SUGGESTED REFERENCES

- *Sun, Earth and Sky by Kenneth Lang*
  http://Space.com
- *Trace website*
  http://vestige.lmsal.com/TRACE/
- *SOHO website*
  http://sohowww.nascom.nasa.gov/
- *Super-Kamiokande website*
  http://www.phys.washington.edu/~superk/
- *New neutrino detector*
  http://amanda.uci.edu/
- *Sun structure, details site*
  http://solar-heliospheric.engin.umich.edu/hjenning/Sun.html

NATIONAL SCIENCE EDUCATION STANDARDS

5 - 8

Physical Science
Transfer of energy

Science in Personal and Social Perspectives
Natural Hazards

9 - 12

Physical Science
Interactions of Energy and Matter

Earth and Space Science
Origin and Evolution of the Universe

**Source: National Science Education Standards, 1996, National Academy Press*

CREDITS

The producers thank Australian Broadcasting Corporation, Content Sales, for materials used in this program.

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VOLUME 34 ISSUE 6

A SCIENTIFIC LOOK AT THE SUN

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SYNOPSIS

Day after day the sun shines in the sky, one of the constants in our lives. But, we know that the sun has a life of its own and someday, like a living organism, it will die as well. Scientists can predict what the end of the sun's life will be like, and that it will happen billions of years in the future.

Scientists predict that the sun carries out nuclear fusion, but until recently the evidence has been indirect. They have developed a model of the structure of the sun and with new spacecraft like SOHO, we can test the model and confirm the actual structure. These theories and others are addressed in this edition of SCIENCE SCREEN REPORT.

CURRICULUM UNITS	RUNNING TIME
■ ASTRONOMY	18:33
■ PHYSICS	
■ EARTH SCIENCE	
■ INTEGRATED SCIENCE	

BACKGROUND

The program shows how a supernova could have caused the formation of the solar system. An animation details how the shockwave from a supernova compresses a region of space containing a cloud of gas and dust. Gravity compresses matter at the center causing some nuclear fusion to occur. The force of nuclear fusion begins to resist the pressure of gravity to compress the matter. The sun contracts until the forces are equal.

Einstein taught us how fusion occurs. His formula, $e = mc^2$, showed that as matter was converted from one form to another there is a small loss of mass. That mass is converted into energy and is released by the sun. An animation of nuclear fusion is shown in the program. Fusion results in the formation of helium, electromagnetic radiation and neutrinos. The neutrinos are released by the sun and travel into space. Nuclear fusion produces millions of neutrinos.

Detecting neutrinos proves that nuclear fusion occurs. Neutrinos were first detected in the 1950's, but only recently have we built devices to try and measure the number of neutrinos. Super Kamiokande is a neutrino detector in Japan. It is filled with pure water. Light sensors line the tank. When a neutrino interacts with an atom, a photon of light is produced. To count neutrinos, count the number of light flashes.

The sun is composed of a core, where nuclear fusion takes place, and two shells, the radiative zone and the convective zone. Outside the convective zone is the photosphere of the sun. Beyond the photosphere is the corona. Scientists cannot look directly inside the sun to determine its structure, but we can use indirect methods to see what is happening and be reasonably certain about our model of its structure.

The photosphere constantly oscillates. Sound waves from the convective zone cause this movement. The matter in the radiative zone heats the gases in the convective zone. At the boundary, gases are heated and rise up to the top of the convective zone and release their energy. They cool and fall back down. This churning gas produces a loud sound.

SOHO "listens" to the sounds of the sun by looking at the oscillations of the photosphere. As sound waves move material away from earth, the sun's light shifts to the red end of the spectrum. Nearer to the earth, the light shifts towards the violet end of the spectrum.

The sun will die when it runs out of hydrogen gas. It will grow brighter as more helium accumulates in its core. Eventually, it will become almost 2,000 times brighter than it is today. Even though the amount of hydrogen is decreasing, the sun must keep producing enough pressure to keep gravity from collapsing the core. The only way to do this is for the sun to burn hotter. The hotter the sun, the brighter it shines.

As the last of the sun's core burns, the star will swell. Gravity will crush the helium atoms so that they ignite. At 100 million degrees Celsius, the helium atoms will undergo nuclear fusion and form carbon and oxygen. The sun will become a white dwarf.

ADVANCED ORGANIZERS

Prior to viewing this video, students should have some understanding of the following Benchmarks* for Science Literacy, Oxford University Press which are excerpted and, in some cases, abbreviated below. Refer to the Benchmarks for more information.

Benchmark 4: The physical setting

Section A - The universe

Know by Grade 8

- The sun is a medium-sized star located near the edge of a disk-shaped galaxy of stars, part of which can be seen as a glowing band of light that spans the sky on a very clear night. The universe contains many billions of galaxies, and each galaxy contains many billions of stars. To the naked eye, even the closest of these galaxies is no more than a dim, fuzzy spot.
- The sun is many thousands of times closer to the earth than any other star. Light from the sun takes a few minutes to reach the earth, but light from the next nearest star takes a few years to arrive.

Know by Grade 12

- Stars condensed by gravity out of clouds of molecules of the lightest elements until nuclear fusion of the light elements into heavier ones began to occur. Fusion released great amounts of energy over millions of years. Eventually, some stars exploded, producing clouds of heavy elements from which other stars and planets could later condense. The process of star formation and destruction continues.

Section E - Energy Transformations

Know by Grade 8

- Most of what goes on in the universe-from exploding stars and biological growth to the operation of machines and the motion of people-involves some form of energy being transformed into another. Energy in the form of heat is almost always one of the products of an energy transformation.
- Heat can be transferred through materials by the collisions of atoms or across space by radiation. If the material is fluid, currents will be set up in it that aid the transfer of heat.

Know by Grade 12

- Energy is released whenever the nuclei of very heavy atoms, such as uranium or plutonium, split into middleweight ones, or when very light nuclei, such as those of hydrogen and helium, combine into heavier ones. The energy released in each nuclear reaction is very much greater than the energy given off in each chemical reaction.

**Benchmarks can be found at www.project2061.org/tools/benchol/bolintro.htm*

CRITICAL THINKING EXERCISES

1. Draw a model of the structure of the sun.
2. Explain the process of nuclear fusion of hydrogen to helium.
3. Describe how scientists can determine the structure of the sun without being able to look inside it.
4. Explain how scientists know that the sun is a second-generation star. List evidence that supports this finding.
5. Design an experiment to identify the elements present in a light source. Use fluorescent light, incandescent light and sunlight.
6. Describe how sunspots form.

VOCABULARY

Absorption lines
Convective zone
Core
Mass spectrometer
Neutrino
Nuclear fusion
Photosphere
Radiative zone
ROY G BIV
Solar flares
Solar storm
Sunspots
Supernova
White dwarf

CAREER POSSIBILITIES

- ASTRONOMER
- PHYSICIST
- SOFTWARE ENGINEER
- MECHANICAL ENGINEER