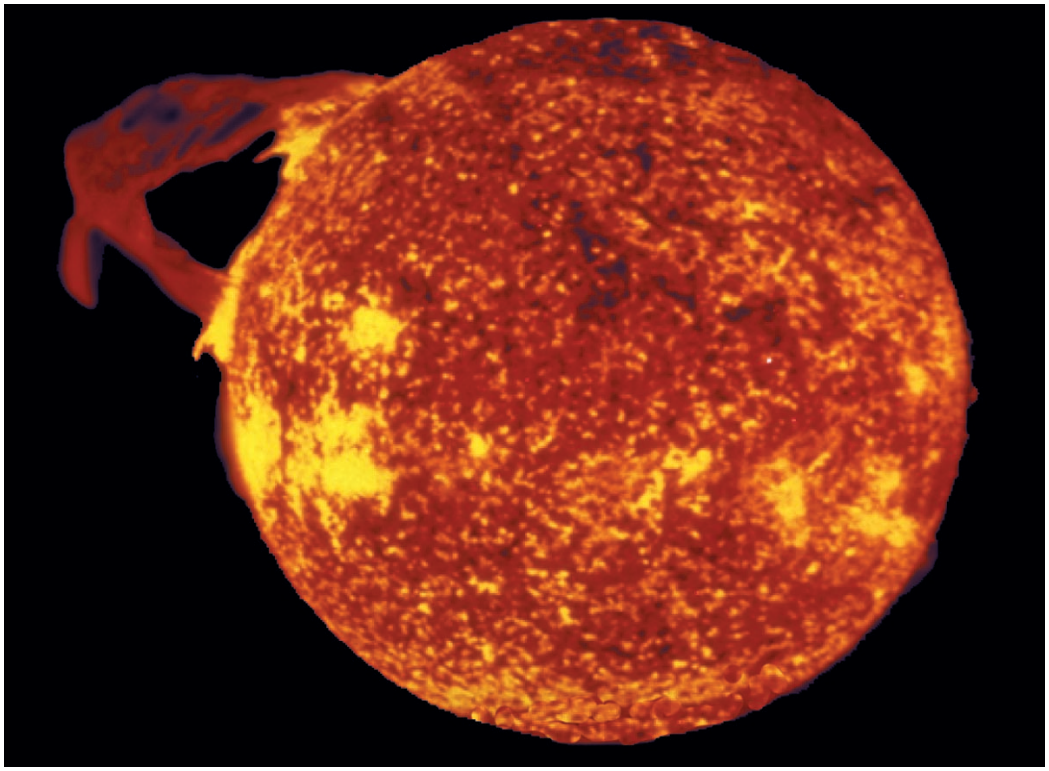
Solarscapes:
Sunspots and Rotation



Secondary School Activities About the Sun

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Letter to Teachers

Dear Teachers:

Dedicated to excellence in space science research & education

I hope that you find this middle school curriculum both inspirational as well as rewarding for you and your students. The primary author of this work is Beverly Meier, an eighth grade teacher in the Boulder Valley Public Schools. The star of the show (no pun intended) is of course our very own Sun. You will be able to explore the Sun using a variety of electromagnetic wavelengths. These waves act like "fingerprints" helping scientists and students to decipher the dramatic changes which occur on the Sun. You and your students will be able to open up the Sun to see phenomena many people have never seen before. Your students will also be able to calculate the period of the so-called solar cycle (which is the rising and falling of the number of sunspots) and even predict the shapes of the next two solar cycles called 23 and 24. The last activity in this unit is calculating the Sun's rotation period using sunspots.

Our goal is to provide activities that are fun for students and convenient and easy for teachers to use. The reading level is aimed at the middle school age group. However, some of the questions that follow each activity can be challenging to high school students. Mathematics is incorporated into Activities # 2, 3 and 4. I hope that you will find these activities flexible enough to adapt to your teaching and classroom style. An on-line version of the curriculum can be found at http://www-ssi.colorado.edu/Education/ResourcesForEducators/1.html. You can download the necessary images needed for Activities # 1 and 4 or you can order a set by contacting me at the Space Science Institute.

Your opinions and evaluation of these activities are vital to us. I am particularly interested in your opinion of the rubrics and the use of the learning cycle. With the assistance of the Science Discovery Program at the University of Colorado/Boulder, I plan to update and improve Solarscapes based on your comments and hope to add activities to the series in the future. An Evaluation Form is included in the "Information to Teachers" section of this document. Please complete the form after you have used the Activities and return it to us so that we can implement your suggestions for improvement.

Best Wishes.

Sincerely,

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PREFACE FOR THE TEACHER USING THESE MATERIALS

Introduction

We often teach our students that the Sun sustains life on Earth. Indeed, without its warmth, energy and relative constancy, life on Earth could not exist. While astrophysicists classify the Sun as an average star in terms of size, temperature and brightness, it remains of central importance to us, the inhabitants of Earth. Because of the Sun's impact on our lives, it naturally engenders interest and curiosity. What is it made of, how far away is it, will it ever stop burning, will it go super nova? These are questions that a curious middle school student may ask.

This curriculum is intended to be a short and focused study of the physical nature of the Sun. It is written to accompany the traveling exhibition entitled, **"Electric Space: Bolts, Jolts, and Volts from the Sun."** Beginning in September, 1996, Electric Space is traveling to museums across the country. The exhibit calls attention to the fourth state of matter, plasma, and to the idea that "space is not empty:" it is filled with electromagnetic fields, charged particles and the interplay between these two. Just as we speak of living things existing in an environment, we can also think of Earth as existing in a space environment. This environment, created by the Sun, is a vast magnetic bubble called the heliosphere. The Sun's heliosphere extends far beyond the solar system. Thus, the Sun encases Earth in its sphere of influence, surrounding us with its magnetic field, subjecting it to the constant solar wind, and occasionally pelting it with great bursts of charged particles that arrive following mass ejections and solar flares from the Sun.

This curriculum is aimed at the middle school level and focuses on the observable features of the Sun. What can we learn by looking closely at images of the Sun? Is it just a fiery ball or are there discernible features? The curriculum then zeros in on the most prominent feature of the Sun, sunspots. If we count sunspots over the years, does a pattern emerge? Why is this pattern important and can we predict it? As an embedded assessment, students are asked to predict the beginning and end of the next two sunspot cycles and the number of sunspots at each maximum. Students are invited to submit their predictions right along with solar scientists to the Space Environment Center located in Boulder, Colorado at the National Oceanic and Atmospheric Administration. Finally, students are asked if they can learn anything about the rotation of the Sun by observing the movement of sunspots across the surface of the Sun. Can they calculate how fast the Sun rotates? Can they apply this knowledge to the rotation of other objects in the solar system?

In order to use this curriculum you will need several images of the Sun. These have already been selected for you by the Space Science Institute to illustrate the essential characteristics of the Sun. If you wish, you may also access them on the World Wide Web at: **http://www-ssi.colorado.edu/Education/ResourcesForEducators/1.html**. Should you not be able to obtain the images from the WWW you may contact the **Space Science Institute at 1540 30th Street, Suite 23, Boulder, Colorado 80303-1012** for details on image prices.

We encourage you, the teacher, to use these written lessons as a jumping off point. Change them as you wish to fit your own style of teaching. Mix your style of delivery to engage all learning styles. Have your students follow-up their questions with information searches in the library and on the WWW. Most of all, have fun!

We want to hear from you as to how Solarscapes worked for you and your students. With this in mind, there is an evaluation form at the end of this section. Please take the time to fill it out and return it to The Space Science Institute.

General Philosophy, Intent, and Internet Version of *Solarscapes*

The general philosophy behind *Solarscapes* is that students should have the opportunity to learn science in a manner not too dissimilar from the way in which science is done. Scientists continually assess prior knowledge, explore new data and ideas, compare prior knowledge to the new information, and try to synthesize all of this into an enhanced understanding of what they are examining. In short, scientists are constructivists. We therefore take a constructivist viewpoint with regard to these activities. To use them as intended, teachers must be "the guide on the side" as opposed to "the sage on the stage," an approach that even the most exemplary teachers continually refine by reflecting on their practice.

Prior knowledge is examined in every activity, and a key self-assessment for students is to compare their prior knowledge with their understanding after the activity. Students are expected to work on the activities in groups, although each is expected to keep a small portfolio for individual assessment. The teacher as facilitator is expected to "float" among the groups, probing with questions and continually assessing in order to help groups focus on the questions at hand and thus to direct them to achieve the learning goals of the activities on their own terms. Our vision is a student-centered environment, where all students achieve some measure of success in these activities.

The intent of S*olarscapes* is to provide a supplement for middle school science whose topic is the Sun and its features. It is intended that these activities (four in number) take about one to two weeks of class time, and that some activities will be spread over more than one class period. While the activities are supplemental and may be used independently of each other, *Solarscapes* was conceived and designed as an integrated experience that builds from lesson to lesson and ideally should be used as a group. We hope that inquiry drives student understanding, though we recognize that inquiry is limited in these activities (especially the first), partly by design and partly by the constraints placed on any such supplementary material.

While all of the materials needed to do the activities are present within this package (assuming some photocopying), all of the images and data are available over the Internet at **(http://www-ssi.colorado.edu/Education/ResourcesForEducators/1.html**. If students are using the Internet, we recommend that they be allowed extra time at the end of the last activity to gather additional information about the Sun (such as current images of the Sun), starting with the links at the Space Science Institute's home page. They should use this information to write a report on the Sun that could be part of their portfolio (especially for students who contract for a better grade), or a separate assignment. Using the Internet to access the images and additional information will

increase the time needed to complete *Solarscapes*, but it will provide students with the opportunity to utilize technology and gain experience with accessing information over the Internet.

Goals for and Assessment of Student Learning

Solarscapes has two clear and assessable goals. These are:

Goal 1 - Students will learn that the Sun has many features, including sunspots, and that sunspots vary over time in a regular and somewhat predictable fashion (the sunspot cycle).

Goal 2 - Students will learn that the Sun rotates and with what rotation period.

We view good instruction and good assessment to be indistinguishable. Thus, in all lessons there is an assessment of student understanding. Rubrics are provided with each lesson to guide the teacher in assessing students. Students should be informed of the rubrics for scoring each lesson at the start of the lesson. All students should also keep a portfolio of all of the material, observations and analysis done in these activities. Portfolios may be judged at the end of the activities by the rubric below:

Portfolio rubric (satisfactory = 2)

0 - Student does not keep portfolio.
1 - Portfolio contains most handouts, images, data, and tables.
2 - Portfolio contains almost all handouts, images, data, and tables, plus observations, and other requested materials (indications of prior knowledge, what was learned in an activity, etc.).

Students could also be allowed the option to contract for a grade based upon their portfolio and successful achievement of the lesson assessments. Better grades could be secured by keeping a more detailed notebook that would include additional writing assignments according to the discussions with the teacher, perhaps in conjunction with a teacher from a different subject area.

Lesson Structure

Each lesson has a specific stated goal. The lesson goals are articulated to lead to the two main goals of the unit. In fact, the end of unit goals were developed first, then these were backmapped to determine what knowledge and skills students would need to achieve the goals. Then the experiences students need to acquire the knowledge determined the lessons. These lessons were trial taught by one of the authors.

The lessons have been constructed on a learning cycle model. For our purposes we define the phases of the learning cycle to be:

1. DISCUSS: (get out prior knowledge, set up activity/lesson)

2. EXPLORE: (do activity)

3. REFLECT: (look back at activity, analyze and discuss, etc.)

4. APPLY: (come to conclusions, communicate to others, identify next steps that lead to next Discuss phase).

Each phase is explicitly discussed in a lesson. The learning cycle concept is also in play over the entire unit. This material is contained in the section for the teacher. Following that is a reading for students, and a student worksheet containing directions for the activity.

Connections to Science Standards

The design of this mini-unit has been guided by the various standards documents - National Science Education Standards, Benchmarks for Science Literacy, and the National Council of Mathematics Standards. In this section we will present a brief overview of the correspondences between the activities and the standards.

National Science Education Standards:

Solarscapes is only a one-to two-week long extension to a regular Earth-space curriculum. Thus, Program and System Standards are not within its purview. Professional development is also not addressed except as implied in the statement of philosophy above. Beginning with the Teaching Standards we find that the unit is aligned with standards A-E, such as "Select teaching assessment strategies that support the development of student understanding..." (A) and "Nurture collaboration among students" (E). Standard F is not addressed. Similar correspondence can be found with the Assessment Standards, since the material uses assessments that "...are deliberately assigned" (A), that "..focus on the science content that is most important for students to learn" (B), and that "assessment tasks are authentic" (C).

In the Content Standards, Science as Inquiry is addressed since every standard referred to on page 145 can be seen in some fashion in *Solarscapes*. In the Earth and Space Science Standard we find that students should know that "Most objects in the solar system are in regular and predictable motion..." By studying solar rotation (and perhaps the rotation of other bodies) students will address this issue. They will also learn that the Sun is a variable star, an important aspect when one considers that students are to understand that "Energy from the Sun transferred by light and other radiation is the primary energy source" for Earth.

In terms of the three remaining Content Standards (Science and Technology, Science in Personal and Social Perspectives, and History and Nature of Science) there is some (but not great) alignment. The weakest is with Science and Technology, since there is little in the way of technological design in this unit. If the unit is done over the Internet there may be a greater, though indirect, connection to technology. There is a somewhat greater relationship to the last two Content Standards through the discussion of the effect of solar variability on climate and the history of sunspot observations that is found in the student readings.

Benchmarks for Science Literacy:

There are a number of places in which *Solarscapes* addresses the Benchmarks. Let us begin with those areas that are common to science generally. Examples range from 1C (p.17), addressed by the student reading of the Chinese discovery of sunspots and their ancient records, 3A (p.46) where it is clear that "Technology is essential to science for such purposes as access to outer space...", and 11C (p.274) where student probing of the sunspot cycle through graphical analysis shows that "things that change in cycles, such as seasons or body temperature, can be described by their cycle length or frequency."

There are specific relationships to the content of *Solarscapes*, such as 10A (p.240) where students are to learn that "Telescopes reveal that…the sun has dark spots…" In addition, these materials provide a vehicle for discussions that relate to content not further pursued in *Solarscapes* due to its scope. For example, the rotational motion of bodies in the solar system can become a forum for discussing that "In the absence of retarding forces…an object will keep its direction of motion and speed." 4F(p.90).

To summarize, Solarscapes is aligned with these Benchmarks for grades 6 through 8:

- 3 A #2
- 2 A #1, #2
- 10 A #3
- 11 B #3
- 11 C #6