Cambridge Core Science Series: Space Science

THE INVISIBLE UNIVERSE

Cambridge Educational

Teacher's Guide

Introduction

This Teacher's Guide provides information to help you get the most out of the *The Invisible Universe,* the fourth 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 Invisible Universe introduces the concept of invisible energy above and below the wavelengths of visible light. The electromagnetic spectrum is presented, and the different types of radiation, from radio
frequencies to gamma rays, are described.

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:

- Name six types of invisible energy—three of greater and three of lesser energy levels than visible light—and give an Earth-based example of each.
- Describe the electromagnetic spectrum.
- Name and explain the three properties that define electromagnetic, or EM, radiation.
- Describe why detecting radiation at some wavelengths and frequencies requires space-based observatories.
- Explain how scientists use different energies of EM radiation to find new objects in space and learn more about familiar ones.
- Name three current and one future space-based observatory and the characteristics of each: the Hubble Space Telescope, the James Webb Telescope, the Chandra X-ray Observatory, the Newton X-ray Observatory.
- Describe cosmic rays, tell where they come from, and list some of their characteristics.

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:

Copyright © 2006 Cambridge Educational®

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.

Standards for the English Language Arts, by the International Reading Association and the National Council of Teachers of English, Copyright 1996 by the International Reading Association and the National Council of Teachers of English. Reprinted with permission.

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.

From BENCHMARKS FOR SCIENCE LITERACY by the American Association for the Advancement of Science, Copyright 1993 by American Association for the Advancement of Science. Used by permission of Oxford University Press, Inc.

Program Overview

This program examines visible light as well as the types of invisible radiation that fill the seemingly empty space between the stars. The electromagnetic spectrum is introduced as well as the concepts of wavelength, frequency, and energy. Common examples of radiation at different wavelengths are given. The program discusses how scientists use radiation at different wavelengths to discover new objects in space and to learn more about familiar objects. Another type of invisible energy, cosmic rays, is defined.

The program presents the rationale for space-based observatories such as the Hubble Space Telescope and the Chandra X-ray Observatory.

Main Topics

Topic 1: Invisible Energy

Light in all its colors is the only electromagnetic radiation we can see without special instruments. But the visible part of light is just a tiny portion of the whole picture. A huge invisible range of energy, called the electromagnetic—or EM—spectrum, extends in both directions from the edges of the spectrum that we see as a rainbow. Humans can’t see this radiation, but can capture and measure it with special instruments. Each of the major categories of invisible energy is introduced, and common examples are given. The concepts of wavelength, frequency, and energy are introduced. The viewer is also given examples of how each level of energy is used to study phenomena in space.

Topic 2: In the Beginning
In 1932, while Karl Jansky was trying to locate the source of radio interference on transatlantic telephone calls, he discovered a whole new way of looking at objects in space. In this segment of the program a brief history of radio astronomy is presented, as well as an overview of the characteristics of electromagnetic radiation of different energy levels.

Topic 3: Low-Energy Radiation
The term *radio astronomy* refers specifically to the study of radiation in the longer radio wavelengths. Special equipment, such as a radio dish, is used to capture lower-energy radiation. In this segment of the program, some of the characteristics of lower-energy radiation (radio frequency, microwave, and infrared) are examined and examples of how astronomers use lower energy radiation to study celestial phenomena are presented.

Topic 4: High-Energy Radiation
This segment of the program focuses on some of the characteristics of high-energy (ultraviolet, X-ray, and gamma ray) radiation. Examples are presented of which phenomena in space generate high-energy radiation.

Topic 5: Cosmic Rays
Cosmic rays are not really rays at all. They are extremely small particles traveling through intergalactic space at an incredible rate of speed. This segment of the program examines the characteristics of cosmic rays—where they come from and how they affect people on Earth and in space.

Topic 6: The Hubble Space Telescope
On April 24, 1990, the Hubble Space Telescope was carried into orbit by the space shuttle Discovery. Since that time, Hubble has sent back thousands of images and a steady stream of data. The Hubble has fundamentally changed our understanding of the universe. This segment of the program focuses on the Hubble Space Telescope and some of its accomplishments. Two other space-based observatories, the Chandra X-ray Observatory and the Newton X-ray Observatory, are also introduced.

Fast Facts

- Visible light in all its colors is the only electromagnetic radiation we can see without special instruments.

- A huge invisible range of energy, called the electromagnetic (or EM) spectrum, extends in both directions from the edges of the visible light spectrum.

- Low-energy radiation lies beyond visible red light on the electromagnetic spectrum. It has longer wavelengths, lower frequencies, and lower energy than visible light.

- As we move beyond visible violet in the EM spectrum we encounter the high-energy wavelengths of ultraviolet, X-ray, and gamma rays. Unshielded energy in this part of the EM spectrum can be dangerous to human beings.

- Radio telescopes have been used to study the distribution of gas in the Milky Way galaxy. These gas clouds are invisible to optical telescopes.

- Stars and interstellar gases emit radio waves, or RF radiation. Charting gas clouds has allowed astronomers to map the shape of the galaxy, and to make predictions about Earth's path through our galaxy's dust clouds.

- Each part of the EM spectrum has a different energy, wavelength, and frequency, and each part has its own unique characteristics.

- Using special types of equipment, astronomers are able to tune into the various portions of the EM spectrum, allowing them to find new objects and see familiar objects in a whole new light.

- Not all energy from space can penetrate Earth's atmosphere. Most infrared and ultraviolet radiation as well as the rest of the high-energy radiation at frequencies above visible light does not reach the ground.

- Radio telescopes look like oversized satellite dishes, but are not designed for man-made signals. Their purpose is to detect RF emissions coming from objects throughout the universe.

- When matter is heated to millions of degrees, it emits X-rays, which are thousands of times more powerful than the visible light that we can see with our eyes.

- Gamma rays have the shortest wavelength, the highest frequency, and the most energy. Like X-rays, they are produced by the hottest objects in the universe (supernovae, neutron stars, and black holes).

Vocabulary Terms

cosmic rays: Galactic cosmic rays (GCRs) are high-energy particles that flow into our solar system from far away in the galaxy. GCRs are mostly pieces of atoms—protons, electrons, and atomic nuclei which have had all of the surrounding electrons stripped away during their high-speed passage through the galaxy.

electromagnetic (EM) spectrum: The name that scientists give to radiation at varying energy levels that travels at the speed of light and spreads out as it goes. Visible light that comes from a lamp in your house and radio waves that come from a radio station are both found on the electromagnetic spectrum. The EM spectrum includes gamma rays, X-rays, UV rays, visible light, infrared, microwaves, and radio waves.

energy: Energy is another way of expressing wavelength and frequency. All three—energy, wavelength, and frequency—are related in a precise mathematical formula. The greater the energy, the higher the frequency and shorter the wavelength.

frequency: A property of an electromagnetic wave that describes how many wave patterns or cycles pass by in a period of time. Frequency is often measured in hertz (Hz), where a wave with a frequency of 1 Hz will pass by at 1 cycle per second.

gamma ray: Electromagnetic radiation of the highest energy, shortest wavelength, and highest frequency.

gamma-ray burst: Short-lived explosions of the most energetic form of light. A burst of gamma rays from space lasts from a fraction of a second to many minutes. There is no scientific consensus as to their cause. At least some of them are associated with a special type of supernova that marks the death of especially massive stars. Recently, their distances from Earth were determined to be large, placing their origins in other galaxies.

Hubble Space Telescope: A telescope that orbits 375 miles above the Earth and sends back data and images of stars, galaxies, nebulae, and other celestial phenomena from the farthest reaches of the universe. Hubble operates in the optical (visible light), near-infrared, and ultraviolet portions of the EM spectrum.

infrared: Invisible energy located just beyond visible red light on the electromagnetic spectrum. Our senses only allow us to feel infrared as heat. Restaurants use infrared lights to keep food warm. Other near-infrared wavelengths are used in your TV's remote control. These shorter wavelengths are not hot. In fact, you can't feel or see them at all.

microwave: Electromagnetic radiation that has a longer wavelength (between 1 mm and 30 cm) than infrared or visible light. Microwaves can be used to study the universe, communicate with satellites in Earth orbit, and make popcorn.

radio frequency (RF) radiation: Electromagnetic radiation that is characterized by long wavelength, low frequency, and low energy.

ultraviolet: Electromagnetic radiation at wavelengths shorter than the violet end of visible light. Earth's atmosphere effectively blocks the transmission of most ultraviolet light. What little that does penetrate gives us sunburns and tans.

visible light: The portion of the EM spectrum we can see with our eyes. Visible (also called "optical") light can be broken into a rainbow of colors with visible violet on one end, visible red light on the other, and the other colors in between.

wavelength: The distance between adjacent peaks in a series of periodic waves. (See *electromagnetic spectrum*.)

X-rays: Electromagnetic radiation that has shorter wavelengths and higher frequencies than ultraviolet light, but longer wavelengths and lower frequencies than gamma ray radiation.

Pre-Program Discussion Questions

1. In addition to visible light, there is a vast spectrum of invisible energy that travels throughout the universe. Is this invisible energy any different than visible light? In what ways?

2. When visible light passes through a prism, it breaks into a rainbow of colors. What is this rainbow of colors called?

3. What kind of energy is used in a TV remote control unit? What kind of energy brings calls to your cell phone?

4. What kinds of light do astronomers use to study various phenomena in the universe?

5. What is the electromagnetic (EM) spectrum?

6. Galactic cosmic rays and gamma radiation can be dangerous to astronauts traveling to the Moon or to Mars. Why aren't they as dangerous to people here on Earth?

Post-Program Discussion Questions

1. Name and describe the three properties or characteristics of electromagnetic radiation.

2. What is the electromagnetic spectrum and what does it show?

3. Scientists study stars, galaxies, and other phenomena in wavelengths other than visible light. What other wavelengths do they use, and why?

4. Name three categories of EM radiation beyond visible red on the EM spectrum. Name three categories of EM radiation beyond visible violet light. What are the characteristics associated with each of these six types of EM radiation?

5. Which wavelengths of electromagnetic radiation penetrate Earth's atmosphere all the way to the ground, and which do not?

6. Of what value are space-based observatories to astronomers? Name two satellite observatories, and describe some of their contributions to our understanding of the universe.

Group Activities

Remote Controlling

Most television remote control units work by means of infrared radiation rather than visible light. That's why you can't see the beam go on when you change channels. Infrared radiation has a longer wavelength than visible light, so it behaves differently when it encounters objects that get in its way. In this activity students will discover how infrared radiation behaves compared to visible light.

Divide students into two- or three-person teams. Using a television's remote control as your source of infrared radiation and a flashlight as your source of visible light, compare their behavior in the following circumstances:

- Clear obstructions between you and the television set. Darken the room. Stand about ten feet away from the set and test your remote control unit to make sure it functions properly. Test your flashlight by shining it against the dark television screen.
- Have your partner stand about halfway between you and the television, directly in front of the screen. Try turning on the television using the remote control. Then try shining the flashlight onto the television screen. Observe what happens in each trial. Have your partner move around and notice how both "light" beams behave.
- Have your partner blow some cornstarch or baby powder in the air between you and the television. Using the remote, try turning on the television through the dust. Repeat the attempt, using the flashlight, and note what happens when you aim it at the screen.
- Place a glass of water directly in front of the remote control unit and try to turn on the television. Now shine the flashlight through it. Note what happens in each case.

- Hold the remote control in your right hand and place your left hand at several distances and angles relative to the remote control. Determine the conditions under which your hand prevents the signal from reaching the television.

Questions

1. Which of the objects interfered with the flashlight beam? Which stopped the infrared beam?
2. Why do you think infrared sensors are good at detecting hot spots in forest fires, yet have problems detecting warm bodies in the fog?
3. How does the longer wavelength of infrared radiation help to explain your observations?

Danger, Danger!

Sometimes what we can't see can harm us! On the Moon, on an EVA (spacewalk) in low Earth orbit, aboard a spacecraft halfway to Mars, or on the surface of Mars—in these situations unshielded high-energy radiation and cosmic rays can be harmful to human beings. In fact, this is one of the major concerns in sending a human mission to Mars. How can we protect ourselves?

Divide students into groups. Have each group research the answer to this question and suggest ways that we can protect ourselves in each of the situations mentioned above. Are the solutions the same for each type of harmful radiation? For each situation? Are the solutions feasible? Groups can present their reports to the class and critique their solutions.

Cosmic Quiz-Show

Create a quiz-show game about the cosmos, or have students work together to create the game. The game should consist of five subject matter categories and five questions of increasing difficulty in each category. Questions range in value from 100 points to 500 points. Have the class play the game while you serve as moderator. Follow this link to see an example of a cosmic quiz game: http://chandra.harvard.edu/edu/games/jeopardy

Individual Student Projects

Portraits from the X-Ray Universe

Have students visit an imaginary *Chandra Portrait Gallery of the X-Ray Universe*. The gallery would contain portraits of galaxy clusters, exploding stars, pulsars, and turbulent regions of space around black holes, all taken in X-ray radiation. The task is to explain the portraits so that others can appreciate and understand what they are looking at.

Students should first choose a false-color X-ray image from the Chandra Web site at http://chandra.harvard.edu. Using any art medium, they should then create a "portrait" of that image that accurately represents the detail of the original image. Finally, have students deliver orally or write out an interpretation of the portrait to be shared with classmates. Reports should include:

- A detailed description of the cosmic object in the portrait
- Where the object was found, including an explanation of distance
- How the object was observed and translated into a visual image
- Interesting and relevant scientific information astronomers have gained or are investigating from the cosmic object in the portrait

Internet Activities

Hubble Deep Field Academy

In this activity students examine the galaxies in the Hubble Deep Field North, the first of two deep visible-light images of the universe (the other is the Hubble Deep Field South). Students will simulate the process astronomers went through to count, classify, and identify objects in the image as well as estimate their distances from Earth. Use the following link to learn more: http://amazing-space.stsci.edu/eds/overviews/explorations/hdf.php

Hubble Servicing Missions: Past, Present, and Future

Have students use the Internet to research and then write a brief report on servicing missions to Hubble. The report should address the following questions: What do the missions accomplish? How long does each mission last? What role do astronauts play? Is there funding for 2006 and future servicing missions? Why or why not? Based on what you have found, what do you think is the future of the Hubble Space Telescope?

De-Coding Starlight: From Pixels to Images

Students get an idea of how scientists create images from astronomical data by completing this assignment. Have students go to http://chandra.harvard.edu/edu/formal/imaging/student_high.html and follow the instructions to decode the image of a supernova remnant from the numerical data given.

Assessment Questions

Q1: True or False: Radio frequency radiation has the longest wavelength and gamma rays have the shortest wavelength on the electromagnetic spectrum.

A: True

Feedback: Radio frequency, or RF, radiation has the longest wavelength of all electromagnetic energy. Moving from longest to shortest, RF radiation is followed by microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays.

Q2: Microwave radiation is used for which of the following:

a) to study galactic gas and dust clouds
b) to cook food quickly
c) to carry calls to your cell phone
d) all of the above

A: d.

Feedback: Using microwaves, scientists are exploring the shape and formation of our galaxy. Microwave energy is also used here on Earth in microwave ovens, and to carry calls to cell phones.

Q3: Which of the following is true of X-rays?

a) They have a wavelength shorter than that of visible light.
b) They are used to study super-hot gases in space.
c) They do not penetrate Earth's atmosphere.
d) All of the above.

A: d.

Feedback: X-rays have a shorter wavelength than that of visible light and of ultraviolet. Astronomers look at X-ray frequencies to study some of the hottest, most violent interactions in the universe, for example when matter spirals down into a black hole or when galaxies or stars collide. X-ray observations must be done from space-based observatories such as the Chandra X-ray Observatory since X-rays are absorbed by the Earth's atmosphere.

Q4: Scientists have found gamma-ray bursts to be associated with which of the following:

a) white dwarf stars
b) red giant stars
c) exploding stars
d) all of the above

A: c.
Feedback: Although scientists do not yet know what causes gamma-ray bursts, they have found them to be associated with a special type of supernova caused by a star exploding at the end of its life. They have also found them to be associated with colliding black holes and neutron stars.

Q5: True or False: Cosmic rays are not really rays at all, but extremely small particles traveling through space at an incredible rate of speed.
A: True
Feedback: Cosmic rays are mostly pieces of atoms—protons, electrons, and atomic nuclei. The original atoms are torn apart during their high-speed journey through the galaxy.

Q6: True or False: Radio telescopes have been used to study gas in our galaxy that is invisible to optical telescopes.
A: True
Feedback: Radio astronomers have used radio telescopes to collect radio frequency radiation and chart gas clouds that are invisible to optical telescopes. This has allowed them to learn more about the origin and formation of our galaxy.

Q7: Which of the following is associated with radio astronomy?

a) Listening to interstellar radio waves to detect patterns
b) Studying cool hydrogen gas
c) Studying stars of exceptional brightness
d) The Hubble Space Telescope

A: b.
Feedback: Radio astronomy is used to study electromagnetic radiation and the distribution of cool hydrogen gas in our galaxy. Scientists use the Very Large Array radio astronomy observatory in New Mexico (a collection of 27 radio telescopes that functions like one antenna 22 miles across) to aid in this study.

Q8: True or False: Astronomical research into high-energy wavelengths has been carried out ever since Karl Jansky first discovered X-rays in 1932.
A: False
Feedback: Jansky discovered radio frequency, or RF, radiation in 1932. The history of radio astronomy dates from that year. But the high-energy part of the EM spectrum could not be studied until the invention of satellite observatories, because most high-energy radiation is absorbed by Earth's atmosphere.
Q9: A Type II supernova explosion is a stage in the life of a __________ .

a) yellow star like the sun
b) white dwarf star
c) super-giant star
d) brown dwarf star

A: c.

Feedback: At the end of their lives only giant or super-giant stars explode in a Type II supernova explosion. Yellow stars like the sun do not end their existence in supernova explosions. Instead, they first swell up into red giants, which dissipates much of the star's mass into space. What is left is the core of the original star that contracts into a white dwarf. At times, in a binary star system, a white dwarf star will steal matter from its companion and explode in a Type Ia supernova.

Q10: True or False: Carbon-14, the carbon isotope archeologists use to date human artifacts and other organic-based elements, is created by cosmic rays.
A: True
Feedback: Cosmic rays from the sun constantly bombard our atmosphere, colliding with atoms and creating energetic neutrons. Once in a while one of these neutrons will collide with a nitrogen atom. The neutron knocks a proton free and takes its place. A basic nitrogen atom has 7 protons and 7 neutrons; after the collision and replacement, the former nitrogen atom will have 6 protons and 8 neutrons, transforming it from nitrogen to an isotope of carbon, carbon-14, which has 6 protons and 8 neutrons.

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

NASA Hubble Site
http://hubblesite.org

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

National Aeronautics and Space Administration
www.nasa.gov

European Space Agency
www.esa.int

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**

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 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. 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 Matter; 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 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. 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.

For information on other programs

Visit our Website at
www.cambridgeeducational.com

2572 Brunswick Pike, Lawrenceville, NJ 08648

Toll Free: 1 800/468-4227
Fax: 1 800/FAX ON US

34744