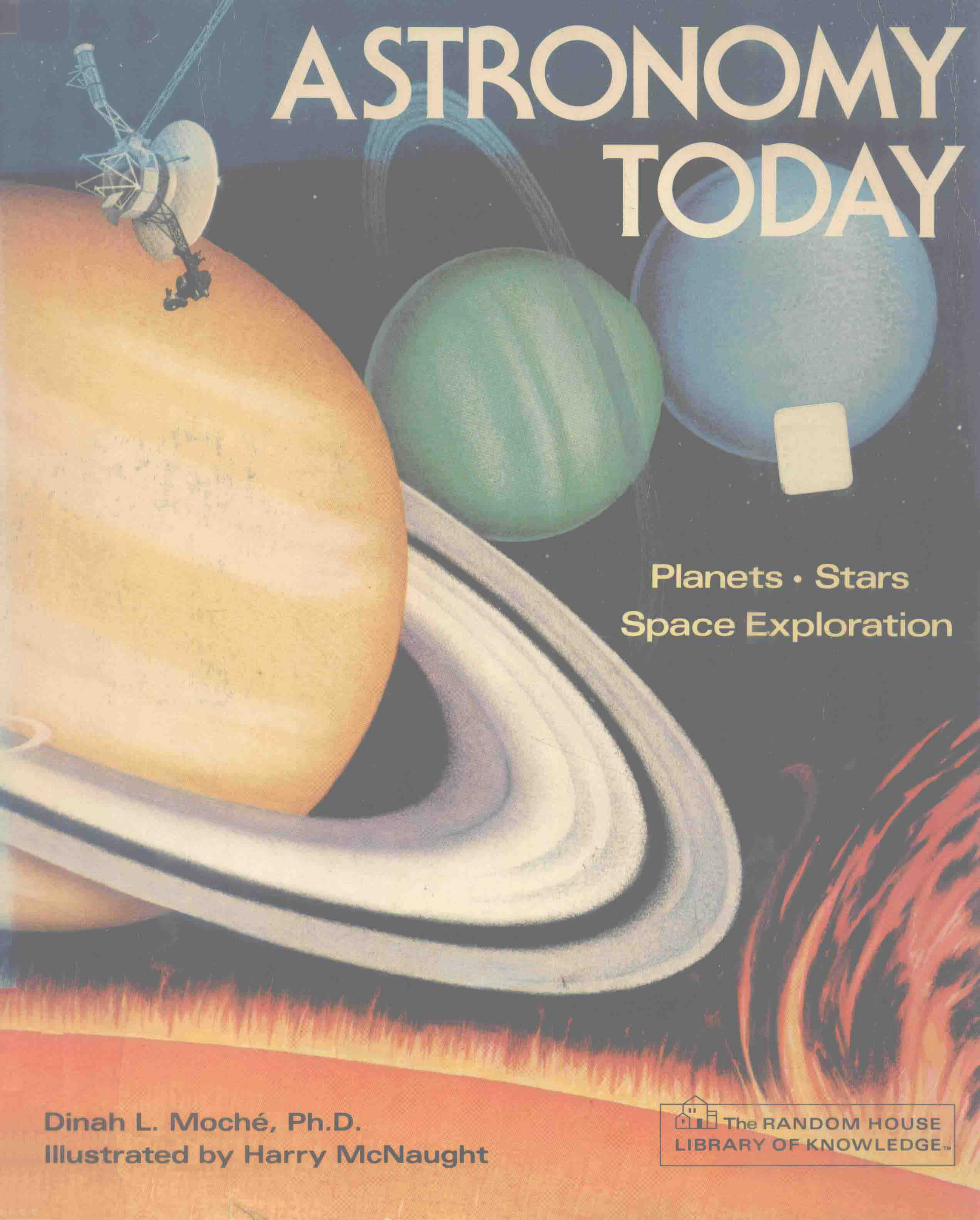
ASTRONOMY TODAY



Planets • Stars
Space Exploration

Dinah L. Moché, Ph.D.
Illustrated by Harry McNaught

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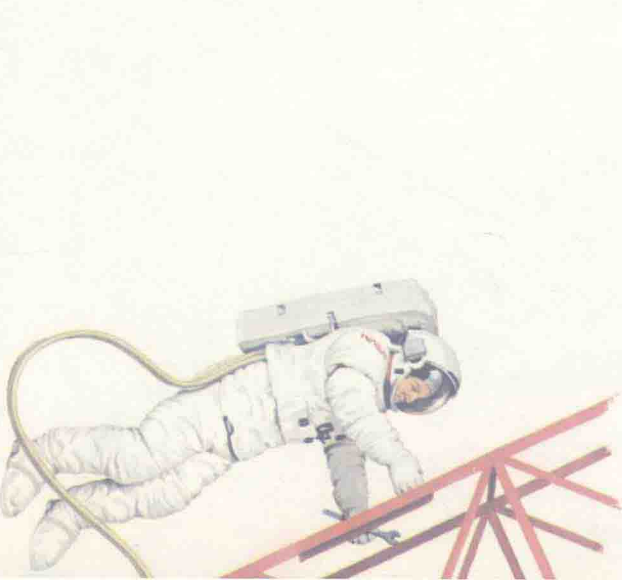

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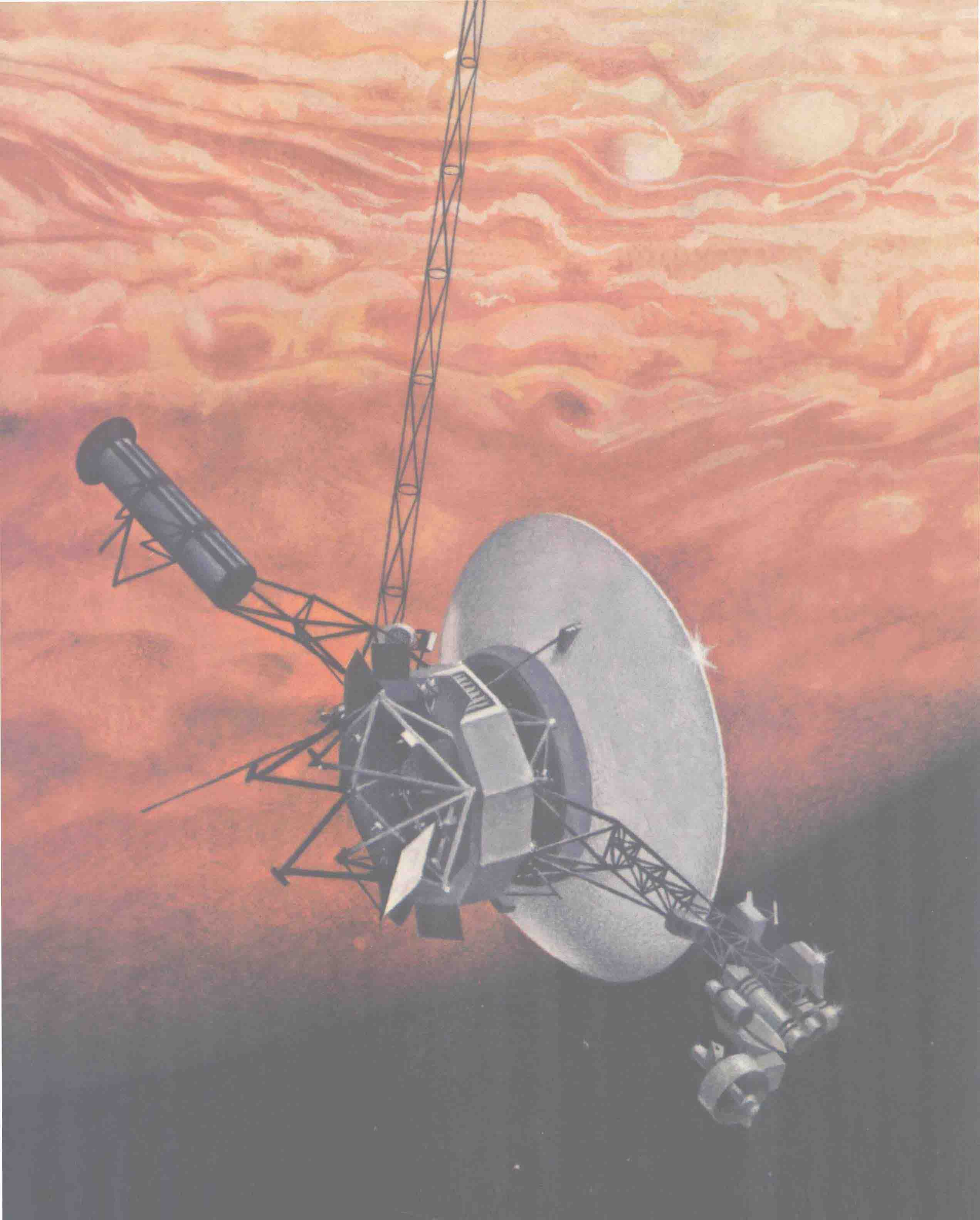

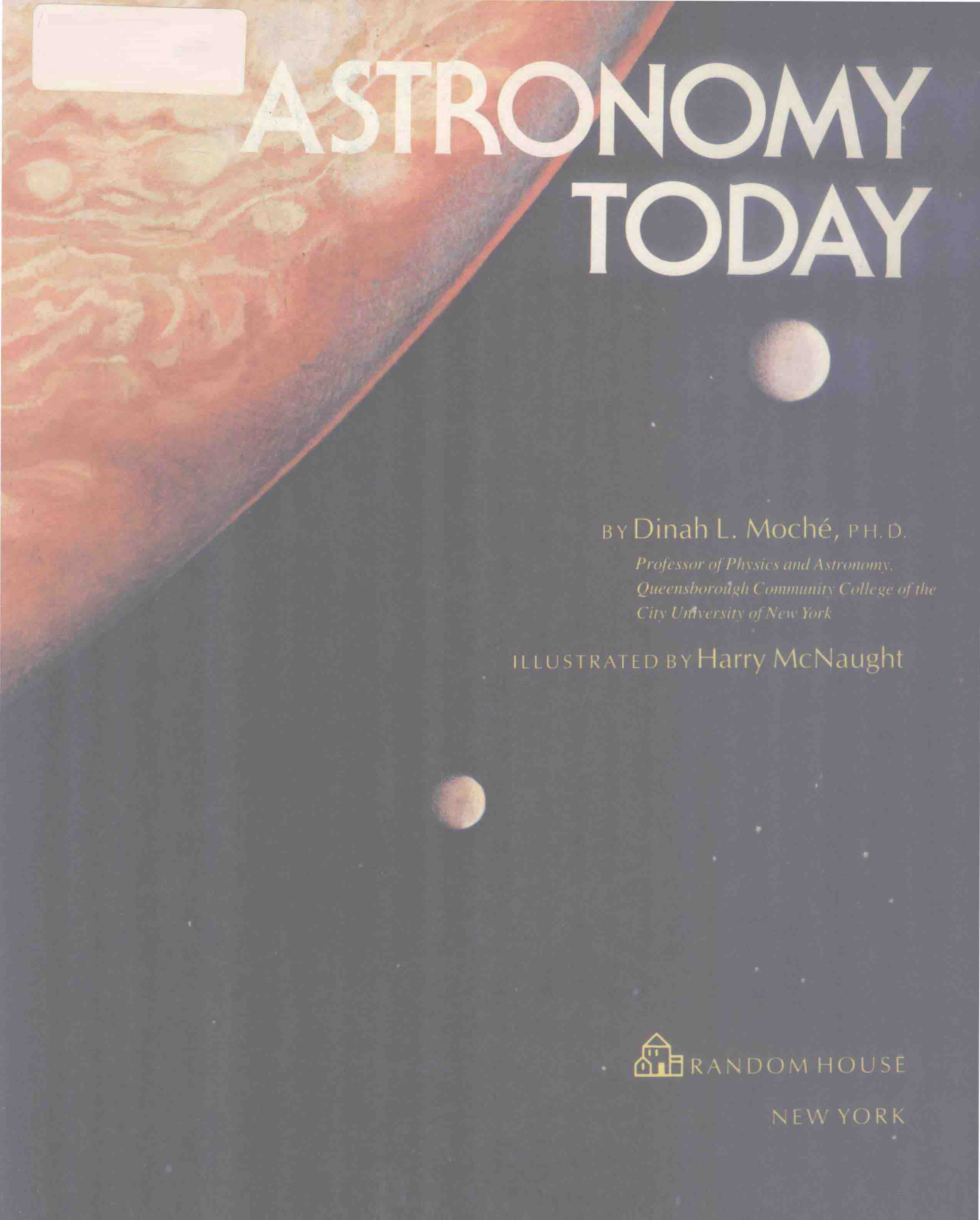

ASTRONOMY TODAY

BY Dinah L. Moché, PH.D.

Professor of Physics and Astronomy, Queensborough Community College of the City University of New York

ILLUSTRATED BY Harry McNaught

RANDOM HOUSE

NEW YORK

To my daughters, Rebecca and Elizabeth—
may they and all young people enjoy the promise of space.

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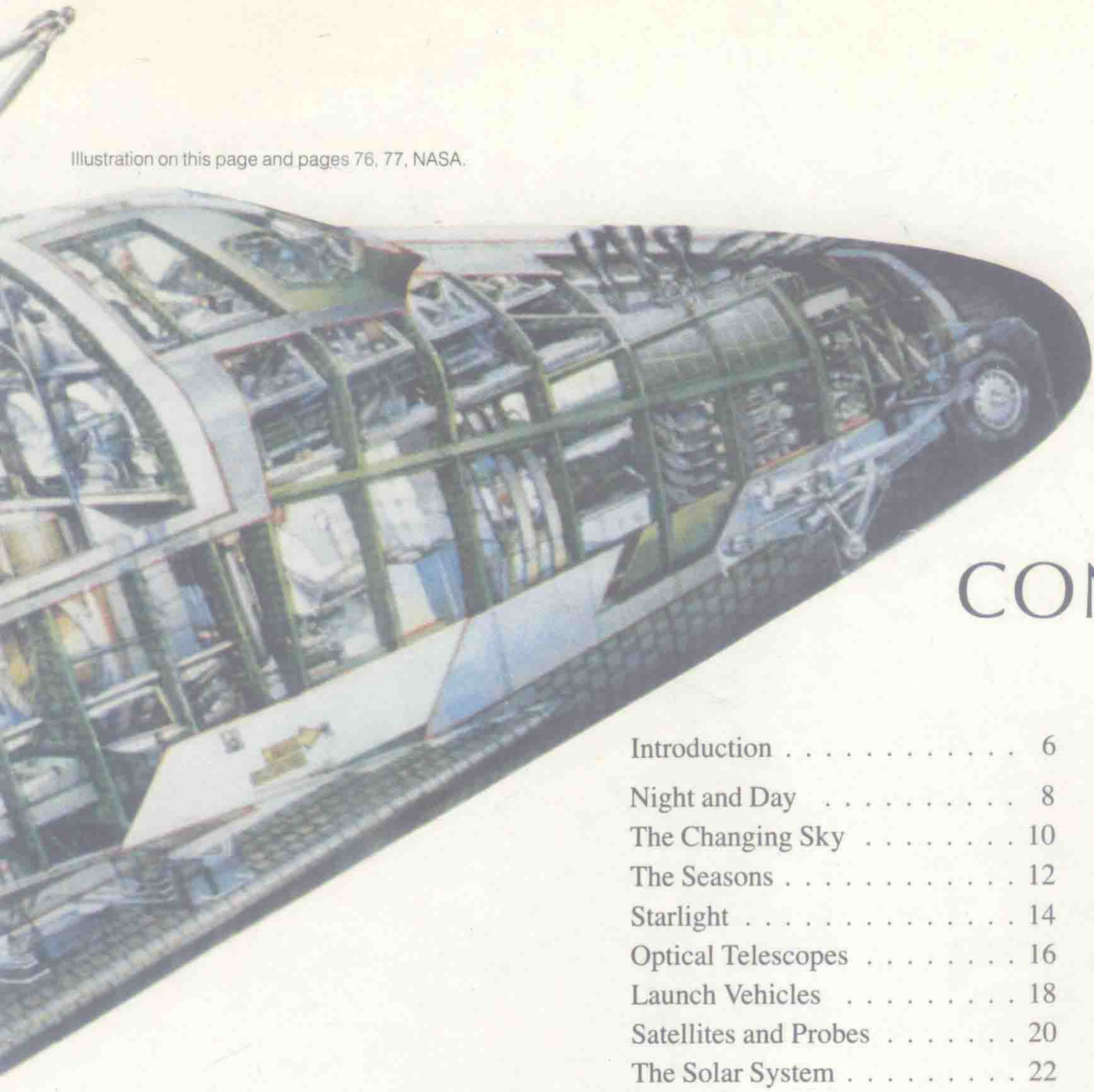

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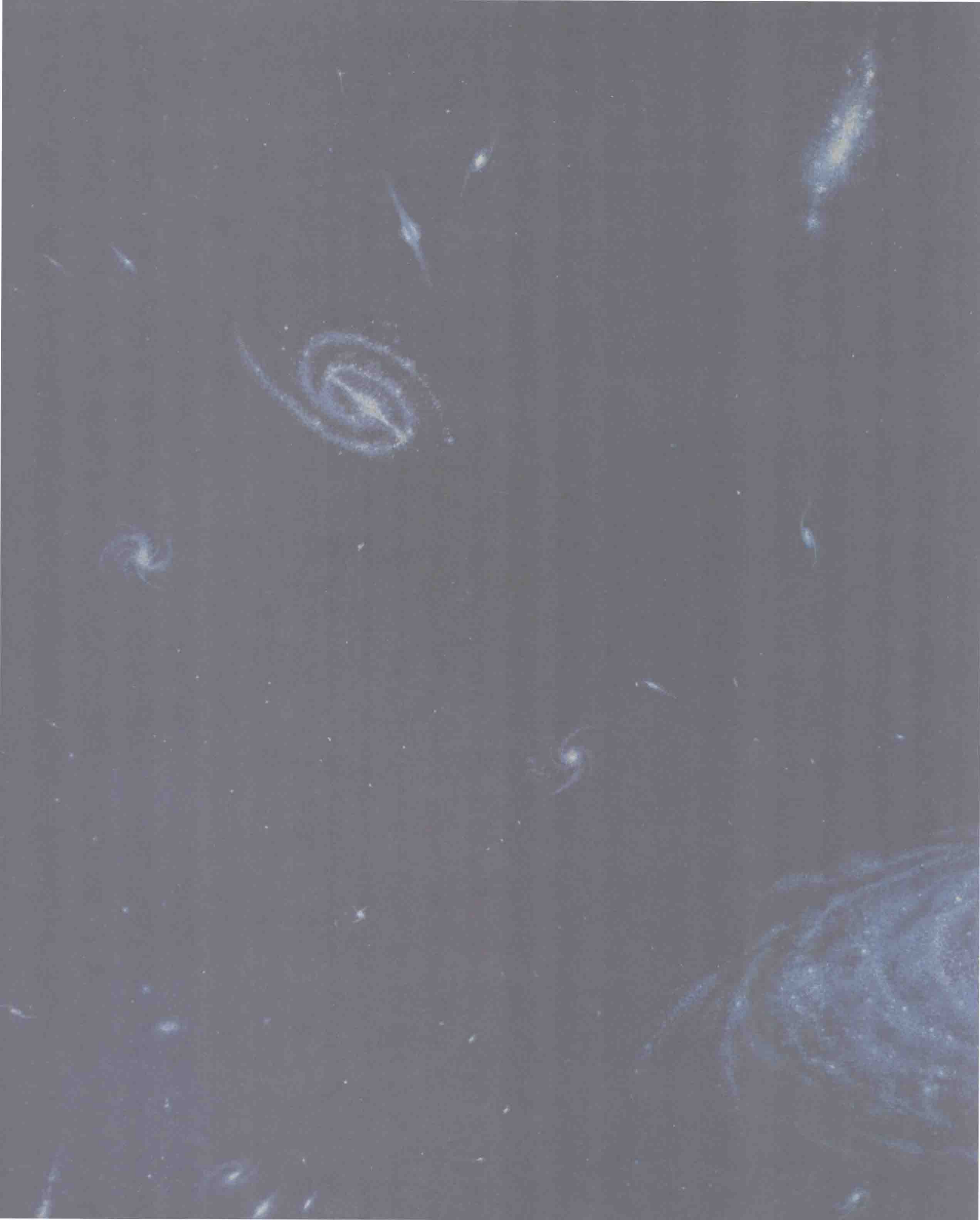
CONTENTS

Introduction 6
Night and Day 8
The Changing Sky 10
The Seasons 12
Starlight 14
Optical Telescopes 16
Launch Vehicles 18
Satellites and Probes 20
The Solar System 22
The Planets 24
The Sun 26
Our Closest Star 28
Mercury 30
Venus 32
Planet Earth 34
Drifting Continents 36
Aerospace 38
The Moon 39
Phases, Tides, and Eclipses 40
Robot Explorers 42
Apollo Mission Profile 44
Mars 46
Exploring Mars 48
Jupiter 50
Jupiter's Moons 52
Saturn 54
Saturn's Moons 56
Uranus 58
Neptune 60
Pluto 61
Asteroids 62
Comets 64
Meteors 66
Humans in Space 68
Space Stations 70
Space Shuttle 72
Space Shuttle Mission Profile 74
Space Shuttle Orbiter 76
Stargazing 78
–Spring Star Map 80
–Summer Star Map 81
–Autumn Star Map 82
–Winter Star Map 83
Stars 84
H-R Diagrams, Binaries, and Variables 86
Evolution of Stars 88
The Milky Way Galaxy 90
Neighboring Galaxies 92
The Universe 94
Index 95



Introduction

THE STARS YOU SEE on a clear, dark night are trillions of miles away and their light travels many years before it reaches your eyes. Earth is just a speck in the vast universe.

Earth is part of the solar system, a family of planets with their moons plus countless objects all circling the Sun. Astronomy today is bursting with exciting discoveries, from life in space shuttles and space stations to spectacular closeups of giant Jupiter and dazzling Saturn.

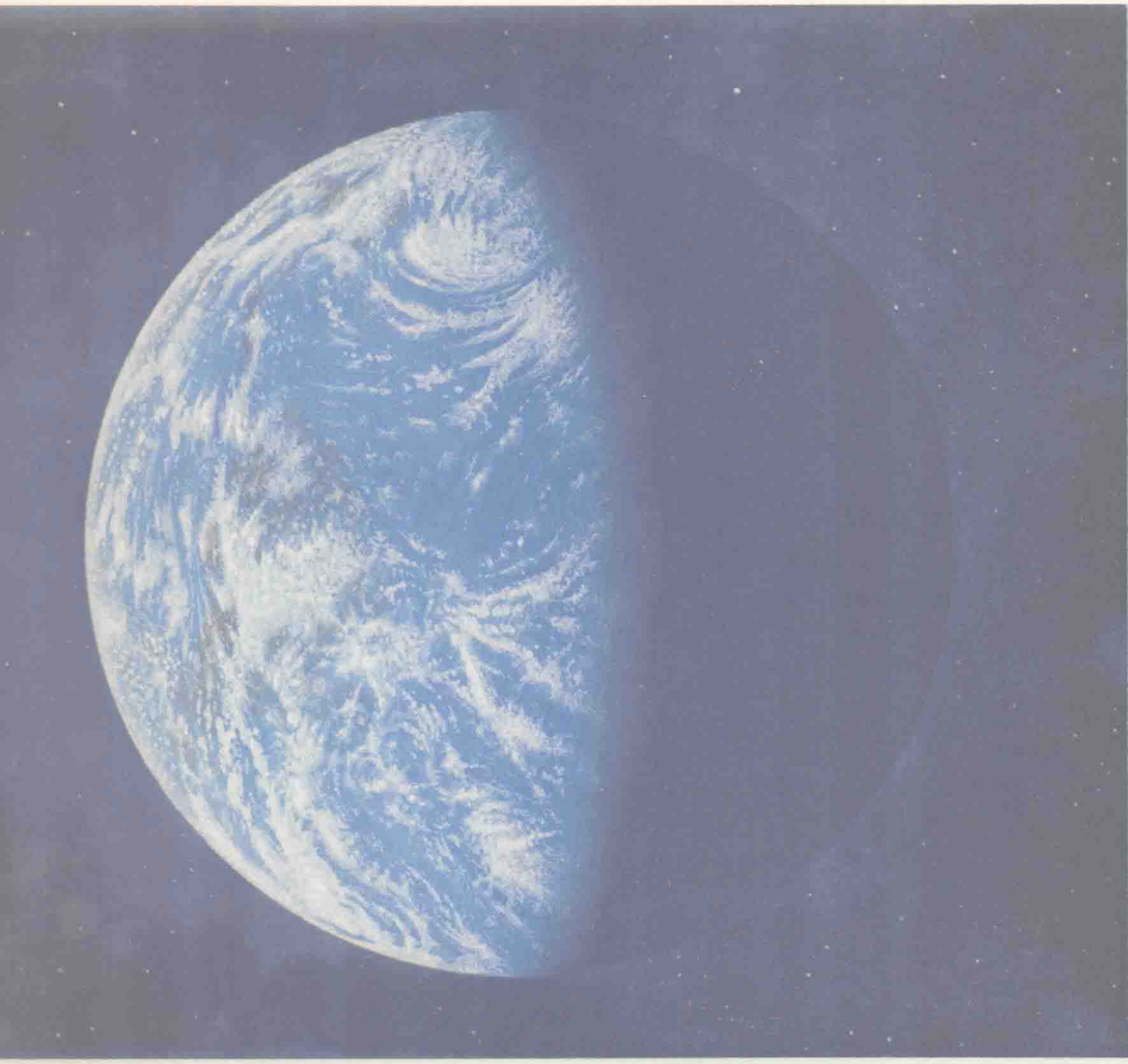
Our solar system belongs to a great system of over 100 billion widely separated stars called the Milky Way Galaxy. The Sun, Earth with its human passengers, and all the other stars in the Galaxy race around its center. The Milky Way Galaxy is so huge that you would have to travel at least 100,000 years to go across it at lightspeed.

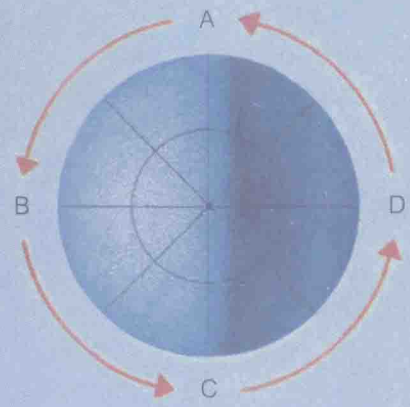
Sophisticated telescopes and instruments provide fascinating pictures of the Milky Way Galaxy, with its many strange objects and violent events powered by energy sources not yet used on Earth. Today's astronomers search for possible black holes, research puzzling objects such as quasars, and listen for messages from intelligent beings who may be on planets circling distant suns.

Beyond our Milky Way Galaxy are billions of other galaxies, each containing billions of stars. These galaxies are extremely far apart from each other. The intergalactic space between them is practically empty. A trip to the closest galaxy like our own would take some two million years at lightspeed.

This book will help you enjoy stargazing. It has the newest information about space, together with the most important ideas from yesterday and thrilling plans for tomorrow. The star maps on pages 80–83 and the fact columns throughout the book will guide you as you explore the wonders of space yourself.

Our solar system is just a speck (pinpointed by a red dot) in the Milky Way Galaxy. There are billions of other galaxies in our universe.





Imagine that you are far out in space, looking down on Earth's North Pole (above). There are four spots marked on Earth—A,B,C, and D. Local time at point A is sunrise, while it is the middle of the day at point B, sunset at C, and midnight at D.

In the illustration at the left, the side of Earth facing the Sun has daylight while the other half has the darkness of night. As Earth rotates from west to east the places in sunlight gradually turn away from the Sun and into the night side.

Night and Day

THE SUN IS A STAR and shines all the time. It lights the side of Earth that faces it. Because Earth rotates, or spins, once every 24 hours, your part of the world has day and night regularly. If Earth were still, half of the world would always be in sunlight and the other half would always be in darkness.

If you observed a clear sky for 24 hours, you would see the Sun rise in the east early in the morning and set in the west in the evening. During the night you would see stars move by.

The Sun and stars don't really move across the sky. They just appear to because you observe them from the spinning Earth.

When your part of the world turns toward the Sun, you have sunrise in the east. As Earth rotates during the day the Sun seems to go across the sky. Glare from sunlight scattered by the atmosphere hides the stars.

When your part of the world turns away from the Sun, you have sunset in the west. At night Earth blocks the sunlight. Then you see stars shining in space. As Earth turns during the night the stars seem to go across the sky.

Night and day are large divisions of time. Long ago people used the position of the Sun to gauge smaller divisions. The time when the Sun was at its highest in the sky was called noon. The period of time from noon of one day to noon of the next day was divided into 24 hours. This method worked well until people began to travel long distances by train.

As early trains traveled east or west, stations along the way had different local times. The time at which noon occurred was different at each location because Earth rotates from west to east. Places in the eastern United States turn toward the Sun before places in the west do. It is local noon at a spot in the east before it is local noon at a place 1,000 miles (1,600 kilometers) to the west. A standard for telling time everywhere in the world was badly needed to avoid confusion.

In the late 1800s an international system for telling time was agreed upon. The world was divided into 24 equal time zones, each one hour apart. Each time zone has a standard time. All places in a time zone use the same standard time instead of their local time.

Standard time is measured from the meridian of longitude that passes through the Greenwich Observatory just outside of London, England. (Meridians are the lines on a globe running from pole to pole.) As you go west, it is one hour earlier in each time zone. It is one hour later in each time zone to the east.

The United States and possessions are divided into eight standard time zones. Many places use daylight-saving time part of the year. Clocks are set one hour ahead of the standard time there. Then there is more sunlight when people are awake.

The three drawings on the right represent views of Earth at three different times. Drawing A shows a view one hour earlier than B, and B shows a view one hour earlier than C. In A, City 1 is experiencing sunrise. Cities 2, 3, and 4 are still in darkness. In B—one hour later—the globe has turned 15° of longitude toward the sunlight. City 1 has had sunlight for one hour, and City 2 is just now experiencing sunrise. In C, City 1 has had sunlight for 2 hours, City 2 has had sunlight for 1 hour, and City 3 is just now experiencing sunrise. City 4 will not experience sunrise for another hour.

The Changing Sky

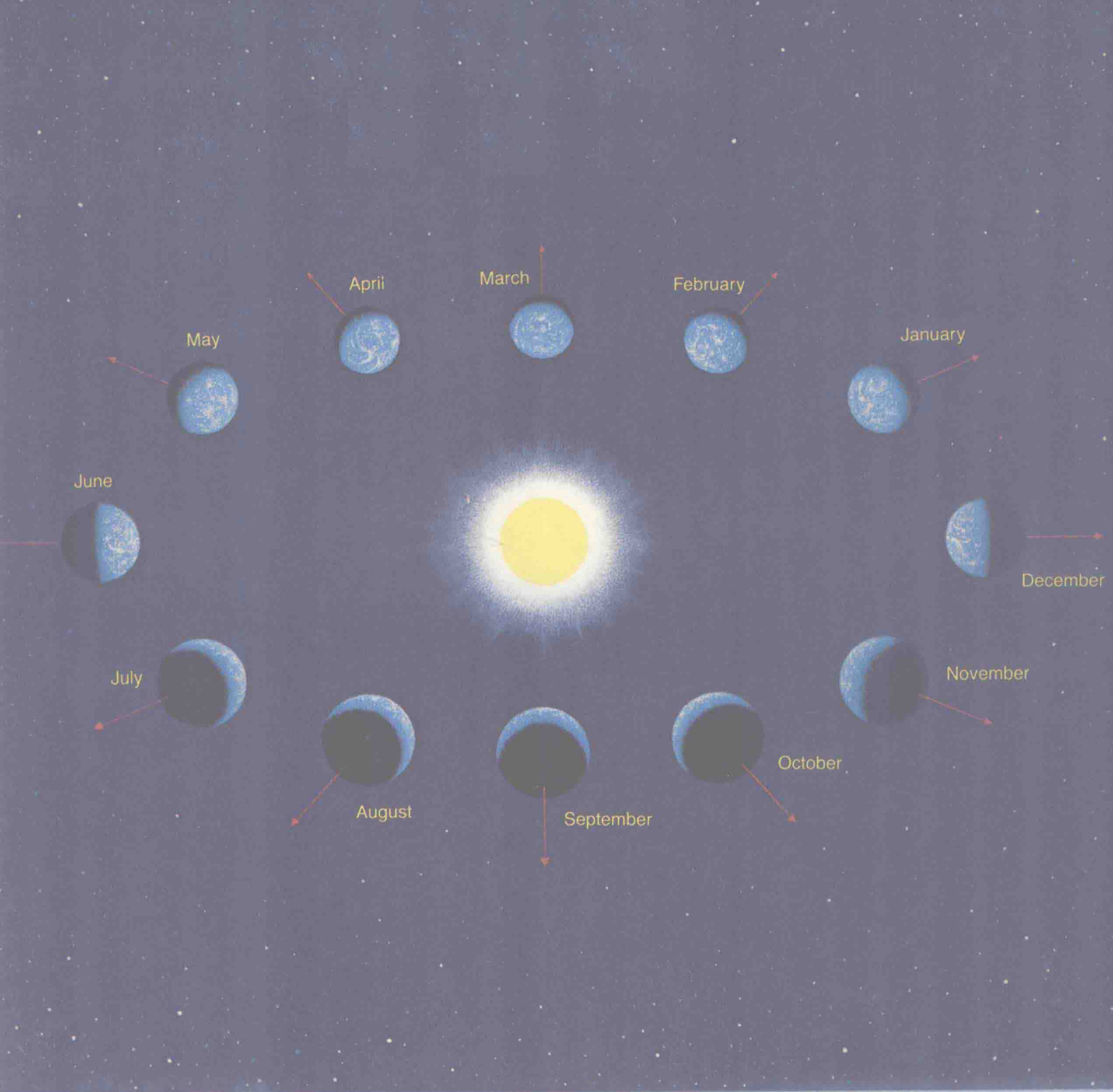
ON A VERY CLEAR, dark night you can see about 2,000 stars. If you go stargazing, you'll see that the stars seem to move across the sky during the night. They seem to move because Earth is turning.

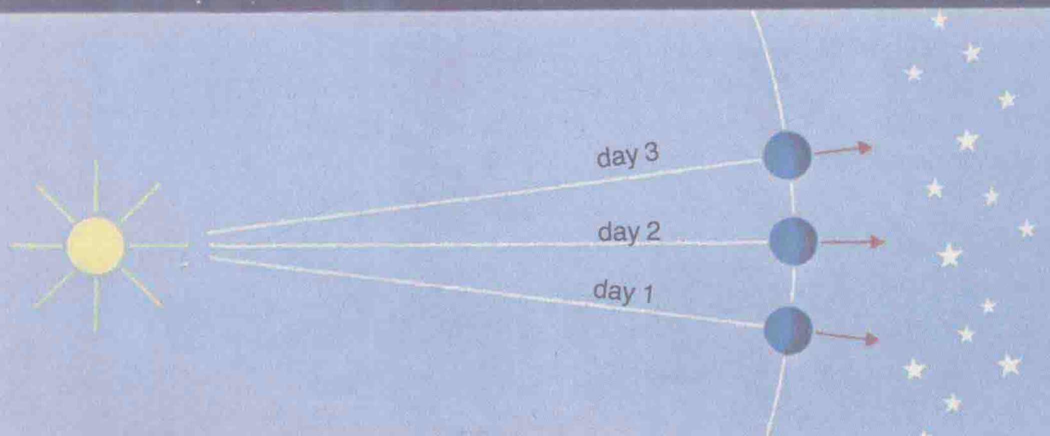
If you were to observe the sky regularly for a whole year, you would see some different stars each season. Your view of space keeps changing because Earth revolves, or travels around the Sun. Every hour Earth speeds more than 67,000 miles (107,000 kilometers) along its orbit, or path.

Imagine drivers in the Indianapolis 500 Memorial Day race. As the drivers speed around the track, they see different parts of the scenery at the edge of the track. In the same way, you see different stars as Earth speeds along its orbit around the Sun.

Earth takes twelve months to orbit once. After one year Earth is back where it started. Then you see the same stars again.

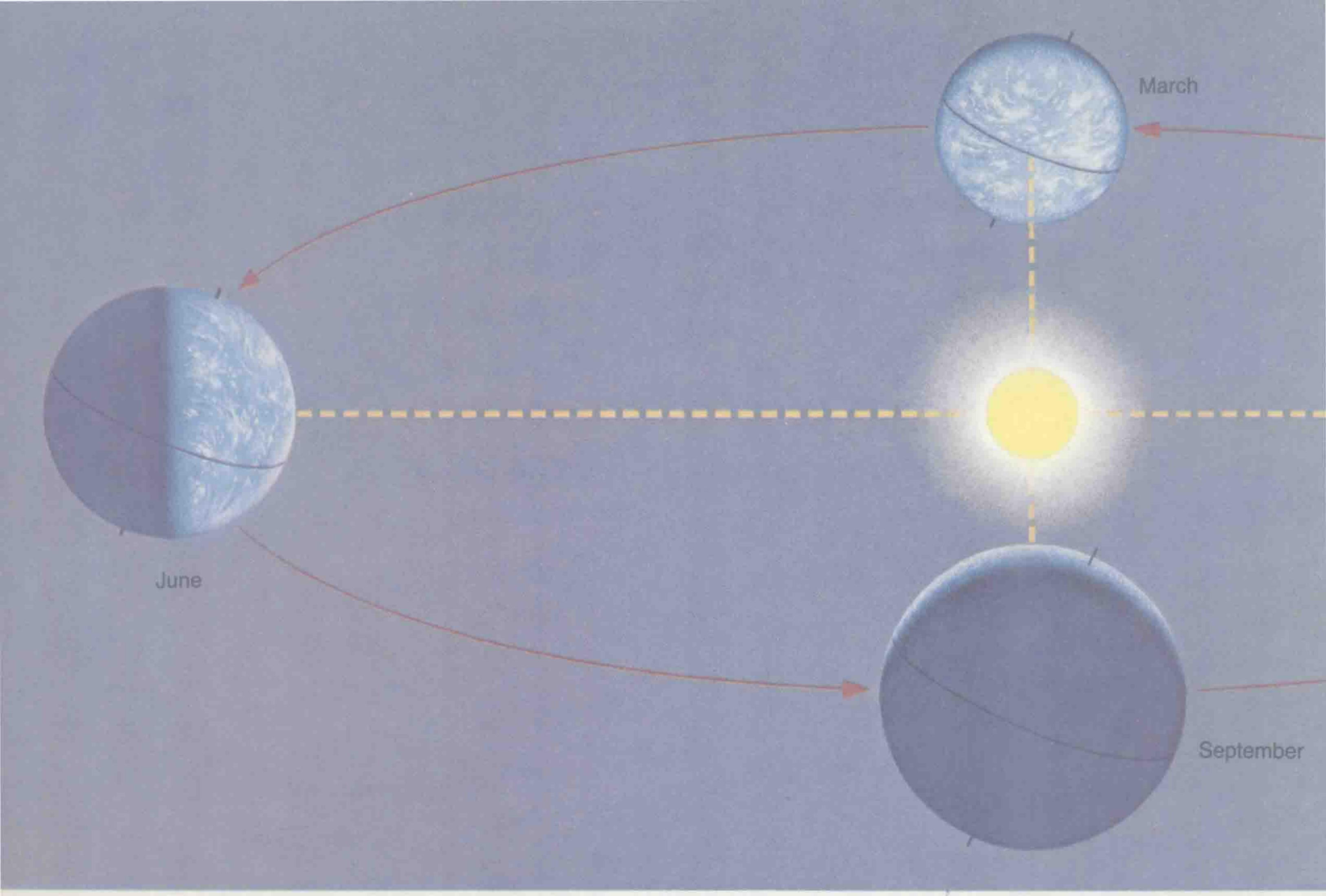
For stargazing, you need a different star map in summer, fall, winter, and spring. On pages 80–83 of this book you will find special star maps to guide you in each of the four seasons.





The illustration above shows the positions of Earth each month during its yearly orbit around the Sun. As Earth revolves around the Sun, you see some different stars in space each season.

The illustration on the left shows Earth's location in its orbit on three consecutive days. Because the spinning Earth travels around the Sun, you get a slightly different view of space each night. You would see a star rise four minutes earlier on day 2 than it did on day 1. On day 3 you would see the star rise eight minutes earlier than it did on day 1.



The Seasons

EARTH ROTATES AROUND its axis, an imaginary line that goes through the North and South poles. The axis is tilted 23.5 degrees. Earth has four seasons because it gets varying amounts of sunlight as it orbits the Sun. If its axis were straight up and down, Earth would get the same amount of sunlight each day and there would be no change of seasons.

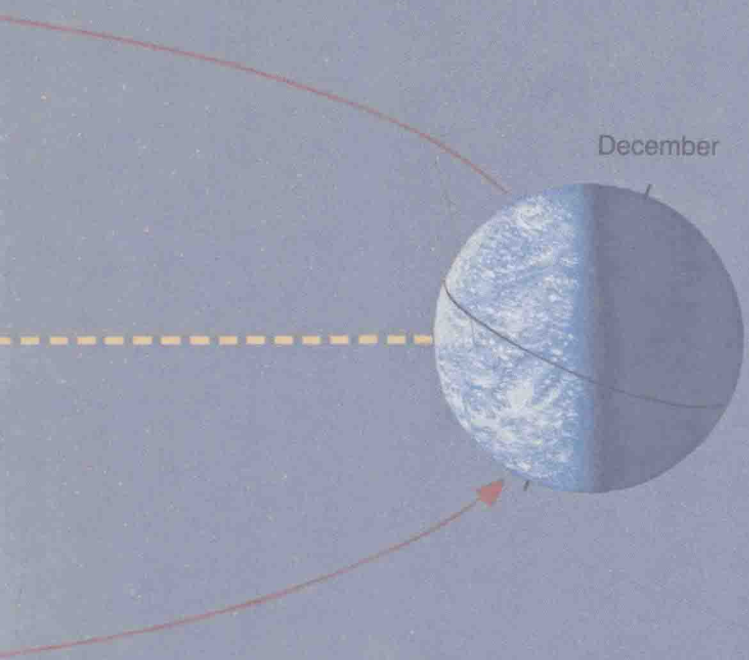
About June 21 Earth's axis tilts most toward the Sun. Then the Sun shines directly on the northern part of the world. People there get more sunshine than on any other day. Above the Arctic Circle people have sunlight for 24 hours (the midnight Sun). Summer officially begins above the equator.

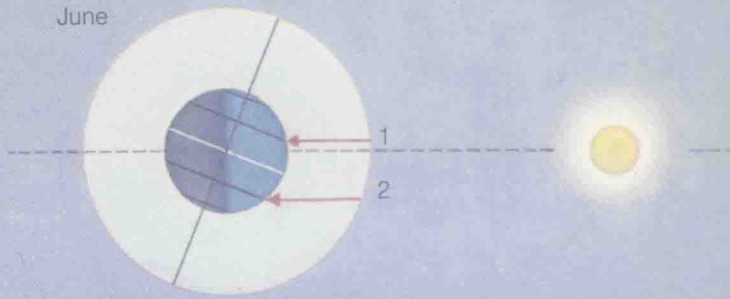
On the same day, sunlight hits the southern part of the world at a slant, delivering less heat to each spot on the ground. People there get their smallest share of sunshine. Below the Antarctic Circle the Sun doesn't shine at all. Winter officially begins below the equator.

Six months later Earth's axis tilts most away from the Sun. About December 22 the seasons are reversed in the world. Winter starts in the northern half while summer starts in the southern half.

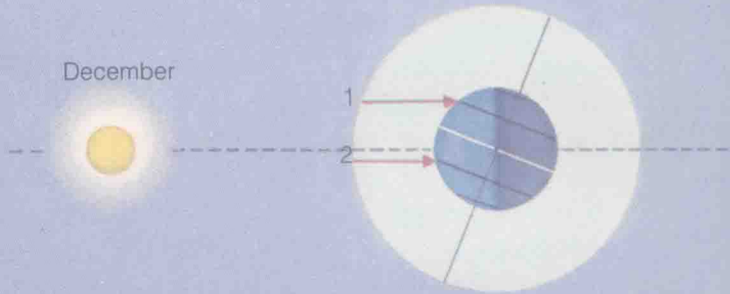
Twice a year, around March 21 and September 23, the Sun shines directly over the equator. All parts of the world have equal day and night. These days are called the equinoxes.

To get an idea of what a 23.5° angle looks like, hold your hand upright with the fingers spread apart. The angle between the ring and middle fingers is about 23.5°.

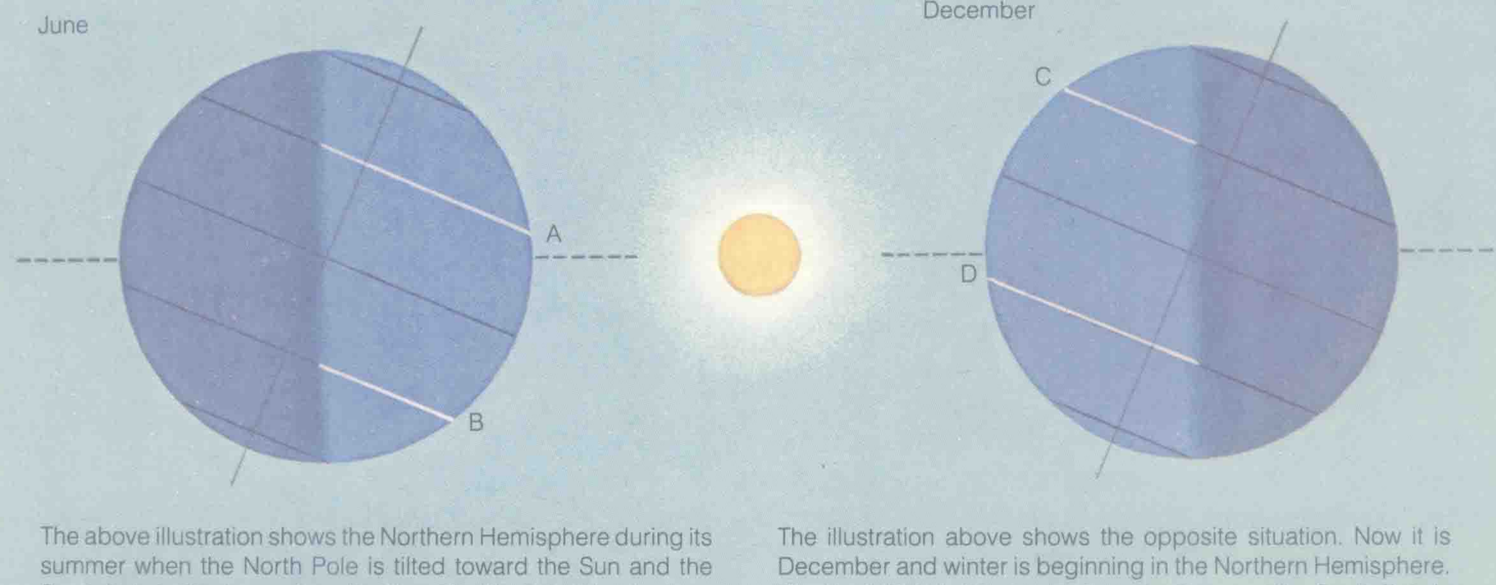




In summertime the Sun is high in the sky. Sunshine pours almost straight down to the ground. Because of this, sunshine is more concentrated in summer than in winter, when it hits at more of an angle. In the illustration above, the rays at region 1 hit Earth more directly than those at region 2 do. It is summertime north of the equator in June.



In December the rays hitting region 2 are more concentrated than the rays hitting region 1 are. The sunshine hitting region 1 is spread out over a greater area. It is summertime south of the equator in December.



The above illustration shows the Northern Hemisphere during its summer when the North Pole is tilted toward the Sun and the South Pole is tilted away from the Sun. The Northern Hemisphere receives longer periods of sunlight than the Southern Hemisphere does. The Northern Hemisphere is having long days and short nights. In June a person at point A has a longer period of daylight than a person at point B does.

The illustration above shows the opposite situation. Now it is December and winter is beginning in the Northern Hemisphere. The North Pole is tilted away from the Sun, and the South Pole is tilted toward the Sun. The Northern Hemisphere is having short days and long nights. The Southern Hemisphere is having long days and short nights. Point D has a longer period of daylight than point C does.

Starlight

ENORMOUS DISTANCES PREVENT us from seeing the stars up close, even with a telescope. Luckily we can learn a lot about space by studying the starlight that comes to Earth.

Starlight is a mixture of several different forms of energy. The light that we can see with our eyes is only a small part of the electromagnetic radiation coming from space. We cannot see the ultraviolet, X, and gamma rays, which have much more energy than the visible light we can see. We also cannot see the infrared rays, which feel warm on our skin, and the radio waves like those that carry radio and television transmissions.

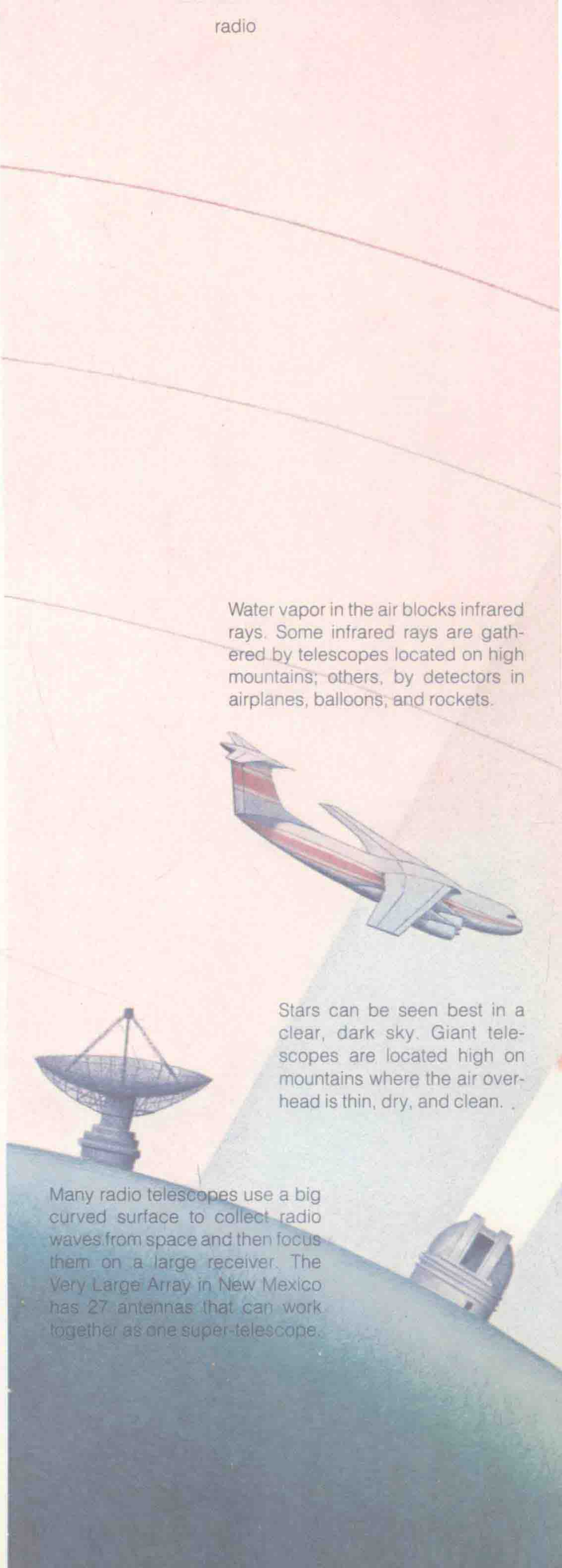
Each kind of star radiates a different mixture of visible and invisible light waves into space. The waves travel through space at the speed of light—over 186,000 miles (299,800 kilometers) per second. A light-year is the distance that light travels at this speed in one year. A light-year is almost 6 trillion miles (9.5 trillion kilometers).

Scientists collect starlight with telescopes. They separate it into patterns that give such information as what the star is made of and how hot it is.

Only some visible light, infrared and radio waves can get through the atmosphere and be collected by telescopes on Earth. So different telescopes are sent up in balloons, airplanes, rockets, and spacecraft to pick up all kinds of starlight before it is blocked by the atmosphere. Computers on Earth change information from invisible waves into pictures that show stars as never before seen by humans.

Our Sun is a star, and sunshine, like all starlight, is a mixture of colors. Here is an experiment that will show you the visible spectrum. Hold a prism so that a beam of sunlight passes through it. Move the prism until you see a rainbow of red, orange, yellow, green, blue, indigo, and violet spread out in a row. (Indigo may be difficult to see.)

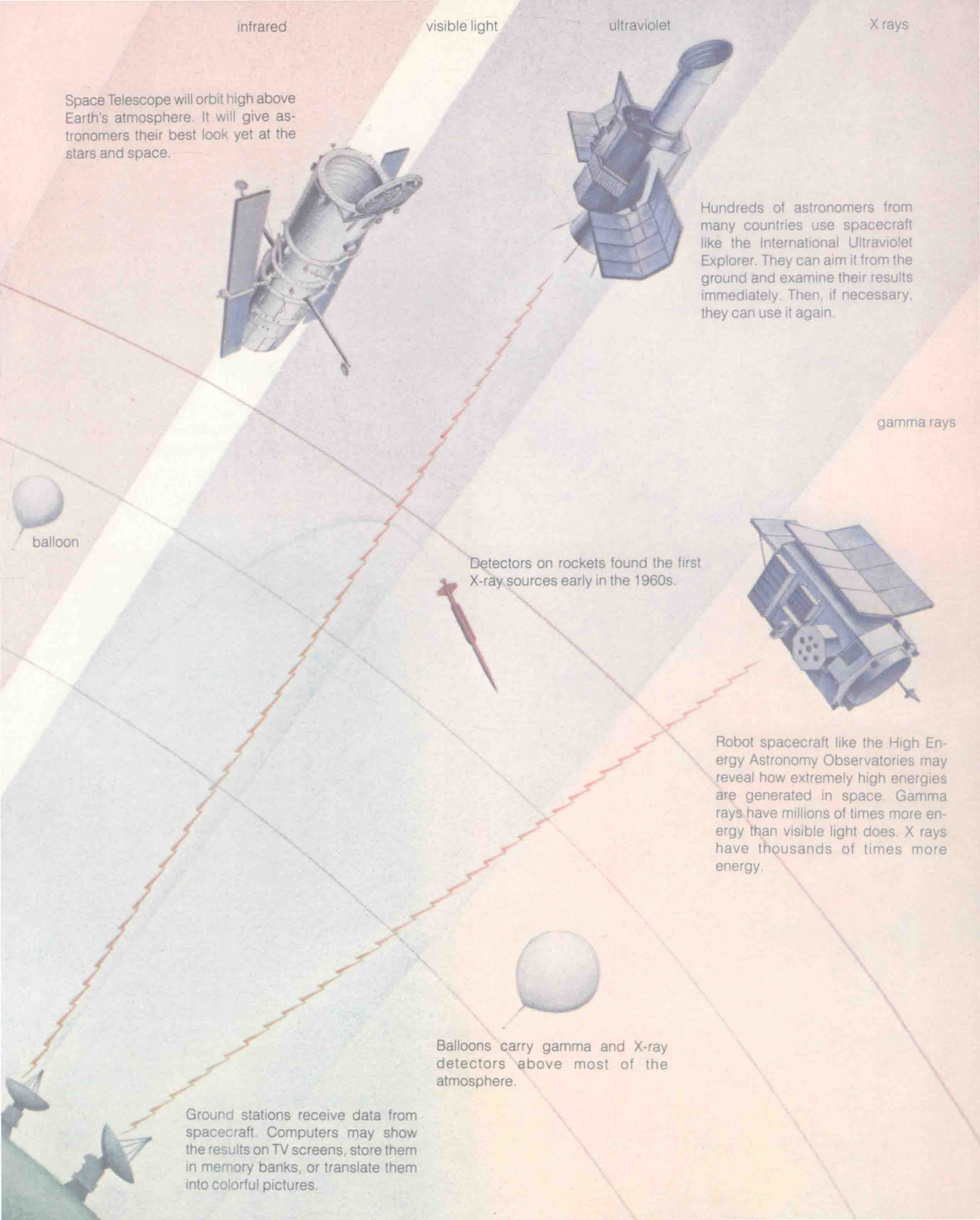
All the colors of the spectrum travel through space together at the speed of light. They separate in materials such as glass and water because some slow down more than others. So when sunlight is passed through these materials, you see its colorful parts.



Water vapor in the air blocks infrared rays. Some infrared rays are gathered by telescopes located on high mountains; others, by detectors in airplanes, balloons, and rockets.

Stars can be seen best in a clear, dark sky. Giant telescopes are located high on mountains where the air overhead is thin, dry, and clean.

Many radio telescopes use a big curved surface to collect radio waves from space and then focus them on a large receiver. The Very Large Array in New Mexico has 27 antennas that can work together as one super-telescope.



infrared
visible light
ultraviolet
X rays
Space Telescope will orbit high above Earth's atmosphere. It will give astronomers their best look yet at the stars and space.
Hundreds of astronomers from many countries use spacecraft like the International Ultraviolet Explorer. They can aim it from the ground and examine their results immediately. Then, if necessary, they can use it again.
gamma rays
balloon
Detectors on rockets found the first X-ray sources early in the 1960s.
Robot spacecraft like the High Energy Astronomy Observatories may reveal how extremely high energies are generated in space. Gamma rays have millions of times more energy than visible light does. X rays have thousands of times more energy.
Balloons carry gamma and X-ray detectors above most of the atmosphere.
Ground stations receive data from spacecraft. Computers may show the results on TV screens, store them in memory banks, or translate them into colorful pictures.

Optical Telescopes

OUR EYES CAN SEE a few of the wonders of space, but we can see many more with a telescope. Even a small telescope can help us see distant stars and galaxies that are too faint to see with our eyes alone. The Moon and the planets look closer through a small telescope, and some of their features can be seen.

A telescope collects light from an object in the sky and forms its image. You can look at this image through a magnifying lens called an eyepiece. You can also record and analyze the image in other ways.

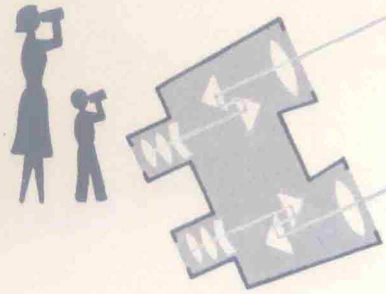
There are two basic types of telescopes: refractors and reflectors. A refracting telescope has a lens to gather the light and form an image. For stargazing, the lens is mounted at the front end of a tube that keeps out stray light. An eyepiece (lens) at the opposite end of the tube magnifies the image. The image is always inverted and reversed, or upside down and left to right.

In a reflecting telescope a mirror produces images. For stargazing, it is mounted at the back end of a tube and reflects incoming light to form an image near the front end. A smaller mirror intercepts the light and reflects it to the eyepiece. Mirrors can be made very large to collect light from extremely faint objects. All the world's largest telescopes are reflectors.

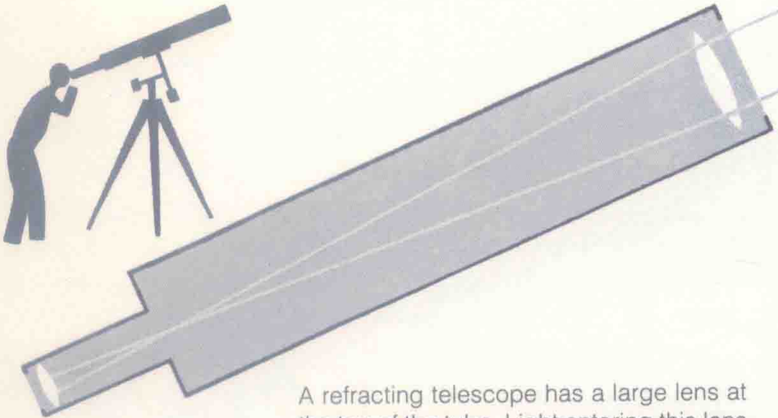
The performance of a telescope depends a lot on the size and quality of its lens or mirror. The size of a telescope, such as a 6-inch (15-centimeter) or 200-inch (5-meter), refers to the main lens or the mirror. Here, bigger is better. A large mirror or lens shows sky objects brighter and clearer than a small one does.

You can use either a reflecting or a refracting telescope for your stargazing. A refractor is easier to care for, but a reflector of the same size is much less expensive. You can also make one yourself.

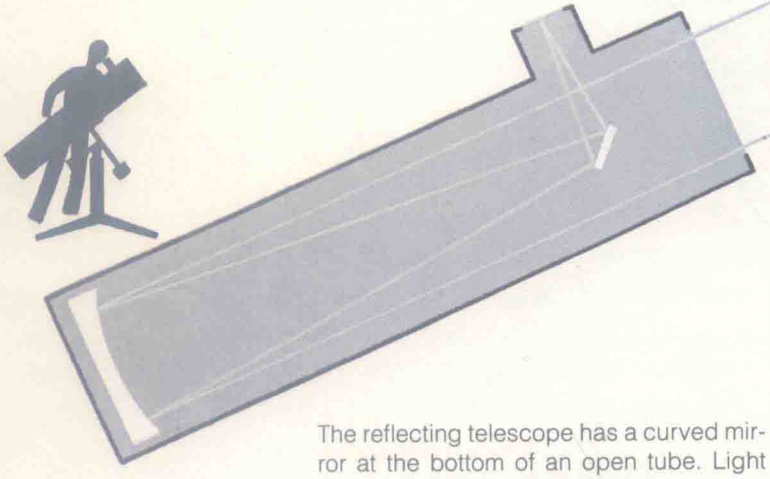
Astronomers rarely look through a giant telescope except to aim it. The light collected by the telescope is focused on electronic imaging systems and is then fed into instruments for analysis. The information may be recorded on photographic film, viewed on a television screen, or processed by a computer.



Binoculars collect more light than our eyes alone can collect. They are marked to give their power (magnification) and the size of their lenses. Binoculars labeled 7 x 50 are useful for stargazing (7 = power, 50 = millimeters of lens size).



A refracting telescope has a large lens at the top of the tube. Light entering this lens is refracted, or bent, and forms an image near the bottom of the tube. With different eyepieces the magnifying power can be increased or decreased.



The reflecting telescope has a curved mirror at the bottom of an open tube. Light striking this mirror is reflected back up the tube and forms an image at the focal point—the point where the image is in focus—where photographic film can be placed.