The Sun and Solar Wind: A Search for the Beginning

The Invisible Sun: How Hot Is It?

TEACHER GUIDE

BACKGROUND INFORMATION

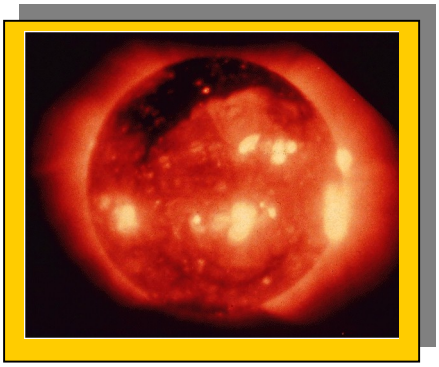


Image courtesy of NASA

In this introductory activity, students will “model the model” of nuclear fusion in the core of the sun. Items for classroom discussion focus on the current Standard Solar Model, the observational instrumentation and data that formed the basis for the model, and on the necessity for further scientific studies of the sun and solar wind. “The Nuclear Fire of the Sun,” (Appendix A), and "The Structured Sun," (Appendix C), contain further background and trace historical scientific studies of the sun. "Mass Spectrometry: A Historic Technique for Analysis of Great Importance to Genesis," (Appendix B), also introduces present ideas regarding the nuclear processes in the solar core. The material in these appendices may either be copied for student use or incorporated in the background that you give your students during classroom discussions.

STANDARDS ADDRESSED

Grades 5-8
Science
Science As Inquiry
- Understandings about scientific inquiry

Science and Technology
- Understandings about science and technology

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

History and Nature of Science
- Science as a human endeavor
- Nature of science and scientific knowledge
- History of science and historical perspectives

Grades 9-12
Science
Science As Inquiry
- Understandings about scientific inquiry

Science and Technology
- Understandings about science and technology

Earth and Space Science
- The origin and evolution of the Earth system
- The origin and evolution of the universe

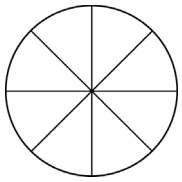
Physical Science
- Properties and changes of properties in matter
- Transfer of energy

History and Nature of Science
- Science as a human endeavor
- Nature of science and scientific knowledge
- History of science and historical perspectives

MATERIALS

For each class:

2 plastic, inflatable mini-basketballs; 1 for the "target," 1 for the "bullet."
(Those that are 11 cm in diameter are best.)
Velcro® strips (2 cm wide)—enough to divide the surface of the balls into 8 zones like the one shown in the illustration.
Length of string to suspend the "target" ball.
Glue to attach Velcro® strips to the balls. (SuperGlue® is best.)
1 or 2 blindfolds.



For each student:

Copy of Student Activity "The Invisible Fire"
Copy of "Standard Model of the Sun"
Copy of Student Text "The Invisible Fire"
Copy of Student Text "Models in Science"

Procedure

1. Before class make copies of the following handouts:
   Student Activity, "The Invisible Fire"
   Handout "Standard Model of the Sun"
   Student Text, "The Invisible Fire"
   Student Text "Models in Science"

2. Use a length of string to suspend the "target" ball from the ceiling so that it hangs at about shoulder height of your students. Using masking tape, mark off a "firing" line no closer than 1m from the suspended ball. The distance from the ball will be determined by the age of your students. It should be far enough from the target to make hitting the target a challenge, yet close enough to make hitting the target possible.

3. Prepare slips of paper with numbers from 1 to 5 (or as many teams as you will have in your class) for the drawing to determine the order in which teams will complete the activity assignment.

4. Divide the class into teams of no more than four students. Have each team elect a team captain and a "recorder."

5. Have the team captains draw to determine the order of completion of the activity assignment.

6. Hand a copy of the Student Activity "The Invisible Fire" to each student.

   Teams should follow the instructions at the top of the page. As a team, they will complete the assignment in the order of the drawing numbers.

   The "recorders" should record:
   a) the number of "hits", "misses", and "sticks" for the team; and,
   b) any verbal instructions or comments that team members make as they complete the assignment.

7. When all teams have completed the assignment, call the class back together. Have each team report their results and their observations, the techniques or methods used to get more "hits" and about the successes and difficulties encountered during the assignment.

8. Hand out copies of the following for students to read before the next class period:
   Handout "Standard Model of the Sun"
   Student Text "The Invisible Fire"
   Student Text "Models in Science"

9. Start the next period's class discussion on models with an introduction that includes the following points:
   a) What you were doing in yesterday's activity was actually modeling the first step of the fusion process which, according to the Standard Solar Model, occurs in the core of the sun.
   b) We must always remember that models are not the real things; otherwise, they wouldn't be models. That is true for scientific models as well as for other types of models. Models always have flaws: oversimplifications that are different from the actual phenomenon or structure that they are modeling. That is the reason we sometimes need more than one model for one natural occurrence or structure. [*See the handout, "Models in Science."*] Scientists and science students always must be aware of the ways in which models are like the real thing and ways in which they are different.

   Follow this introduction with questions similar to the following:

   1. How is the model similar to or different from the "real" thing according to the Standard Solar Model?
      a) What are the characteristics of a good scientific model?
      b) What is the purpose of a scientific model?
      c) In the fusion reaction that you modeled in the assignment:
         i. What did the "target" ball represent?
         ii. What did the "bullet" balls represent?
         iii. What was the significance of the fact that the "target" and "bullet" balls were alike? How is this similar to or different from the "real" thing according to the Standard Solar Model?
         iv. What was the significance of the fact that you were blindfolded during the second try?
         v. What was the significance of the number of "hits" and "misses" that you recorded? How is this similar to or different from the "real" thing?
         vi. Critique this model of the sun's fusion process. Was it a good model, an adequate model, or a poor model? Defend your rating of the model.
      d) Based on the students' critique of the model, devise a list of criteria for a good model of proton-proton fusion in the sun's core.

   2. What role did technological instrumentation play in obtaining the data used as the basis for the processes in the sun's core?

   3. What processes of scientific inquiry did scientists use to design the Standard Solar Model? What happens when new information, observations, or data show the model to be incorrect or to not adequately represent a time of known occurrences?

   4. How did scientists use their understanding of the relationship between science and technology to improve the design of the Standard Solar Model?

   5. Divide the class into teams of four to design another, perhaps better, model for the nuclear processes that are occurring in the sun's core after re-reading the Student Texts "Models in Science" and "The Invisible Fire."

   6. Have each team make an illustrated oral presentation of their model. The presentations can be evaluated either by other class members or by you, using the criteria developed by the class. (See the Informative Speaking section of the Creator's Kitchen for additional tips.)

TEACHER RESOURCES

NEUTRINOS:

http://www.ps.uci.edu/~superk/oscillation.html
A Web site on the weird nature of neutrinos.

http://www.ps.uci.edu/~superk/glossary.html
A Web site on neutrinos.

THE SUN:

http://www.agu.org/revgeophys/ogilvi00/node3.html
A Web site about solar composition.

http://seds.lpl.arizona.edu/nineplanets/nineplanets/sol.html
This Web site offers information about the sun.

http://www.sel.noaa.gov/solar_images/ImageIndex.cgi
A Web site that tracks sun spots.

http://sohowww.estec.esa.nl/
NASA's solar and heliospheric observatory (SOHO).