles accelerate. It will also uncover the 3-D structure of a CME en route to Earth.

STP | (multiple missions) | ![Explore](http://stp.gsfc.nasa.gov) | Participating Missions:
- GEC
- MC
- MAS
- Solar-B
- STEREO
- TIMED

(find these listed alphabetically)
## Sun-Earth Connection Missions

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<td><strong>TIMED</strong></td>
<td>(2001 – )</td>
<td><a href="http://stp.gsfc.nasa.gov">http://stp.gsfc.nasa.gov</a></td>
<td>TIMED will study the atmospheric properties (e.g., winds, temperature, chemical constituents, and energetics) of the Mesosphere, Lower Thermosphere, and Ionosphere (MLTI) region on a global scale.</td>
</tr>
<tr>
<td>Thermosphere•Ionosphere•Mesosphere•Energetic Dynamics</td>
<td></td>
<td><a href="http://stp.gsfc.nasa.gov/timed/timed.htm">http://stp.gsfc.nasa.gov/timed/timed.htm</a></td>
<td></td>
</tr>
<tr>
<td><strong>TRACE</strong></td>
<td>(1998 – )</td>
<td><a href="http://vestige.lmsal.com/TRACE/">http://vestige.lmsal.com/TRACE/</a></td>
<td>Study of the 3-D structure of features seen on the Sun’s surface; how the corona is heated; and what triggers solar flares.</td>
</tr>
<tr>
<td><strong>TWINS</strong></td>
<td>(2003 – )</td>
<td>No Education Page</td>
<td>This mission will provide new ways for stereoscopic imaging of Earth’s plasma environment in order to study its dynamics.</td>
</tr>
<tr>
<td><strong>Ulysses</strong></td>
<td>(1990 – )</td>
<td><a href="http://ulysses.jpl.nasa.gov/">http://ulysses.jpl.nasa.gov/</a></td>
<td>To study what the solar wind looks like near the poles of the Sun; what the Sun’s magnetic field looks like near its poles; and how the polar wind and magnetic field change during maximum sunspot conditions.</td>
</tr>
<tr>
<td><strong>Voyager</strong></td>
<td>(1997 – )</td>
<td>See Mission pages for outreach components</td>
<td>To find the solar heliopause located beyond the orbit of Pluto; to uncover the properties of the interstellar medium, and to study the interaction of the interstellar medium and the solar wind.</td>
</tr>
<tr>
<td><strong>Wind</strong></td>
<td>(1994 – )</td>
<td><a href="http://istp.gsfc.nasa.gov/istp/wind/">http://istp.gsfc.nasa.gov/istp/wind/</a></td>
<td>To study plasma interactions as the solar wind impacts the Earth’s magnetosphere; and how energy is transported out of the Earth’s magnetosphere and into the upstream solar wind.</td>
</tr>
<tr>
<td><strong>Yohkoh</strong></td>
<td>(1991 – )</td>
<td><a href="http://www.lmsal.com/SXT/Yohkoh">http://www.lmsal.com/SXT/Yohkoh</a></td>
<td>To observe how the Sun produces X-ray flares and other activity; how the level of activity changes over time; and how the chromosphere and corona are heated.</td>
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Website Resources

Educational solar sites listed by grade level.

**Grades K-12**

Windows to the Universe
http://www.windows.ucar.edu/space

**Grades 6-8**

Solar Storms and You
IMAGE Science & Math Workbook
http://image.gsfc.nasa.gov/poetry/workbook/workbook.html

A Soda Bottle Magnetometer
http://image.gsfc.nasa.gov/poetry/workbook/workbook.html

**Grades 8-9**

Solarscapes
Space Science Institute Workbook
http://www-ssi.colorado.edu/education/ResourcesForEducators/

Exploring the Earth’s Magnetosphere
http://www-space.gsfc.nasa.gov/education/intro.html

International Solar-Terrestrial Physics (ISTP)
http://istp.gsfc.nasa.gov/istp/

Science Education Gateway (SEGway)
http://cse.ssl.berkeley.edu/segway/

Solar Flare Theory

Stanford Solar Center
http://solarcenter.stanford.edu/index.html

The Sun in Time
http://science.ssl.mssl.nasa.gov/solpad/solar/suntime/suntime.html

**Grades 9-12**

Differential Rotation of the Sun

Solarscapes
Space Science Institute Workbook
http://www-ssi.colorado.edu/education/ResourcesForEducators/

Cosmic and Heliospheric Learning Center
http://helios.gsfc.nasa.gov/

How Astronomers Use Spectra to Learn About the Sun
http://orpheus.nascom.nasa.gov/serts/

Exploring the Earth’s Magnetosphere
http://www-space.gsfc.nasa.gov/education/intro.html

International Solar-Terrestrial Physics (ISTP)
http://istp.gsfc.nasa.gov/istp/

Science Education Gateway (SEGway)
http://cse.ssl.berkeley.edu/segway/

Solar Flare Theory

Stanford Solar Center
http://solarcenter.stanford.edu/index.html

The Sun in Time
http://science.ssl.mssl.nasa.gov/solpad/solar/suntime/suntime.html

**Grades 12+**

How Astronomers Use Spectra to Learn About the Sun
http://orpheus.nascom.nasa.gov/serts/

**General Audience**

Storms From the Sun
ISTP Poster

The Dynamic Sun
CD Rom
http://sohowww.nascom.nasa.gov/explore/DynSun.html

Space Science Education Resource Directory
http://teachspace.science.stsci.edu

Solarscapes
Space Science Institute Workbook
http://www-ssi.colorado.edu/education/ResourcesForEducators/

Windows on the Universe
http://www.windows.ucar.edu/

Yohkoh Public Outreach Project
http://www.lmsal.com/YPOP/

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Galileo sunspot drawing from The Galileo Project.
http://es.rice.edu/ES/humsoc/Galileo/

Solar image taken by the Extreme Ultraviolet Imaging Telescope aboard the SOHO satellite. Image from the Solar Data Analysis Center at NASA Goddard Space Flight Center.
http://umbra.nascom.nasa.gov/80/umbf.html

Windows to the Universe
http://www.windows.ucar.edu/spweather/spweather_5.html

Solarscapes
Space Science Institute Workbook
http://www-ssi.colorado.edu/education/ResourcesForEducators/
Colors of the Sun
The visible spectrum is only part of what the Sun emits within the electromagnetic spectrum. Study how astronomers use technology to learn more about objects that are far away.

Ulysses: An Expedition Over the Sun’s Poles
Learn about the discoveries made by the Ulysses spacecraft. Video includes an educator guide.

Ulysses: A Voyage to The Sun
Based on information obtained from Skylab, this program describes the joint mission to explore the Sun’s atmosphere.

Earth-Sun Relationship
This animated presentation includes the formation of the Sun and planets, the death of a star, and how NASA’s space probes discovered the Van Allen Belt.

Partnership Into Space: Mission Helios
Follow the development and launch of Helios, which orbited the Sun closer than any human-made object to date.

BLACKOUT! Solar Storms and Their Effects on Planet Earth
Follow the path of solar storms – in 3-D animation – as they travel from the Sun to Earth. Produced and written by a educator for the typical middle school student.

Images of Earth and Space II
Take a video field trip to the solar system and outer space that includes the study of magnetic fields, El Niño, ocean currents, an asteroid collision, the surface of Mars, and a tiny explosion in a binary neutron star system.

Comet Halley Returns
Study the comet’s 1985-86 rendezvous with Earth and the Sun and learn about its next visit to our vicinity.

Sun Splash Ozone Video
Computer graphics and animation illustrate ozone depletion and how ozone protects us from ultraviolet radiation.

Station Reel Time Two-Part Series
Learn how electricity will be generated on the International Space Station, the largest structure ever built in space.

Blackout: An Expedition Over the Sun’s Poles
Learn about the discoveries made by the Ulysses spacecraft. Video includes an educator guide.

Episode 1: Our Star the Sun
Three Skylab missions of the 1970s provide the data for this analysis of the physical and chemical composition of the Sun.

Episode 11: Universe
Visit the planets – with emphasis on Mars and Jupiter – and explore the solar system: galaxies, nebulae, pulsars, black holes, and the Sun.

The Dynamic Sun
Study the Sun and its effects on Earth with this CD-ROM multimedia presentation that includes Sun study projects.

Apollo 12 The NASA Mission Reports
Follow the Apollo 12 crew to the Moon in this detailed overview that includes over 2,100 photographs and five QuickTime panoramas. This material is highly technical and not intended for general audiences.

PCs in Space
Encourage student interest in space exploration with these free Internet materials. For more information, visit http://muspin.gsfc.nasa.gov/pcinspace.html.

Views of the Solar System
The National Science Educators Association offers this multimedia collection of astronomical facts and activities. Preview the CD-ROM at http://www.nsta.org/pub/special/psb128e.htm.
There are several ways you can observe the Sun, and hopefully sunspots, for yourself. The easiest and safest is to project the Sun by building your own pinhole camera. If you have a telescope, you will have to equip it with a solar filter or use a solar telescope that you can access via the Web.

*These lessons can be adapted for higher grade levels by including telescope mirrors and observing eclipses. Educators can also project the Sun’s image through a telescope resulting in a larger image for tracking sunspots and other solar activity.
Projecting the Sun

You can easily and safely observe the Sun by projecting it through a tiny hole onto a white sheet of paper. This simple device is called a "pinhole camera."

1. With the pin, punch a hole in the center of one of your pieces of paper.
2. Go outside, hold the paper up and aim the hole at the Sun. (Don't look at the Sun either through the hole or in any other way!)
3. Now, find the image of the Sun that comes through the hole.
4. Move your other piece of paper back and forth until the image rests on the paper and is in focus (i.e., has a nice, crisp edge). What you are seeing is not just a dot of light coming through the hole, but an actual image of the Sun.

Experiment by making your hole larger or smaller. What happens to the image? What happens when you punch two holes in the piece of paper? Try bending your paper so the images from the two holes lie on top of each other. What do you think would happen if you punched a thousand holes in your paper, and you could bend your paper so all the images lined up on top of each other?

In fact, optical telescopes can be thought of as a collection of millions of "pinhole" images all focused together in one place!

You can make your pinhole camera fancier by adding devices to hold up your piece of paper, or a screen to project your Sun image onto, or you can even make your pinhole camera a "real" camera by adding film.

If you want to learn more about how light works, you can join artist Bob Miller's Web-based "Light Walk" at the Exploratorium. It's always an eye-opening experience for students and educators alike. His unique discoveries will change the way you look at light, shadow, and images!

You'll need:
- 2 sheets of stiff white paper
- 1 pin
- A sunny day
- Perhaps a friend to help

Related Resources

Bob Miller's Light Walk
http://www.exploratorium.edu/light_walk/lw_main.html

Several sites give instructions for building more exotic pinhole cameras for observing the Sun:

Cyberspace Middle School
http://www.scri.fsu.edu/~dennisl/CMS/pdf/pinhole.html

Jack Troeger's Sun Site
http://www.cnnde.iastate.edu/staff/jtroeger/sun.html

CAUTION!

Don't EVER look directly at the Sun, with or without a telescope.

Living With a Star
Using Your Own Telescope

The safest way to look at the Sun through your own telescope is NOT to!
Looking at the Sun can cause serious damage, even blindness, to your eyes, unless you have proper filters.

Galileo Galilei used telescopes to observe and track sunspots c.1600. Picture from The Galileo Project.
http://es.rice.edu/ES/humsoc/Galileo/

Related Resources

Viewing the Sun With a Telescope
http://www.sunspot.noao.edu/PR/answerbook/telescope.html#q1.5
Dr. Sunspot gives more detailed information about safely viewing the Sun with a telescope and filters.

Observing the Sun in H-Alpha
http://www.4w.com/pac/halpha.htm
This site gives technical information on how to observe the Sun with your own telescope using an H-alpha filter. Includes detailed information on what features of the Sun are best seen in H-alpha. By Harold Zirin, Peter V. Foukal, and David Knisely.

The safest practical way to see the Sun is by eyepiece projection. Line up your telescope with the Sun, but instead of looking through the eyepiece, hold a sheet of white paper behind the eyepiece. You'll see a solar image projected onto the paper. What happens when you move the paper farther back?

Experiment with the paper to get a sharp viewing contrast. You should be able to see the largest sunspots with this method.

CAUTION!
Don’t EVER look directly at the Sun, with or without a telescope.

Classroom Activities

Using Remote Solar Telescopes

Using Mike Rushford’s robotic solar observatory in Livermore, California, you can get a real-time view of the Sun by controlling a telescope from your Web browser. At cloudy times, there are other things to do as well!

Related Resources

Eyes on the Skies
http://sunmil1.uml.edu/eyes/index.html

Activities courtesy of the Stanford Solar Center
http://solar-center.stanford.edu/observe/observe.html
A solar eclipse occurs when the Moon, during its monthly revolution around Earth, happens to line up exactly between Earth and the Sun. Why isn’t there an eclipse every month? Because solar eclipses occur during a new moon, but not at every new moon. Most often the Moon passes a little higher or a little lower than the Sun. There is a solar eclipse about twice a year, when the Moon’s and the Sun’s positions line up exactly.

You can safely observe a TOTALLY eclipsed Sun with the naked eye, but you will need a pinhole camera, an appropriate type of welder’s glass, or special Mylar glasses to safely observe the beginning and ending of a full or partial eclipse.

Related Resources

Fred Espenak’s Eclipse Home Page
http://sunearth.gsfc.nasa.gov/eclipse

Eclipse: Stories From the Path of Totality
http://www.exploratorium.edu/eclipse

Solar Data Analysis Center Eclipse Information
http://umbra.nascom.nasa.gov/eclipse

Eclipse Paths
http://umbra.nascom.nasa.gov/eclipse/predictions/eclipse-paths.html

The glory of a solar eclipse comes from the dramatic view of the Sun’s corona, or outer atmosphere, which we can see only when the brilliant solar disk is blocked by the Moon. The corona is not just light shining from around the disk: It is actually the outermost layer of the solar atmosphere. Although the gas is very sparse, it is extraordinarily hot (800,000 to 3,000,000 Kelvin), even hotter than the surface of the Sun! (The heating of the corona is still a mystery.) The corona shines up as pearly white streamers, their shape dependent on the Sun’s current magnetic fields. Thus every eclipse will be unique and glorious in its own way.

A solar eclipse is only visible from a small area of Earth. It’s unlikely that, during your lifetime, you will ever see a total solar eclipse directly over the place you live. Many people travel long ways to experience a total solar eclipse. If you’re lucky, you might someday see a partial solar eclipse (one where the Moon doesn’t quite cover all the Sun’s disk) nearby. You can safely observe a TOTALLY eclipsed Sun with the naked eye, but you will need a pinhole camera, an appropriate type of welder’s glass, or special Mylar glasses to safely observe the beginning and ending of a full or partial eclipse.
Until recently, astronomers have had to rely on drawings or sketches to document what they’ve seen. Charge-coupled device (CCD) cameras and other technological wonders have changed all that. Historic drawings, however, are still very important. And even today, drawings are still more accurate at recording exactly what the eye sees, unaltered by the processing of fancy electronics.

Galileo’s drawings of sunspots (c. 1600) still survive today. And the solar telescope at Mt. Wilson, above Pasadena, California, has been collecting sunspot drawings since 1917. The tradition continues. You can check current sunspot drawings each day at the Websites listed here, and compare them with your own.

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Activities courtesy of the Stanford Solar Center
http://solar-center.stanford.edu/observe/observe.html

Related Resources

Daily Sunspot Drawing Observations at Mt. Wilson
http://www.astro.ucla.edu/~obs/150_draw.html

Daily Sunspot Images from SOHO
http://sohowww.nascom.nasa.gov/latestimages

Galileo’s Sunspot Drawings
http://es.rice.edu/ES/humsoc/Galileo/Things/g_sunspots.html

Sunspots at the Exploratorium
http://www.exploratorium.edu/sunspots

These classroom activities can be found at:
http://solar-center.stanford.edu/observe/observe.html
Created by Deborah Scherrer, April 1997. Last revised by DKS on 2 December 1997.

CAUTION!
Don’t EVER look directly at the Sun, with or without a telescope.
## NASA Educator Workshop Resources

An annotated listing of sites that provide educator training and educator materials.

**Note:** Check these website URLs for current workshop updates!

<table>
<thead>
<tr>
<th>Resource</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISTP Sun-Earth Connections Educators Workshops <a href="http://istp.gsfc.nasa.gov/istp/outreach/workshop">http://istp.gsfc.nasa.gov/istp/outreach/workshop</a></td>
<td>Educators learn about the connection between the star that heats us and our home planet. The site provides workshop information: links to activities and information, Web versions of speaker presentations, and evaluation forms.</td>
</tr>
<tr>
<td>URCEP Urban and Rural Community Enrichment Program <a href="http://aesp.nasa.okstate.edu/URCEP">http://aesp.nasa.okstate.edu/URCEP</a></td>
<td>NASA Aerospace Education Services Program specifically designed to present urban and rural middle school students with interesting and broadening educational activities.</td>
</tr>
<tr>
<td>Making Sun-Earth Connections <a href="http://sunearth.gsfc.nasa.gov/SECEF_SunEarthDay/overview.html">http://sunearth.gsfc.nasa.gov/SECEF_SunEarthDay/overview.html</a></td>
<td>Ready-made presentations and captions</td>
</tr>
<tr>
<td>NASA’s Educator Resource Centers <a href="http://education.nasa.gov/ercn/index.html">http://education.nasa.gov/ercn/index.html</a></td>
<td>Located on or near NASA Field Centers, museums, colleges, or other nonprofit organizations, ERCs provide educators with in-service and preservice training, demonstrations, and access to NASA instructional products.</td>
</tr>
<tr>
<td>NASA Lunar-Meteorite Sample Loan Program <a href="http://education.nasa.gov/lunar.sample/index.html">http://education.nasa.gov/lunar.sample/index.html</a></td>
<td>Educators can be certified to borrow lunar and meteorite materials by attending a training seminar on security requirements and proper handling procedures. Learn how!</td>
</tr>
<tr>
<td>NEW NASA Educational Workshops <a href="http://education.nasa.gov/new/index.html">http://education.nasa.gov/new/index.html</a></td>
<td>Selected participants will spend two weeks in the summer at one of NASA’s centers. Travel expenses, housing, and meals are included as part of the program. Graduate credit is available.</td>
</tr>
<tr>
<td>Meteorology Educator’s Training <a href="http://education.gsfc.nasa.gov/MET/MET.html">http://education.gsfc.nasa.gov/MET/MET.html</a></td>
<td>NASA’s Goddard Space Flight Center is proud to offer a full day of intermediate-to-advanced level training for experienced educators of meteorology content in the classroom.</td>
</tr>
</tbody>
</table>
Aurora  Light radiated by ions and atoms in the Earth’s upper atmosphere, mostly in polar regions, the result of bombardment by energetic electrically charged particles from the magnetosphere.

Bow Shock  The shock wave that flanks the magnetosphere on the day side, and partially deflects the solar wind. It causes the solar wind to become more turbulent through sudden changes in temperature and density.

Chromosphere  The part of the Sun (or another star) between the photosphere and the corona.

Corona  The Sun’s outer atmosphere.

Coronal Mass Ejection (CME)  A vast magnetic bubble of plasma that erupts from the Sun’s corona and travels through space at high speed. Coronal mass ejections may cause intense geomagnetic storms and accelerate vast quantities of energetic particles.

Heliosphere  The outer edge of the heliosphere, where the solar system ends and the interstellar space begins. At the heliosphere, the pressure of the solar wind balances that of the interstellar medium.

Interstellar Medium  Electrified gas and dust between the stars.

Iosphere  The highest region of the Earth’s atmosphere containing free electrons and ions.

Magnetometer  A device used to measure the Earth’s magnetic field and changes that may be caused by solar storms.

Magnetopause  The boundary of the magnetosphere, lying inside the bow shock, usually about 10 Earth radii toward the Sun.

Magnetosheath  The region between the bow shock and the magnetopause, characterized by very turbulent plasma. For Earth, along the Sun–Earth axis, the magnetosheath is about two Earth radii thick.

Magnetosphere  The region surrounding a planet within which the planetary magnetic field is the dominant force on electrically charged particles that can be trapped within it.

Magnetotail  A cometlike extension of a planet’s magnetosphere formed on the planet’s dark night side by the action of the solar wind. It can extend hundreds of planetary radii away from the Sun.

Photosphere  The visible portion of the Sun.

Plasma  A low-density gas in which the individual atoms are charged and which contains an equal number of electrons.

Spectrum  A particular distribution of wavelengths, frequencies, or energies.

Solar Flare  An explosive release of energy of the Sun.

Solar Wind  The charged particles (plasma), primarily protons and electrons, that are continuously emitted from the Sun and stream outward throughout the solar system at speeds of hundreds of kilometers per second.

Sunspot  A region of the solar surface that is dark and relatively cool; it has an extremely high magnetic field.
Additional NASA Resources

Links to NASA education and public dissemination sites.

Other Resources

NASA Education
http://education.nasa.gov/

Office of Space Science
http://spacescience.nasa.gov

Teach Space Science
http://teachspacescience.stsci.edu

Space Science News
http://science.nasa.gov or http://spacescience.com

Spacelink
http://spacelink.nasa.gov/index.html

NASA CORE
Central Operation of Resources for Educators
http://core.nasa.gov/

Education Resource Center Network (ERCN)
http://education.nasa.gov/ercn/index.html

NASA Television
http://spacelink.nasa.gov/education.html

NASA QUEST
The Internet in the Classroom
http://quest.arc.nasa.gov

NASA Educator Workshop & Fellowship Opportunities
http://education.nasa.gov/workshop.html

A Guide to NASA Education Programs

Aerospace Education Service Program (AESP)
http://www.okstate.edu/aesp/AESP.html

NASA Student Involvement Program (NSIP)
http://education.nasa.gov/nsip

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Shane Bussmann

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ideum.com

Sunspots observed in an H-alpha image from Big Bear Solar Observatory.
http://www.bbso.njit.edu/
Living With A Star
Educator Resources Guide

EDUCATOR REPLY CARD

To achieve America's goals in Educational Excellence, it is NASA's mission to
develop supplementary instructional materials and curricula in science, mathematics, and technology. NASA seeks to involve the educational community in
the development and improvement of these materials. Your evaluation and
suggestions are vital to continually improving NASA educational materials.

1. With what grades did you use the educator guide?
   Number of Teachers/Faculty:
   K-4  5-8  9-12  Community College
   College/University - Undergraduate  Graduate

   Number of Students:
   K-4  5-8  9-12  Community College
   College/University - Undergraduate  Graduate

   Number of Others:
   Administrators/Staff  Parents  Professional Groups
   General Public  Civic Groups  Other

2. What is your home 5- or 9-digit zip code?  __ __ __ __ __ — __ __ __ __

3. This is a valuable educator guide?
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5. What kind of recommendation would you make to someone who asks about this
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   [ ] Excellent  [ ] Good  [ ] Average  [ ] Poor  [ ] Very Poor

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   [ ] Lecture  [ ] Science and Mathematics
   [ ] Team Activities  Standards Integration
   [ ] Other: Please specify:

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   [ ] Fellow Educator
   [ ] Workshop/Conference
   [ ] Other: Please specify:

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This reply card is intended for educators only.
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