National Aeronautics and
Space Administration

Educational Product	
Educators & Students	Grades K-12

EG-2001-01-005-GSFC

Living with a Star

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

About This Educator's Guide

This guide is designed to provide educators with a quick reference to materials and resources that are useful for understanding the connections between the Sun and Earth.

The Sun-Earth Connection Education Forum *NASA/GSFC • UCB/SSL*

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.

http://sunearth.ssl.berkeley.edu
http://sunearth.gsfc.nasa.gov

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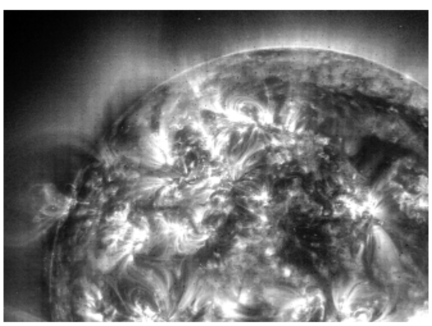
Contents

Educator Resources for Understanding Connections Between the Sun and Earth



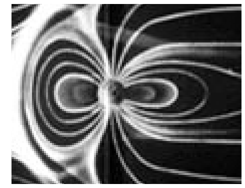
Solar image taken by the Extreme Ultraviolet Imaging Telescope aboard the SOHO satellite.
Image from the Solar Data Analysis Center at NASA Goddard Space Flight Center.
http://umbra.nascom.nasa.gov:80/sdac.html

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/

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



Would you like to explore the Earth's magnetosphere?
http://image.gsfc.nasa.gov/poetry
http://www-spof.gsfc.nasa.gov/Education/Intro.html

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

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

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

Where can I "hear" the Earth's magnetosphere?
http://www-pw.physics.uiowa.edu/mcgreevy/

What does the Sun look like today?
http://umbra.gsfc.nasa.gov/images/latest.html

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

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

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

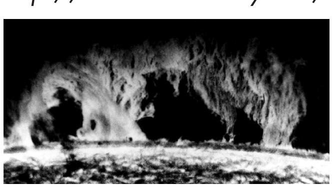
How does radiation affect astronauts?
http://flick.gsfc.nasa.gov
http://see.msfc.nasa.gov

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

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

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

New Launches
http://spacescience.nasa.gov



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

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

Images: (top)Earth's Magnetosphere illustration courtesy of NASA's Sun-Earth Connection.
(middle) Solar eclipse image from Fred Espenak's Eclipe Home page at NASA's Goddard Space Flight Center. *http://sunearth.gsfc.nasa.gov/eclipse/eclipse.html*
(bottom) Solar prominence image from Big Bear Solar Observatory *http://www.bbso.njit.edu/*

Sun-Earth Connection Missions

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

NASA SEC Mission (Launch Date)	Mission Education Page	Science Objective
ACE (1997 –) **Advanced Composition Explorer** *http://helios.gsfc.nasa.gov/ace/*	**Cosmic and Heliospheric Learning Center** *http://helios.gsfc.nasa.gov*	Study of the physics and chemistry of the solar corona, the solar wind, and the interstellar medium.
Cluster II (2000 –) *http://sci.esa.int/cluster*	*http://istp.gsfc.nasa.gov/istp/outreach*	Study of Earth's magnetic field, electric surroundings, and the effects of the solar wind on the Earth's protective magnetosphere.
CRRES (1990 – 1991) **Combined Release and Radiation Effects Satellite** *http://www.ball.com/aerospace/crres.html*	No Education Page	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.
FAST (1996 –) **Fast Auroral SnapshoT Explorer** *http://plasma2.ssl.berkeley.edu/fast*	*http://cse.ssl.berkeley.edu*	How the particles and fields in the upper atmosphere change during an aurora.
Genesis (2001 –) *http://www.genesismission.org*	*http://www.genesismission.org/educate* - also visit - *http://sun.jpl.nasa.gov/*	The search for origins of the universe through the study of solar wind and fusion chemistry.
Geospace Electrodynamic Connections (GEC) (2008 –) *http://stp.gsfc.nasa.gov/missions/gec/gec.htm*	*http://stp.gsfc.nasa.gov/educ_out/educ_out.htm*	GEC will determine how the ionosphere-thermosphere (I-T) system reponds to magnetosphere forcing and how the I-T system is dynamically coupled to the magnetosphere.
GEOTAIL (1992 –) *http://istp.gsfc.nasa.gov/istp/geotail*	*http://istp.gsfc.nasa.gov/istp/outreach/*	Study of the magnetotail region and the change over time, and how the magnetotail, plasma sheet, and magnetopause interact.
HESSI (2001 –) **High Energy Solar Spectroscopic Imager** *http://hesperia.gsfc.nasa.gov/hessi/*	*http://cse.ssl.berkeley.edu/hessi_epo/*	Study of solar flares, the effect on electron and proton acceleration and the origin of energy for solar flares.

Sun-Earth Connection Missions

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

NASA SEC Mission (Launch Date)	Mission Education Page	Science Objective
IMAGE (2000 –) **Imager for Magnetopause-to-Aurora Global Exploration** *http://image.gsfc.nasa.gov/*	*http://image.gsfc.nasa.gov/poetry/*	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.
IMEX (2001 –) **Inner Magnetosphere Explorer** *http://ham.space.umn.edu/spacephys/imex.html*	No Education Page	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.
IM (2009 –) **Ionospheric Mappers** *http://lws.gsfc.nasa.gov/lws_missions_im.htm*	*http://lws.gsfc.nasa.gov/lws_education.htm*	A global network of satellites that will gather knowledge of how the ionosphere behaves as a system, linking solar energy with Earth's atmosphere.
IMP-8 (1973 –) **Interplanetary Monitoring Platform** *http://nssdc.gsfc.nasa.gov/space/imp-8.html*	No Education Page	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.
INTERBALL (1995 –) *http://www.iki.rssi.ru/interball.html*	No Education Page	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.
ISTP (mutiple missions) **International Solar-Terrestrial Physics Program** *http://istp.gsfc.nasa.gov/*	*http://istp.gsfc.nasa.gov/istp/outreach/*	Participating Missions: • **CLUSTER II** • **POLAR** • **WIND** • **GEOTAIL** • **SOHO** *(find these listed alphabetically)*
LWS (mutiple missions) **Living With a Star Program** *http://lws.gsfc.nasa.gov*	*http://lws.gsfc.nasa.gov/lws_education.htm*	Participating Missions: • **IM** • **SDO** • **RBM** • **Solar Sentinels** *(find these listed alphabetically)*

Sun-Earth Connection Missions

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

NASA SEC Mission (Launch Date)	Mission Education Page	Science Objective
MC (2010 –) **Magnetospheric Constellation** *http://stp.gsfc.nasa.gov/missions/mc/mc.htm*	*http://stp.gsfc.nasa.gov/educ_out/educ_out.htm*	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.
MMS (2006 –) **Magnetospheric MultiScale** *http://stp.gsfc.nasa.gov/missions/mms/mms.htm*	*http://stp.gsfc.nasa.gov/educ_out/educ_out.htm*	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.
Polar (1996 –) *http://istp.gsfc.nasa.gov/istp/polar/*	*http://istp.gsfc.nasa.gov/istp/outreach/*	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.
RBM (2008 –) **Reaiation Belt Mappers** *http://lws.gsfc.nasa.gov/lws_missions_rbm.htm*	*http://lws.gsfc.nasa.gov/lws_education.htm*	To understand the origin and dynamics of Earth's radiation belts and determine the evolution of the penetrating radiation during magnetic storms.
SAMPEX (1992 –) **Solar Anomalous and Magnetospheric Particle Explorer** *http://surya.umd.edu/www/sampex.html*	*http://surya.umd.edu/www/outreach.html*	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.
SDO (2006 –) **Solar Dynamics Observatory** *http://lws.gsfc.nasa.gov/lws_missions_sdo.htm*	*http://stp.gsfc.nasa.gov/lws_education.htm*	To observe the Sun's dynamics and understand the nature and source of variations, from the stellar core to the turbulent solar atmosphere.
Sentinels (2009 –) *http://lws.gsfc.nasa.gov/*lws_missions_sentinels.htm	*http://lws.gsfc.nasa.gov/lws_education.htm*	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.

Sun-Earth Connection Missions

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

NASA SEC Mission (Launch Date)	Mission Education Page	Science Objective
SNOE (1998 –) *http://lasp.colorado.edu/snoe*	No Education Page	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 –) **Solar and Heliospheric Observatory** *http://sohowww.nascom.nasa.gov*	**Explore:** *http://sohowww.nascom.nasa.gov/explore/* **Stanford Solar Center:** *http://solar-center.stanford.edu/index.html*	Study of how the solar corona is heated, the internal structure of the Sun, and what causes the acitivity seen on the surface ot the Sun.
Solar-B (2005 –) *http://stp.gsfc.nasa.gov/missions/solar-b/solar-b.htm*	*http://stp.gsfc.nasa.gov/educ_out/educ_out.htm*	Solar-B seeks to understand the magnetic origins of solar activity and variability and how they influence and sometimes change the Earth's environment.
Solar Probe (2007 –) *http://www.jpl.nasa.gov/ice_fire//sprobe.htm*	*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) *http://umbra.gsfc.nasa.gov/spartan*	No Education Page	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 –) **Solar TErrestrial RElations Observatory** *http://stp.gsfc.nasa/gov/missions/stereo/stereo.htm*	*http://stp.gsfc.nasa.gov/educ_out/educ_out.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 (mutiple missions) **Solar Terrestrial Probes Program** *http://stp.gsfc.nasa.gov*	*http://stp.gsfc.nasa.gov*	Participating Missions: • **GEC** • **Solar-B** • **MC** • **STEREO** • **MMS** • **TIMED** *(find these listed alphabetically)*

Sun-Earth Connection Missions

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

NASA SEC Mission (Launch Date)	Mission Education Page	Science Objective
TIMED (2001 –) **Thermosphere•Ionosphere•Mesosphere• Energetic Dynamics** *http://stp.gsfc.nasa.gov/missions/timed/timed.htm*	*http://stp.gsfc.nasa.gov*	TIMED will study the atmospheric properties (e.g., winds, temperature, chemical constitiuents, and energetics) of the Mesosphere, Lower Thermosphere, and Ionosphere (MLTI) region on a global scale.
TRACE (1998 –) *http://vestige.lmsal.com/TRACE/*	*http://vestige.lmsal.com/TRACE/Public/eduprodu.htm*	Study of the 3-D structure of features seen on the Sun's surface; how the corona is heated; and what triggers solar flares.
TWINS (2003 –) **Two Wide-angle Imaging Neutral-atom Spectrometers** http://nis-www.lanl.gov/nis-projects/twins/	No Education Page	This mission will provide new ways for stereoscopic imaging of Earth's plasma environment in order to study its dynamics.
Ulysses (1990 –) *http://ulysses.jpl.nasa.gov/*	*http://ulysses.jpl.nasa.gov/outreach/outreach.html*	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.
Voyager (1997 –) *http://vraptor.jpl.nasa.gov/voyager/voyager.html* – or – *http://www.jpl.nasa.gov/voyager/*	*See Mission pages for outreach components*	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.
Wind (1994 –) *http://istp.gsfc.nasa.gov/istp/wind/*	*http://istp.gsfc.nasa.gov/istp/outreach/*	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.
Yohkoh (1991 –) *http://www.lmsal.com/SXT/Yohkoh*	*http://www.imsal.com/YPOP/*	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

Website Resources

Educational solar sites listed by grade level.

Grades K-12

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

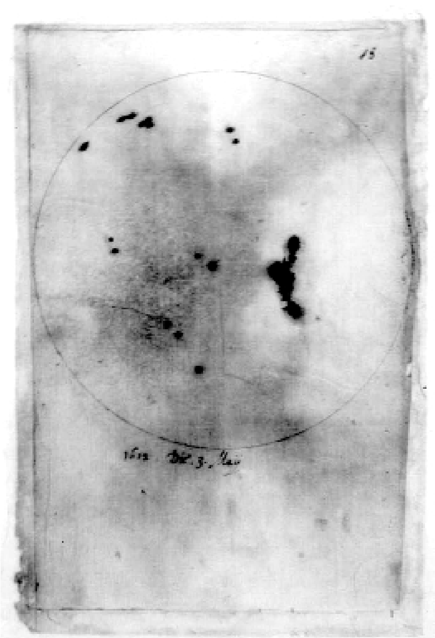
Grades 6-8

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/



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

Grades 9-12

Differential Rotation of the Sun
http://sohowww.estec.esa.nl/explore/lessons/diffrot9_12.html

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-spof.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/

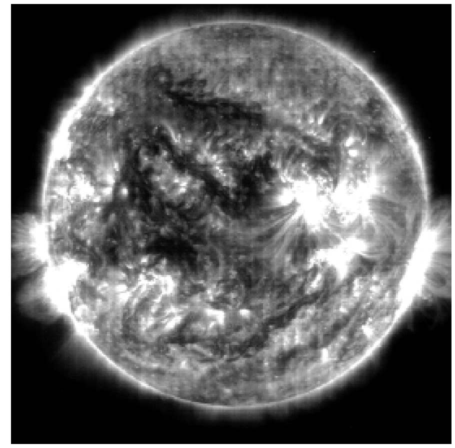
Solar Flare Theory
http://hesperia.gsfc.nasa.gov/sftheory/index.htm

Stanford Solar Center
http://solar-center.stanford.edu/index.html

The Sun in Time
http://science.msfc.nasa.gov/ssl/pad/solar/suntime/suntime.htm

Grades 12+

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



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/sdac.html

General Audience

Storms From the Sun
ISTP Poster
http://istp.gsfc.nasa.gov/istp/outreach/cmeposter/index.html

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

Space Science Education Resource Directory
http://teachspacescience.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/

NASA CORE Materials

At the NASA CORE (Central Operation of Resources For Educators) Website you can order free NASA videos and other educational materials.
http://core.nasa.gov

Videocassette General

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.

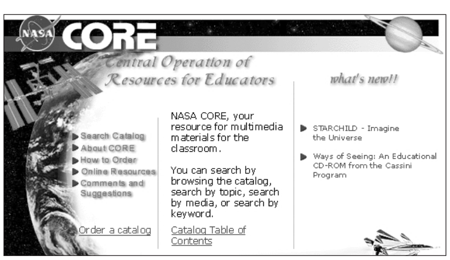
Ulysses: An Expedition Over the Sun's Poles
Learn about the discoveries made by the Ulysses spacecraft. Video includes an educator guide.

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 Nino, ocean currents, an asteroid collision, the surface of Mars, and a titanic 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.

Space Flight: The Application of Orbital Mechanics
Animation interspersed with footage from Shuttle missions explains planetary motion and orbital mechanics in detail.

Ulysses: Encounter With Jupiter
Travel with Ulysses in this computer-animated scenario of the spacecraft's 10-day tour of Jupiter on its way to the Sun.

Videocassette Series

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.

30-Part Series Condensed Onto Four Video Cassettes
Uncover new insights into the size, formation, and makeup of the universe that complement existing physics and earth science curricula. Set includes a 90-page educator's guide.

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.

Computer Materials

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/pubs/special/pb128x.htm.*

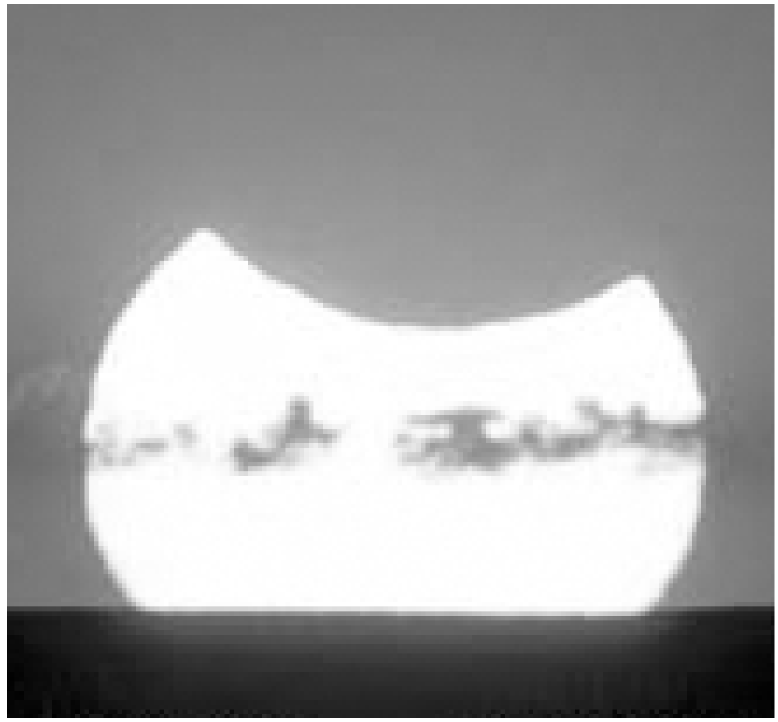
Hands-on activities for use in the classroom.

Observing the Sun for Yourself

http://solar-center.stanford.edu/observe/observe.html

Classroom Activities
Grade Level 3-5*

Courtesy of the
Stanford Solar Center



Partial solar eclipse image from Fred Espenak's Eclipse Home Page at NASA's Goddard Space Flight Center.
http://sunearth.gsfc.nasa.gov/eclipse/eclipse.html

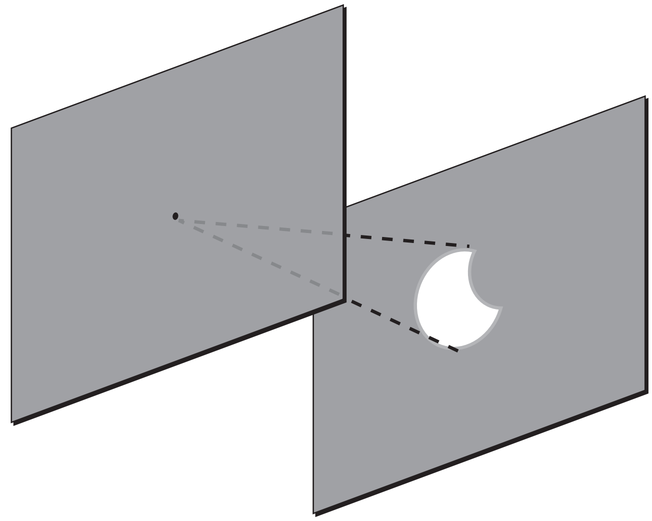
There are several ways you can observe the Sun, and hopefully sunspots, for yourself. The easiest and safest is to project the Sun by building your own pinhole camera. If you have a telescope, you will have to equip it with a solar filter or use a solar telescope that you can access via the Web.

CAUTION!
Don't EVER look directly at the Sun, with or without a telescope
(unless you have the proper filters).

*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.

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

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."

You'll need:

- **2 sheets** of stiff white paper
- **1 pin**
- **A sunny day**
- Perhaps **a friend** to help

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!

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/sf/pinhole.html

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

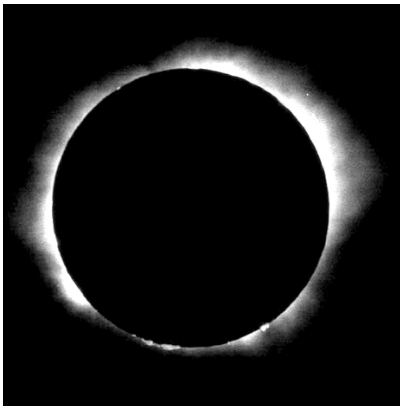
CAUTION!

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

(unless you have the proper filters).

Classroom Activities

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



Solar Eclipse © 1999 Paul Mortfield
http://www.backyardastronomer.com

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

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#q15

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!

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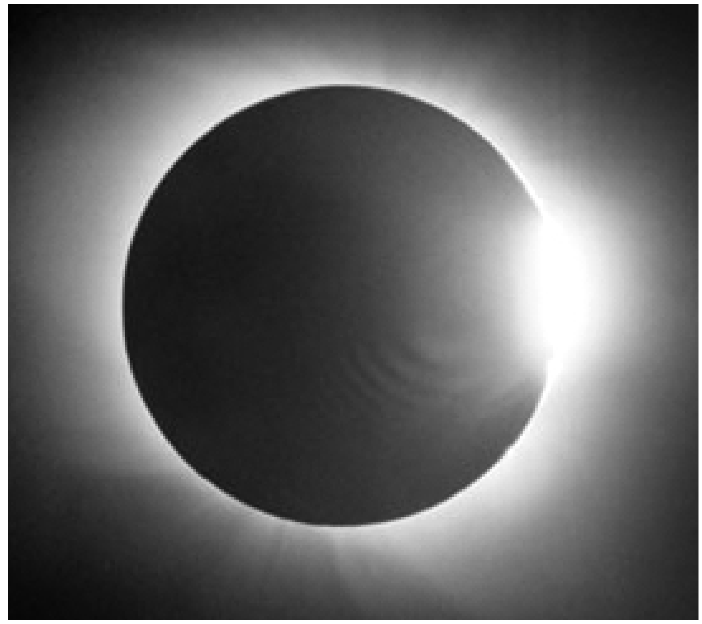
(unless you have the proper filters).

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

Observing Solar Eclipses

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.



Solar eclipse image from Fred Espenak's Eclipse Home Page at NASA's Goddard Space Flight Center.
http://sunearth.gsfc.nasa.gov/eclipse/eclipse.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 shows 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.

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 Anaylsis Center Eclipse Information
http://umbra.nascom.nasa.gov/eclipse

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

CAUTION!

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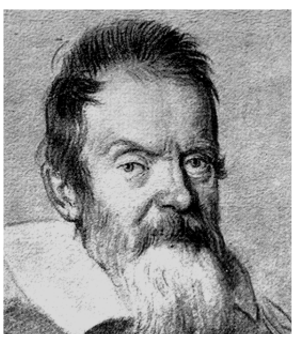
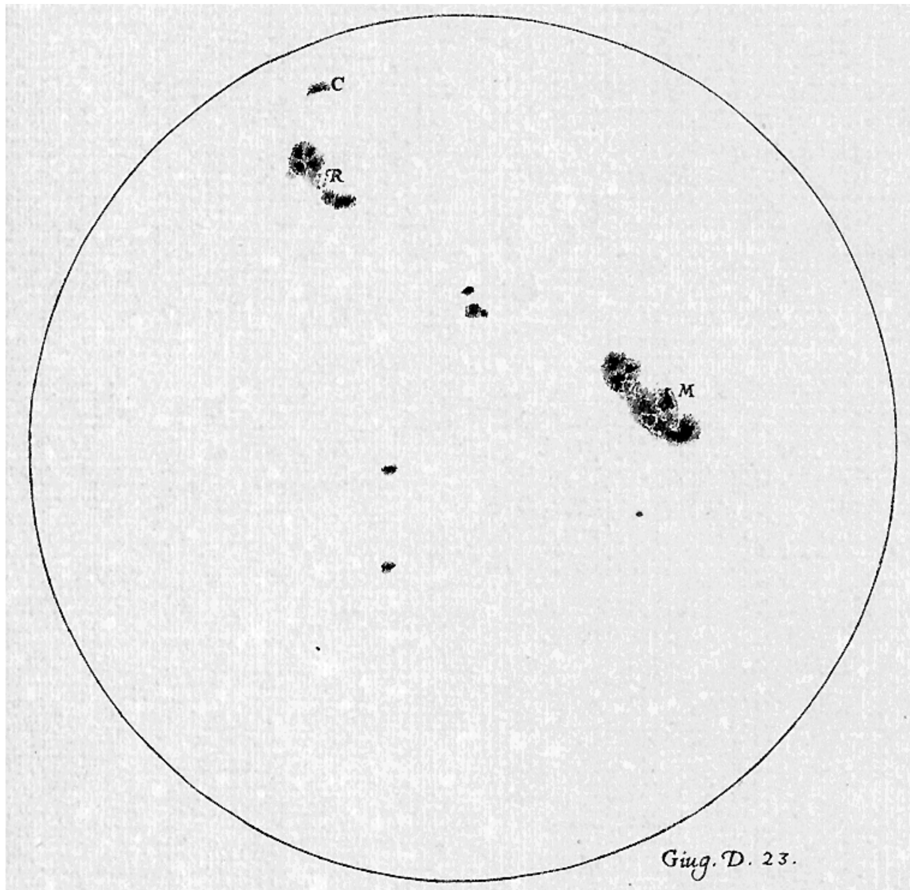
(unless you have the proper filters).

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

Sunspot Drawings

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 Galilei (left) and sunspot drawings (above) from The Galileo Project.
http://es.rice.edu/ES/humsoc/Galileo/

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.

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.

CAUTION!

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

(unless you have the proper filters).

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!*

Resource	Summary
ISTP **Sun-Earth Connections Educators Workshops** *http://istp.gsfc.nasa.gov/istp/outreach/workshop*	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.
URCEP **Urban and Rural Community Enrichment Program** *http://aesp.nasa.okstate.edu/URCEP*	NASA Aerospace Education Services Program specifically designed to present urban and rural middle school students with interesting and broadening educational activities.
Making Sun-Earth Connections *http://sunearth.gsfc.nasa.gov/SECEF_SunEarthDay/overview.html*	Ready-made presentations and captions
NASA's Educator Resource Centers *http://education.nasa.gov/ercn/index.html*	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.
NOVA **NASA Opportunities for Visionary Academics** *http://education.nasa.gov/nova/index.html*	Works to create, develop, and disseminate a national framework for enhancing science, mathematics, and technology literacy for preservice educators in the 21st century.
NASA Lunar-Meteorite Sample Loan Program *http://education.nasa.gov/lunar.sample/index.html*	Educators can be certified to borrow lunar and meteorite materials by attending a training seminar on security requirements and proper handling procedures. Learn how!
NEW **NASA Educational Workshops** *http://education.nasa.gov/new/index.html*	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.
Meteorology Educator's Training *http://education.gsfc.nasa.gov/MET/MET.html*	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.

Glossary

Visit the Space Environment Center for a complete glossary of solar-terrestrial terms.
http://www.sel.noaa.gov/info/glossary.html

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.

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

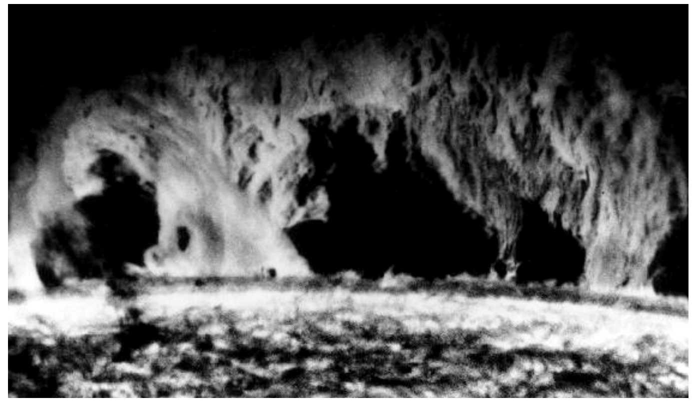
Interstellar Medium Electrified gas and dust between the stars.

Ionosphere 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.



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

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.

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Lang, Kenneth, "Sun, Earth and Sky." New York, Springer-Verlag, 1995

Moore, Patrick, ed., "The International Encyclopedia of Astronomy." New York, Orion Books, 1987

Pasachoff, Jay M., "Journey through the Universe." New York, Saunders College Publishing, 1994

Stockley, Corinne, and Oxlade, Chris, and Wertheim, Jane, "The Usborne Illustrated Dictionary of Science." Oklahoma, EDC publishing, 1988

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.file

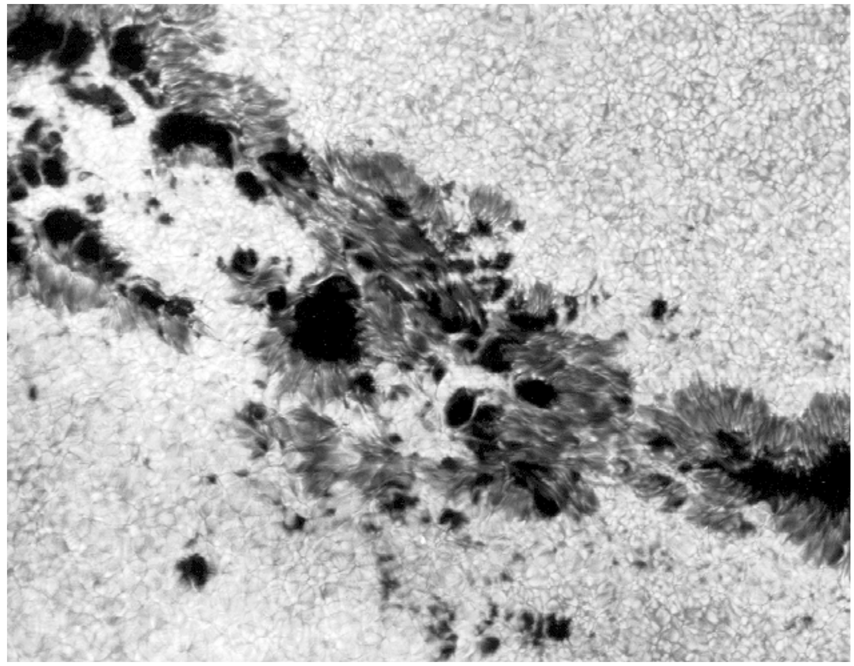
NASA QUEST
The Internet in the Classroom
http://quest.arc.nasa.gov

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

A Guide to NASA Education Programs
http://ehb2.gsfc.nasa.gov/edcats/1999/nep/programs/index.html

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

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



Sunspots observed in an H-alpha image from Big Bear Solar Observatory.
http://www.bbso.njit.edu/

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LIVING WITH A STAR

Educator Resources for Understanding Connections
Between the Sun and Earth

EG-2001-01-005-GSFC

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.

Please take a moment to respond to the statements and questions below. You can submit your response through the Internet or by mail. Send your reply to the following Internet address:

http://ehb2.gsfc.nasa.gov/edcats/educator_guide

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Otherwise, please return the reply card by mail. Thank you.

1. With what grades did you use the educator guide?
   Number of Teachers/Faculty:
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   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?

   ❑ Strongly Agree ❑ Agree ❑ Neutral ❑ Disagree ❑ Strongly Disagree

4. I expect to apply what I learned in this educator guide.

   ❑ Strongly Agree ❑ Agree ❑ Neutral ❑ Disagree ❑ Strongly Disagree

Fold along line and tape closed.

5. What kind of recommendation would you make to someone who asks about this educator guide?

   ❑ Excellent ❑ Good ❑ Average ❑ Poor ❑ Very Poor

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   ❑ NASA Educator Resource Center
   ❑ NASA Central Operation of Resources for Educators (CORE)
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   ❑ Workshop/Conference
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8. What features of this educator guide did you find particularly helpful?

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9. How can we make this educator guide more effective for you?

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10. Additional comments:

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