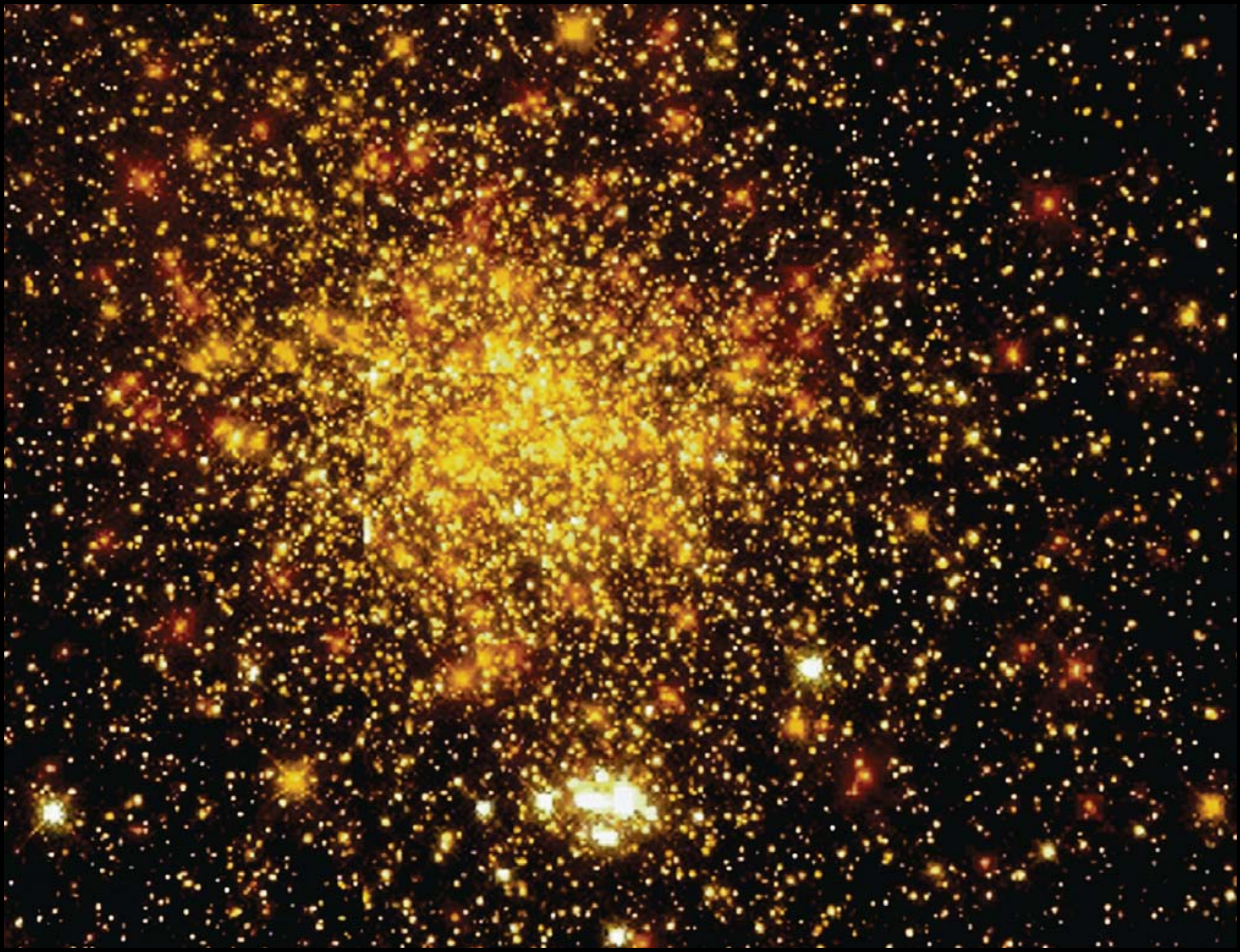
Cambridge Core Science Series: Space Science

THE SUN AND STARS



Cambridge Educational

Teacher's Guide

Introduction

This Teacher's Guide provides information to help you get the most out of the *The Sun and Stars,* the second title in Cambridge Educational's eight-part *Space Science* series. The guide will allow you to prepare your students before viewing the program and to present follow-up activities to reinforce the program's key learning points.

The Sun and Stars presents an overview of the origin, life cycles, and characteristics of stars. It also addresses our sun's past and future, and its importance to Earth. This program builds upon the first segment of the series, *The Planets*, which was an overview of the major planetary bodies in our solar system.

The *Space Science* video program series consists of eight titles:

- The Planets
- The Sun and Stars
- Just How Big Is Space?
- The Invisible Universe
- Black Holes, Pulsars, and Other Odd Bodies
- Yesterday the Moon, Tomorrow Mars?
- Living in Space
- Is Anybody Out There?

Learning Objectives

After viewing the program, students will be able to:

- Explain the life cycles of stars
- Describe the types of stars and their relative sizes
- Identify the components of the sun
- Describe the importance of the sun to the Earth
- Explain the past and future of the sun and how its future will impact the Earth

Educational Standards

This program series correlates with the National Science Education Standards for grades 9-12. The content of this program has been aligned with the following educational standards from this publication:

Science as Inquiry Standards

CONTENT STANDARD A: As a result of activities in grades 9-12, all students should:

- Develop an understanding of scientific concepts
- Understand and appreciate "how we know" what we know in science
- Understand the nature of science
- Develop the skills necessary to become independent inquirers about the natural world
- Develop the dispositions to use the skills, abilities, and attitudes associated with science

History and the Nature of Science Standards

CONTENT STANDARD G: As a result of activities in grades 9-12, all students should:

- Develop understanding of science as a human endeavor
- Develop understanding of the history of science
- Develop an understanding of the nature of scientific knowledge

The National Science Educational Standards reprinted with permission of the National Committee on Science Education Standards and Assessment, National Research Council.

English Language Arts Standards

The activities in this Teacher's Guide were created in compliance with the National Standards for the English Language Arts from the National Council of Teachers of English.

- Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes.
- Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and non-print texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience.
- Students use a variety of technological and information resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.

This program series also coordinates with the following *Benchmarks for Science Literacy* by the American Association for the Advancement of Science for grades 9 through 12:

The Scientific World View

By the end of the 12th grade, students should know that:

- Scientists assume that the universe is a vast single system in which the basic rules are the same everywhere. The rules may range from very simple to extremely complex, but scientists operate on the belief that the rules can be discovered by careful, systematic study.
- From time to time, major shifts occur in the scientific view of how the world works. More often, however, the changes that take place in the body of scientific knowledge are small modifications of prior knowledge. Change and continuity are persistent features of science.
- No matter how well one theory fits observations, a new theory might fit them just as well or better, or might fit a wider range of observations. In science, the testing, revising, and occasional discarding of theories, new and old, never ends. This ongoing process leads to an increasingly better understanding of how things work in the world but not to absolute truth. Evidence for the value of this approach is given by the improving ability of scientists to offer reliable explanations and make accurate predictions.

Scientific Inquiry

By the end of the 12th grade, students should know that:

- Investigations are conducted for different reasons, including to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories.
- Hypotheses are widely used in science for choosing what data to pay attention to and what additional data to seek, and for guiding the interpretation of the data (both new and previously available).

- Sometimes, scientists can control conditions in order to obtain evidence. When that is not possible for practical or ethical reasons, they try to observe as wide a range of natural occurrences as possible to be able to discern patterns.
- There are different traditions in science about what is investigated and how, but they all have in common certain basic beliefs about the value of evidence, logic, and good arguments. And there is agreement that progress in all fields of science depends on intelligence, hard work, imagination, and even chance.
- Scientists in any one research group tend to see things alike, so even groups of scientists may have trouble being entirely objective about their methods and findings. For that reason, scientific teams are expected to seek out the possible sources of bias in the design of their investigations and in their data analysis. Checking each other's results and explanations helps, but that is no guarantee against bias.
- In the short run, new ideas that do not mesh well with mainstream ideas in science often encounter vigorous criticism. In the long run, theories are judged by how they fit with other theories, the range of observations they explain, how well they explain observations, and how effective they are in predicting new findings.
- New ideas in science are limited by the context in which they are conceived; are often rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly, through contributions from many investigators.

Program Overview

The Sun and Stars explains the life cycles of stars and discusses the various types of stars found in the universe. The program provides details about the origins of stars, their relative sizes, and their physical characteristics. The program also focuses on our sun, its significance to Earth, its physical characteristics, and its past and future.

Main Topics

Topic 1: What Do We Know About Stars?
Approximately 5,000 stars can be viewed from Earth with the naked eye. With the aid of telescopes, the number of stars and galaxies we can see is nearly limitless.

Topic 2: Life Cycles of Stars
All stars are formed from interstellar clouds of dust and gas called “nebulae.” The nature of gas is to expand, but if the cloud contains sufficient matter, the force of gravity will cause it to contract into clumps called “proto-stars.” A star is born when the pressure and temperature in its core increase sufficiently to trigger a nuclear reaction. Each star has a life cycle, but its life cycle is different depending on its mass. Stars in the most stable part of their existence are called “main sequence stars.” After its main sequence phase, the sun will expand into a red giant, then contract into a white dwarf. Stars with significantly more mass will become red super-giants, then explode in a supernova, and then become either neutron stars or black holes.

Topic 3: Classifying Stars
Stars can be classified according to their color and spectrum. Color indicates temperature. A spectrum is simply a star's light broken into its component colors. From its spectrum, astronomers can gather a lot of information about a star's size, mass, what it's made of, its structure, and many other things.

Topic 4: What Do We Know About the Sun?
The sun is by far the largest body in our solar system, accounting for 99.8% of the solar system's total mass. The sun's gravitational pull keeps all the planets, their moons, the asteroids, and comets in their orbits. Like most stars, the sun is powered by hydrogen fusion at its core.

The surface of the sun is called the "photosphere," and its "chromosphere" lies just above the photosphere. The hottest part of the sun that we can see is its corona, a halo of million-degree gas that stretches millions of miles into space. The solar wind is an extension of the corona. CMEs, or coronal mass ejections, spew hydrogen into the solar system and can cause significant damage to satellites and communication systems here on Earth. Sunspots are places where the sun's surface, or photosphere, gets warped by its magnetic field.

Topic 5: The Sun's Importance to Earth
Life on Earth could not exist without the sun. Plants use the sun's energy to make food, and in the process, give off the oxygen humans and other animals breathe. Plants also provide food for other organisms. The sun is responsible for Earth's weather patterns. A number of different space missions are under way to collect data about the sun.

Topic 6: The Sun's Past and Future
Our sun was formed about 4.5 billion years ago. As it continues through its main sequence phase it will get hotter. In fact, the sun will likely be hot enough to boil away the Earth's oceans in approximately 3 billion years. In 7 billion years it will have used up its hydrogen supply and will grow into a red giant. At 8 billion years, it will collapse into a white dwarf.

Fast Facts

- Luminosity is the intrinsic brightness of a star—as it would appear if you were orbiting it. Luminosity is measured in solar units. The sun's luminosity is 1 solar unit. Sirius has a luminosity of 23, and Betelgeuse, 55,000. The Pistol star, possibly the brightest star yet discovered, is a million times more luminous than the sun.

- The sun is the largest object in our solar system. It contains 99.8% of the system's total mass.

- The smallest mass needed to form a main sequence star is about 8% percent that of our sun, or 80 times the mass of the planet Jupiter.

- The sun's surface, or photosphere, is about 10,000°F, while its core temperature is 27 million degrees.

- It takes about a million years for energy released at the center of the sun to make its way to the surface.

- After the sun, the next closest star is Proxima Centauri, 4.3 lightyears from Earth.

- The sun currently consists of 70% hydrogen and 28% helium by mass. As it ages, its hydrogen content will diminish and its helium content will increase.

- When a star like our sun runs out of hydrogen to fuel fusion reactions in its core, it becomes a red giant.

- Giant and super-giant stars, with a mass at least 8 to 100 times greater than the sun's, will eventually become black holes or neutron stars.

- Proto-star, main sequence, red giant, white dwarf, neutron star, and black hole are all stages in the life cycle of a star—but not all stars will go through all these phases. A star's life cycle is determined primarily by its mass.

- The sun is multilayered, with a core, photosphere, chromosphere, corona, and solar wind.

- The sun's gravitational pull keeps the planets, their moons, comets, asteroids and other objects in our solar system in their respective orbits.

Vocabulary

corona: The outermost region of the solar atmosphere that extends millions of miles out into space. At one million degrees Fahrenheit, the corona is the hottest part of the sun that we can see.

coronal mass ejections: The sun ejects billions of tons of hydrogen gas, called "coronal mass ejections," or CMEs, that travel millions of miles per hour throughout the solar system.

galaxy: A large collection of stars held together by gravity. The Milky Way galaxy is composed of more than 200 billion stars.

hydrogen fusion: Hydrogen is converted to helium, releasing energy in the process. The hydrogen fusion cycle is the source of the sun's energy.

magnetosphere: An invisible magnetic field that surrounds and protects the Earth from much of the sun's harmful radiation.

proto-star: A dense clump of gas and dust within a stellar nebula. A proto-star will become a main sequence star when pressure at its core becomes sufficient to ignite hydrogen fusion.

radiation: Energy of various wavelengths and frequencies. The electromagnetic spectrum is a way of describing radiation of various energies, wavelengths, and frequencies.

red giant: A star approaching the end of its life. The hydrogen fuel in its core has been depleted, and there is no longer enough energy and pressure from hydrogen burning to support the outer layers of the star. As the star collapses, the pressure and temperature rise until helium burning begins. The star expands into a red giant to radiate the energy produced by the helium burning.

solar wind: A steady breeze from the sun that acts like a conveyor belt to bring space weather to the Earth and other planets in the solar system.

sunspots: Cooler areas on the surface of the sun where the sun's magnetic field exits the solar surface.

ultraviolet light: Invisible energy that falls between visible light and X-ray radiation on the electromagnetic spectrum. The ultraviolet radiation that reaches the Earth causes tans and sunburns, but the atmosphere blocks most ultraviolet light from reaching Earth's surface.

Pre-Program Discussion Questions

1. How did some early civilizations regard the sun?
2. How many stars do you think there are in our Milky Way Galaxy? In the universe? How did you arrive at this number?
3. The sun is necessary to sustain life on Earth. Do you think there are other solar systems somewhere in our galaxy with life-sustaining planets like the Earth? Explain your answer.
4. We know that energy from the sun is essential for life on Earth, but the sun produces harmful effects as well. What are they?
5. How long do you think our sun will continue to shine? What do you think sustains it?
6. What will happen to the sun in the far distant future? What will happen to Earth? How about the other planetary bodies in the solar system?

Post-Program Discussion Questions

1. How are stars formed?
2. What did you learn about the sun and other stars that surprised you?
3. How does the life cycle of a giant or super-giant star differ from that of our sun?
4. The Earth is expected to remain hospitable for the next 500 million years. How will the sun's life cycle affect conditions here on Earth?
5. Of what importance is sunspot activity to Earth?
6. What are CMEs, and why are they of concern to us?

Group Activities

From Time to Time

Ask students to divide into groups, with each group representing an early culture (such as the ancient Mayans, Egyptians, Greeks, etc.). Have each group explain their culture's views of the stars and sun, and how those views have been carried forward into the modern era. Students should address similarities and differences between the various cultures.

Lifecycles

Stars like the sun have distinct life cycle stages. Divide students into four groups and assign them each a stage to research. Have each group present their assigned life cycle stage, including a discussion of its relevance or significance to Earth, to life as we know it, and to the other planetary bodies in our solar system.

Individual Student Projects

The Mother of Invention
Ask students to "invent" a new tool to study the stars or the sun. Have the student explain the purpose of the tool, how it would be used, and what it would be used to discover or describe.

Around the World
While many of us are familiar with the role and projects of NASA (National Aeronautics and Space Administration), other nations around the world do space-related research and projects, too. Have students research the work being done by other countries and report back on how those efforts complement or diverge from U.S. efforts.

Internet Activities

My Night Sky
In March 2006, students and teachers world-wide participated in a project called The Globe at Night, designed to measure light pollution by observing the magnitude of visible stars. Students logged their observations of the skies where they live in to a database at www.globe.gov/GaN. Have students visit this and other Web sites to learn about the magnitude scale of stars. Students should then write a brief paper on light pollution and the magnitude scale. With parental supervision, students may also observe and record which stars and constellations are visible from where they live—and then compare their results with those of their classmates.

The History of Space
Have students write a report on the the history of astronomy, using information from Web sites such as www.mhhe.com/physsci/astronomy/arny/student/timeline.mhtml. When did people around the world first start keeping track of solstices and eclipses? How did they do this? How accurate were the observations of ancient Greek, Chinese, and Mesoamerican astronomers? Discuss the experience of pioneers such as Galileo and Copernicus.

Assessment Questions

Q1: True or False: Stars are formed from gas and dust.
A: True
Feedback: Stars form in giant, swirling clouds of gas and dust called nebulae. The force of gravity causes the gas to shrink and clump together to form proto-stars. Temperature and pressure at the core of the proto-star increases until hydrogen fusion is triggered and a main sequence star is born.

Q2: How many stars can be seen from Earth without a telescope?

a) 1,000
b) 5,000
c) 500,000
d) 1,000,000

A: b.
Feedback: On a clear night without the aid of a telescope, we can see about 5,000 stars. With a telescope, stars and galaxies full of stars go on in every direction as far as we can see—almost 14 billion lightyears.

Q3: Which of the following is a stage in the life cycle of a star?

a) proto-star
b) main sequence
c) neutral sequence
d) black phase

A: b.

Feedback: "Main sequence" is the most stable stage in the life cycle of a star. Other life cycle stages include proto-star, red giant, white dwarf, neutron star, and black hole.

Q4: Approximately how many white dwarf stars have been identified?

a) 1,000
b) 5,000
c) 500
d) 100

A: c.

Feedback: About 500 white dwarfs have been identified; two of the 20 stars closest to Earth are of this type. White dwarfs are extremely dense. One teaspoon of the matter from a white dwarf star would weigh about 900 metric tons.

Q5: True or False: The sun contains 90% of all matter in the universe.

A: False

Feedback: The sun is the largest body in the solar system, and includes 99.8% of the matter within the solar system.

Q6: True or False: The sun's photosphere is 250 kilometers deep, and registers about 10,000° F.

A: True

Feedback: The photosphere is the sun's surface. The visible light we see on Earth originates there.

Q7: What is the hottest part of the sun that is visible to us?

a) Core
b) Corona
c) Chromosphere
d) Photosphere

A: b.

Feedback: The corona is a million-degree gas halo that extends from the sun's chromosphere millions of miles into space. The best way to see the corona is to block out the disk portion of the sun.

Q8: True or False: Like the Earth, the sun rotates around an axis and has a uniform rotation of 25.4 days.

A: False

Feedback: While the sun does rotate around an axis, its rotation is not uniform. The sun's equator rotates once every 25.4 days, while at the poles a full rotation can take as long as 36 days.

Q9: Which of the following are affected by the sun?

a) Earth's long-term weather patterns
b) Communication systems and satellites
c) Creation of oxygen and carbon dioxide
d) All of the above

A: d.

Feedback: The sun is responsible for our long-term weather patterns, and solar activity such as coronal mass ejections can affect our satellites and communications systems. Plants use energy from the sun to create oxygen and take in carbon dioxide.

Q10: True or False: The sun is made up of 70% helium and 28% hydrogen.
A: False
Feedback: The sun's composition is 70% hydrogen and 28% helium by mass. Over time, hydrogen will be converted to helium and the overall composition will change.

Additional Resources

NASA Space Science Education Resource Directory
http://teachspacescience.org/cgi-bin/ssrtop.plex

Science Teacher Lesson Plans
www.ncsu.edu/sciencejunction/terminal/imse/lowres/4/lessons.htm

The International Space Station
www.shuttlepresskit.com/ISS_OVR

SETI Institute
www.seti.org

BBC: Science & Nature: Space and the Solar System
www.bbc.co.uk/science/space/solarsystem

The Nine Planets: A Multimedia Tour of the Solar System
www.nineplanets.org

NASA Hubble Site
http://hubblesite.org

The European Homepage for the NASA/ESA Hubble Space Telescope
www.spacetelescope.org

Additional Resources at www.filmsmediagroup.com

Available from Films Media Group • www.filmsmediagroup.com • 1-800-257-5126

Space Science Video Library
- **DVD #30964**
- **Correlates to National Science Education Standards.**
- **User's Guide included**

The *Space Science Video Library* contains 19 video clips on the structure of the universe, star formation and destruction, the solar system, and space exploration. It is part of the complete Discovery Channel/Films for the Humanities & Sciences *Science Video Library*. A User's Guide is included, containing an overview; a numbered index of clips, with brief descriptions and lengths; suggested instructional strategies; and a list of additional resources. A Discovery Channel/FFH&S Production. © 2003.

How Scientists Look at the Sun

- **VHS/DVD-R #34120**
- **Correlates to National Science Education Standards.**
- **Produced in association with the Accreditation Board for Engineering and Technology and the Junior Engineering Technical Society.**
- **Viewable/printable Teacher's Guide included**

This *Science Screen Report* explores the sun's multilayered structure, the forces at work inside it, and the methods by which scientists study it. Detailing the activities of the SOHO spacecraft, the video also explains various solar phenomena: nuclear fusion, the release of neutrinos, oscillation of the photosphere, and the processes by which the sun may have formed as well as those that will eventually cause its collapse. A viewable/printable teacher's guide is available at www.cambridgeeducational.com. (19 minutes) © 2004.

The Complete Cosmos

- **13-part series**
- **VHS/DVD-R #8622**
- **Preview clip online at www.films.com (Search on 8622)**
- **"Best Educational Program," Radio & Television Golden Laurels, French Senate, 1999**
- **"Special Award," Jules Verne Film Festival, France, 1999**

This unique series is a visual encyclopedia of the planets, the galaxy, and the universe. Rich in awe-inspiring images and meticulous research, it presents information on everything from the reason for seasons, to the Hale-Bopp comet and black holes. A definitive introduction to the study of space and astronomy. The series includes *From Stonehenge to Hubble: Looking to the Stars; Home Star: The Sun and the Planets; Venus and Mars: Earth's Sisters; The Blue Planet and Pale Moon Above; Jupiter and Saturn: Probing the Planets; Uranus, Neptune, and the Milky Way: Dark, Deep Space; Impact! Comets and Asteroids; Celestial Wonders: Eclipses, Auroras, and Light Fantastic; Black Holes, Dark Matte; Space Explorers: A History of the Last Frontier; The Next Step: Of Robots and Space Stations; The Expanding Universe: From Big Bang to Big Crunch?; Spaceship Earth and the Search for Intelligent Life.* (20 minutes each) © 1998.

Space Frontier: The Future of Space Exploration

- **VHS/DVD-R #8622**

By 2019, a colony on the Red Planet—the stuff of science fiction—is expected to become scientific fact. Using computer simulations and interviews with scientists, robotics experts, and officials from NASA and the National Space Society, this program investigates the four main challenges to initiating a self-sustaining colony on Mars. An economical, single-stage, reusable spacecraft must be developed, such as the proposed Venture Star. The effects of long-term low- and zero-gravity living must be studied and counteracted, on the Moon and at the multi-national Alpha space station. The Moon must be developed as a launch platform. And robots must be sent to Mars to prepare for human habitation and create stores of fuel. Once established, a Mars colony will become the jumping-off point for exploring the rest of the solar system and the cosmos beyond. (54 minutes) © 1997.

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