GENESIS SEARCH FOR ORIGINS **Education**

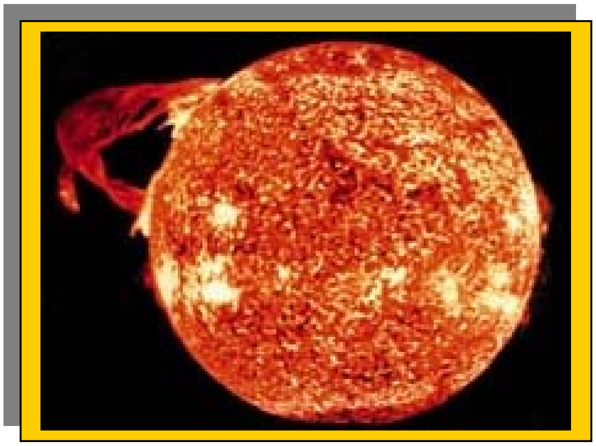
Science Modules

This science module focuses on the role of model development in scientific inquiry and on the technology underlying the formulation of the Standard Solar Model. If you're using Genesis science modules for the first time, read the User's Guide thoroughly before you begin. (*View User's Guide as PDF*.)

The following classroom materials are available in Portable Document Format (PDF) for your browsing and printing convenience. The files are print-optimized, and should be printed to achieve maximum resolution. Adobe's new Acrobat Reader 4.0 is required to view and/or print. To install the FREE reader, visit the Adobe Web site.

Take a look at other science modules that are available. All technical terms in the science modules are compiled in the Glossary for easy access.

Technology Applications are available for this module.



Cosmic Chemistry: The Sun & Solar Wind

Which came first, the model or the technology?

The goal of this education module is to help students understand how the development of the Standard Solar Model has been limited by available analytical instrumentation and technology. However, refinements of the model have played crucial roles in the design of more advanced instrumentation and technology, such as will be used in the Genesis project, which is designed to help scientists determine how our solar system began and evolved.

During the initial exploration, students will examine the Standard Solar Model, based on data from past investigations, using then-current technology. In the final activity, students will develop a model that could account for the presence of heavy elements that are not predicted by the Standard Solar Model.

Instructional materials for this phase are incorporated in the Exploration activities below.

Briefing

During the Apollo program, a series of solar wind experiments were conducted on the surface of the moon. For three days, a flag-sized sheet of aluminum foil collected solar particles. When neon and helium isotopes were analyzed in the Apollo samples, it was observed that the ratios of these isotopes were different from those ratios observed on Earth. This confirmed the need for more extensive sampling and analysis of the solar wind.

Genesis will continue solar wind experimentation where Apollo left off. It will obtain the first extraterrestrial samples since Apollo and bring it back to Earth for analysis. Plans are being made to analyze these data for the presence of every element from lithium to uranium, including all the isotopes along the way.

Even as the Genesis mission is launched, researchers will be invited to propose *advanced new instrumentation* to study the solar wind samples. When these analyses are complete, they will be a factor in the interpretation of a wide variety of space phenomena, resulting in a more thorough understanding of the composition of the original solar nebula. It is inevitable that the Genesis data from the solar wind will result in either improvement in the current model of the sun's composition or the design of new models.

The Invisible Sun: How Hot Is It?
- Teacher Guide

The Invisible Fire
- Student Activity
- Student Text

Models in Science
- Student Text
- PowerPoint Presentation
- PowerPoint as PDF

Exploration

In the activities of this module on the sun and solar wind, the teacher's primary instructional role is Socratic. Through effective questioning, students should be made aware of the relationship between what scientists observe and the models they used to explain that information.

The Student Activity, "The Invisible Fire," can be used to introduce students not only to the Standard Solar Model, but also to some of the history and technology involved in the design of the model. This awareness will grow as they are involved in modeling the fusion reaction thought to occur in the core of the sun.

During the activity, students should be guided to an understanding of the following characteristics of scientific models:

- Models corresponding to real events and objects help scientists understand and explain how things work. These explanations also generate logic-based models through the incorporation of new findings.
- A good model is based on knowledge—and knowledge is achieved through scientific inquiry and observation using available instrumentation. The development of new and better models often depends upon the development of new and better technological instrumentation. But the reverse often occurs.

Curriculum Connections
National Standards Addressed

Grades 5-8

Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Physical Science
- Properties and changes of properties in matter
- Transfer of Energy

Earth and Space Science
- Structure of the Earth System
- Earth's history
- Earth in the Solar System

Science and Technology
- Abilities of Technological Design
- Understandings about Science and Technology

History and Nature of Science
- Science as a Human Endeavor
- Nature of Science
- History of Science

Student Mission

Students will explore various aspects of the Standard Solar Model and gain an appreciation for the interrelationship between what scientists learned from empirical observation and the development of that model.

Photons in the Radiative Zone: Which Way is Out? An A-Maz-ing Model
- Teacher Guide
- Student Activity
- Student Text

Development

Use the Student Activity, "Photons in the Radiative Zone: Which Way is Out?" to create interest in learning more about the Standard Solar Model. The activity starts with students simulating photons finding their way out of a circular maze, which models what we think happens in the sun's radiative zone.

The activities focused on electromagnetic radiation and solar wind, both of which affect the Earth and the rest of the solar system, will correlate the Standard Solar Model with energy and matter leaving the sun.

MASS MASS – Who has the MASS? Analyzing Tiny Samples
- Teacher Guide
- Student Activity

Analyzing Tiny Samples Using Mass Spectrometry
- Teacher Guide
- Student Activity

The Solar Wind
- Student Text

Here Comes the Light!
- Teacher Guide
- Student Activity

Electromagnetic Radiation
- Student Text

The Fraunhofer Lines
- Student Text

Interaction/Synthesis

Students interact with peers to accomplish the tasks assigned in the Exploration and Development sections above. Each activity contains group work, with the whole class participating in preliminary and summary discussions.

Where Did This Come From? Where Does It Fit?
- Teacher Guide
- Student Activity

Assessment

Students should be able to use their direct observations and/or data from other sources to decide whether or not the Standard Solar Model completely accounts for observations that do not appear explicitly in the model. If they decide that the current model is not adequate, they will then be challenged to supplement the model to include the observations and/or data presented.

TEACHER RESOURCES

View a listing of additional resources that includes URLs, books, and periodicals.

This education module, *Cosmic Chemistry: The Sun & Solar Wind*, was developed by educators at Mid-continent Research for Education and Learning.

McREL

Writers: Dr. Donna Bogner, McREL
Dr. B. J. McCormick, Science Consultant
Dr. L. Raymond Fox, Science Consultant

Graphics created by:
Judy Schlecte, McREL
Dawn McGill, McREL

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Dr. Marcia Neugebauer, Jet Propulsion Laboratory
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