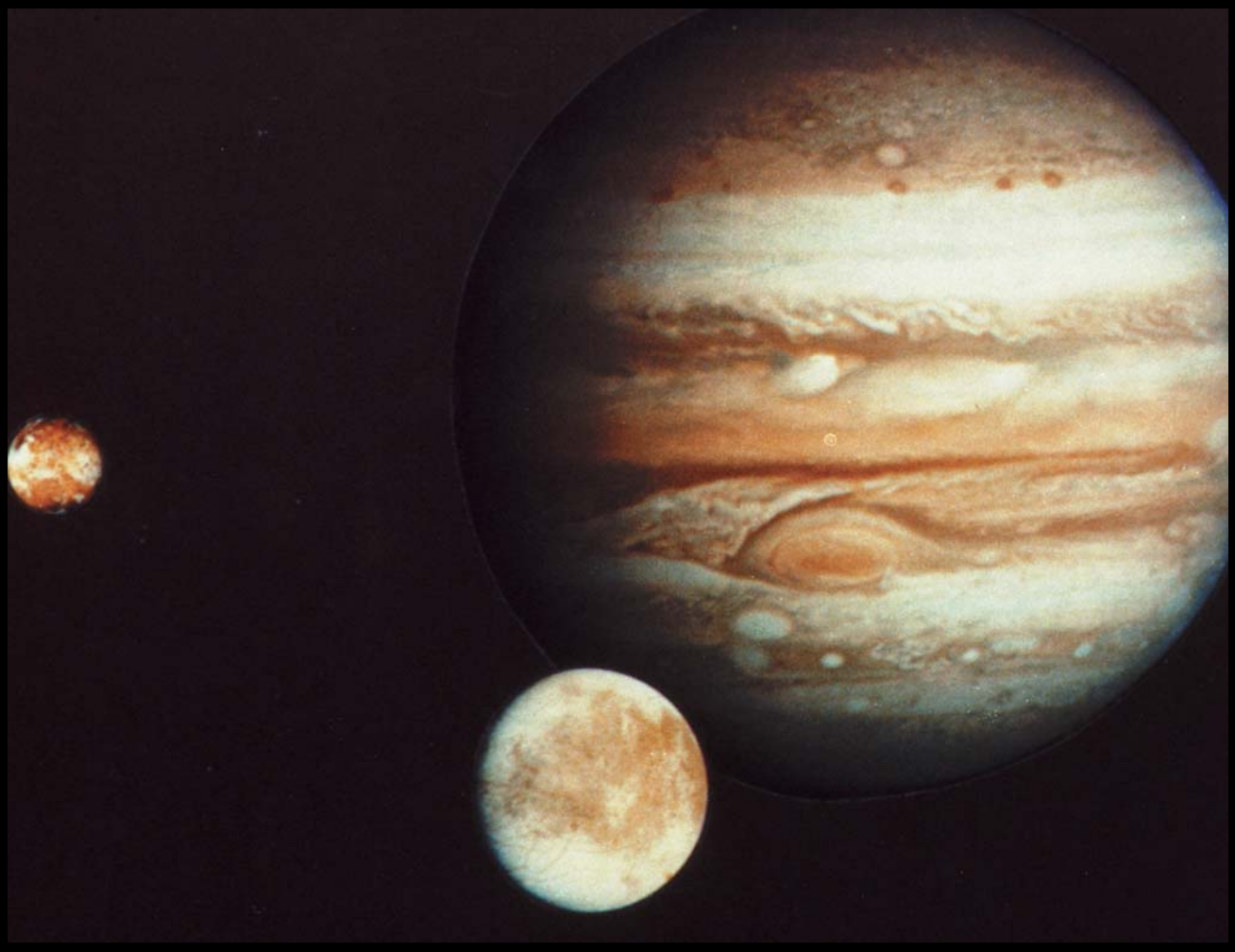
Cambridge Core Science Series: Space Science

THE PLANETS



Cambridge Educational

Teacher's Guide

Introduction

This Teacher's Guide provides information to help you get the most out of the *The Planets,* the first 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.

Since prehistoric times people have gazed skyward and wondered what was out there. This series provides a broad overview of the nature of space and the objects that populate its vast domains. It also reviews our efforts to explore space and the latest theories about who or what may be out there.

The Planets presents an overview of the solar system, including its origins and components. The program profiles each planet, focusing on its distance from other planets and the sun, its structure, surface and atmospheric conditions, and moons. The idea of finding life somewhere in the solar system other than on Earth is explored.

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:

- Describe the evolution of the solar system.
- Name each of the planets and identify distinguishing characteristics.
- Convey and compare the relative distances between planets in the solar system.
- Identify which of the planetary bodies in the solar system may support life and why.

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

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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.

Program Overview

The Planets explains the origins of the solar system and describes its various components. The program details each planet, including its distance from the sun, its atmosphere, surface conditions, interior composition, and its satellites. The requirements for the evolution of life are presented, and the possibility of life on each of the planets is examined.

Main Topics

Topic 1: Formation of the Solar System

Our solar system and its planets began forming over four billion years ago from a ball of swirling gas and dust called a solar nebula. As the nebula began to shrink and flatten out, matter at the center of the nebula compressed to form the sun. Clumps of matter in the arms of the disk formed proto-planets that eventually became the round planetary bodies we see today.

Topic 2: What's Included in Our Solar System

Our solar system includes the planets, their moons, comets, asteroids, and the sun. The sun provides the gravitational pull that holds each of the nine planets, the comets, and the asteroids in their respective orbits.

Topic 3: Is There Life Out There?
Humankind has long wondered whether life exists elsewhere in our universe. The program explores the basic requirements for the evolution of life elsewhere in the cosmos. In addition to liquid water, earth-like life requires certain chemical building blocks like carbon, oxygen, hydrogen, and nitrogen, a source of energy, and a planetary atmosphere.

Topic 4: The Inner Planets
The planets can be classified based on their proximity to the sun as well as their composition. The four inner, or terrestrial, planets are all characterized by a composition of rock and metal and a solid surface on which to land a spacecraft. The specific characteristics of each of the inner planets are presented, and the question of the possibility of life is explored.

Topic 5: The Outer Planets
The outer planets include Jupiter, Saturn, Uranus, Neptune, and Pluto. The four largest are divided into gas giants (Jupiter and Saturn) and ice giants (Uranus and Neptune). The program includes a discussion of the characteristics of each planet and its moons. Pluto is presented in a category by itself. The program mentions the recent discoveries of large, planet-sized bodies in the Kuiper Belt, and mentions the current controversy over classifying Pluto as a planet or a Kuiper Belt object.

Fast Facts

- The solar system began forming about 4.5 billion years ago.
- We did not have maps of all of Earth until the 20th century, when satellites allowed us to view the entire planet from space.
- Most planetary orbits fall within a few degrees of the ecliptic, an imaginary plane based on the orbit of Earth around the sun.
- A small amount of carbon dioxide and other gases in Earth's atmosphere are responsible for the greenhouse effect. The greenhouse effect raises the average surface temperature on Earth by about 63°F—otherwise, the average worldwide temperature would be 6° below zero Fahrenheit. Even a slight increase in the greenhouse effect could lead to global warming, which may negatively impact life on Earth.
- Jupiter is the largest planet in the solar system. Jupiter has more than 60 moons. The four largest—Ganymede, Europa, Callisto, and and Io—were discovered by Galileo in the 17th century, and are called the Galilean moons.
- Mars is the planet most similar to Earth, and is considered the most likely to have developed life at some time in its past.
- Although no signs of life have been found on Mars, there is still hope that some of the moons of Jupiter (Europa, Io) and Saturn (Titan) may provide the necessary conditions to support life.
- For about 20 of the 248 years it takes Pluto to circle the sun, it is actually closer to the sun than Neptune. Pluto is the only planet that has not been visited by a spacecraft. But the New Horizons spacecraft is on its way. Launched on January 19, 2006, the spacecraft is scheduled to reach Pluto on July 14, 2015.

- The evolution of life requires four basic ingredients: a source of energy, liquid water, chemical building blocks (e.g., carbon, oxygen, hydrogen, and nitrogen), and a protective atmosphere.

- Asteroids are small rocky bodies that orbit the Sun between Mars and Jupiter. Scientists believe that they are the remains of a planet that never formed due to Jupiter's gravitational influence.

Vocabulary Terms

atmosphere: The gas that surrounds a planet or star. The Earth's atmosphere is mostly nitrogen, while the sun's is primarily hydrogen.

asteroids: Rocky chucks that orbit the sun in the area between Mars and Jupiter. Asteroids range in size from a few meters up to 1,000 kilometers (620 miles) in diameter.

comet: A small, frozen mass of dust and gas orbiting the sun.

density: A measure of how much mass an object contains per unit of volume; the ratio between the mass of an object and its volume.

galaxy: A group of stars, gas, and dust held together by gravity.

gravity: A mutual physical force attracting two bodies.

mass: How much matter an object contains. It is not the same as weight, although an object's mass does help determine how much it will weigh.

moon: A naturally occurring satellite that orbits a larger planetary body.

nebula: A diffuse mass of interstellar dust and gas.

orbit: The closed path that an object takes as it revolves around another body.

satellite: A body that revolves around a larger body. Many man-made satellites and one natural satellite (the Moon) orbit the Earth.

Pre-Program Discussion Questions

1. What do you think early civilizations thought as they viewed the stars and other celestial bodies?

2. What inventions do you think had the greatest impact on our ability to study space, the planets, and other objects?

3. Do you think that life exists outside of the Earth? Where do you think it exists, and why?

4. What has shaped your perception of the universe? Have you ever visited a planetarium or a museum featuring exhibits on space? Are movies about space travel accurate?

5. Which planets have been visited by spacecraft? How have those visits changed what we know about those planets?

Post-Program Discussion Questions

1. Which planets or moons are most likely to harbor life? What evidence supports your answer?

2. Who do you believe to be the most influential person in the development of our current understanding of space? Who is the most famous? Why do you think these people may not be the same?

3. Why do you think the United States has invested so much time, effort, and money to explore space and the other planets in the solar system?

4. There is evidence that liquid water existed on Mars at some time in the past. What is the evidence found indicating the presence of liquid water? Why isn't it possible to have liquid water on the surface today?

5. What are Kuiper Belt objects, and what do they have to do with the current controversy over classifying Pluto as a planet?

Group Activities

Our Solar System
Ask students to divide into groups, with each group representing a planet within the solar system. Each group should report on their planet and the unique characteristics associated with it. Students should address issues of size, distance from the sun, similarities, and differences among the planets.

Stargazers
Divide students into groups, and have each group select and research a historical figure associated with space exploration. Each group should describe the discoveries and theories associated with the chosen person and his or her contributions to our knowledge of the universe. Be sure to include the period of time in which the person lived and the prevailing ideas of the sun, the moon, and the planets at that time.

What's in a Name?
Ask students to divide into groups and assign each group a planet, excluding the Earth. Have each group research its Greek or Roman name in mythology and report to the class about that mythological figure. Have the groups relate the planet's name to one of its features. Then have them develop a theory for why each planet was given that name.

Individual Student Projects

Study Hall
Ask students to create a list of scientific experiments they would conduct in space, their goals and objectives, anticipated outcomes, and equipment and staffing needed.

Pack Your Bags
The trip into space is a difficult one. The exploration of another planet would require a very long journey. Have students list the ten most important items necessary for the success of the trip, with justification for each one. Have the students list the five luxury or comfort items they would take along, and how they would make each one "space travel-ready."

Interview with an Alien
Have students create a script for an interview with an extraterrestrial being, including questions about its home planet's climate, geography, food sources, scientific knowledge, arts, and social structures. Pair students to role-play the interviews.

Internet Activities

What's the Latest?
Have students use the Internet to research recent astronomical discoveries. Have them identify how these discoveries have changed conventional thinking and commonly held ideas about the planets and solar system. (For example, Pluto was considered to be a planet until Sedna and other Kuiper Belt objects were discovered. Now there is considerable controversy among scientists as to whether it is a planet, or simply another Kuiper Belt object.)

Just Fun and Games
Have students go to www.bbc.co.uk/science/space/solarsystem and complete the Solar System Jigsaw Puzzles. Students can complete one puzzle for each of the three levels that include the Solar System, the Planetary Moons, and Spacecraft.

Mars Madness
Mars has held a unique position of curiosity from a scientific, literary, and entertainment perspective. Have students visit two Web sites—for instance, www.space.com/php/multimedia/marsmadness and www.marsquestonline.org/mer—to get a historical perspective of our fascination with Mars and our current exploration activities. Have students create a timeline showing scientific discoveries and how they have changed attitudes about the planet.

Assessment Questions

Q1: How old is our solar system?
A: Approximately 4.5 billion years old.
Feedback: The solar system started out as a swirling ball of gas and dust called a solar nebula.

Q2: The four inner planets are also called the _____ planets because they are largely composed of rock with a metal core.

a) Jovian
b) giant
c) terrestrial
d) gas

A: c.
Feedback: The four inner planets are called the terrestrial planets because, like the Earth (sometimes called Terra), they are composed primarily of rock with a dense metallic core.

Q3: Jupiter and Saturn are known as the _____.

a) ice giants
b) gas giants
c) distant planets
d) Kuiper Belt objects

A: b.
Feedback: These planets are primarily comprised of hydrogen, helium, and methane gas; they are the largest of the nine planets.

Q4: Which of the following statements about comets is true?

a) They are visible throughout their flights.
b) They form tails when they pass through the Kuiper Belt.
c) They were first discovered by Sir Edmund Halley.
d) They have two tails: a dust tail and an ionic tail.

A: d.
Feedback: Comets' tails form from an interaction between the solar wind and the sun's magnetic field. The dust tail points back along the comet's path and the ionic tail points directly away from the sun.

Q5: True or False: Mercury is best viewed late at night.
A: False
Feedback: Mercury is visible to the naked eye, and is best viewed just before sunrise or just after sunset.

Q6: True or False: All planets have been visited by spacecraft.
A: False
Feedback: Pluto is the one planet that has not been visited by a spacecraft.

Q7: Which of the following statements about Venus is true?

a) After the moon, it is the brightest object in the night sky.
b) It is covered in clouds.
c) It is about the same size as Earth.
d) All of the above.

A: d.
Feedback: Aside from our moon and the sun, Venus is the brightest object in the sky, is cloud-covered, and is about the same size as Earth. It is best seen before sunrise and after sunset.

Q8: True or False: Mars has the highest mountain in the solar system.
A: True
Feedback: Olympus Mons rises 78,000 feet, or 14 miles, above the Martian plain. Mt. Everest, by comparison, is just over 29,000 feet, or 5.5 miles high.

Q9: Uranus' blue color is attributed to:

a) ice on the planet's surface.
b) methane gas.
d) clouds.
d) a deep atmosphere.

A: b.
Feedback: The blue color is due to the absorption of red sunlight by methane gas.

Q10: True or False: Neptune is the only giant planet that does not have rings or moons.
A: False
Feedback: Like the other giant planets, Neptune has both moons and rings.

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.

For information on other programs

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