

ALWAYS LEARNING PEARSON

Earth Science Edward J. Tarbuck Frederick K. Lutgens

Illustrated by

Dennis Tasa

PEARSON

Boston Columbus Indianapolis

New York San Francisco Upper Saddle River

Amsterdam Cape Town Dubai London

Madrid Munich Paris Montréal Toronto

Delhi Mexico City São Paulo Sydney

Hong Kong Seoul Singapore Taipei Tokyo

Earth Science, Global Edition

Table of Contents

Cover
Title
Copyright
Contents
1 Introduction to Earth Science
FOCUS ON CONCEPTS
What Is Earth Science?
Geology
Oceanography
Meteorology
Astronomy
Earth Science Is Environmental Science
Scales of Space and Time in Earth Science
The Nature of Scientific Inquiry
Hypothesis
GEO GRAPHICS World Population Passes 7 Billion
Theory
Scientific Methods
EYE ON EARTH
Early Evolution of Earth
Origin of Planet Earth
The Inner Planets Form The Outer Planets Develop
·
Earths Spheres
GEO GRAPHICS Solar System: Size and Scale
Hydrosphere
Atmosphere Biosphere
EYE ON EARTH
Geosphere
A Closer Look at the Geosphere
Earths Internal Structure

The Mobile Geosphere

The Face of Earth



Major Features of the Continents

Major Features of the Ocean Basins

EYE ON EARTH

Earth as a System

Earth System Science

The Earth System

Concepts in Review

Give It Some Thought

UNIT ONE | EARTH MATERIALS

2 Matter and Minerals

FOCUS ON CONCEPTS

Minerals: Building Blocks of Rock

Defining a Mineral

What Is a Rock?

Atoms: Building Blocks of Minerals

Properties of Protons, Neutrons, and Electrons

Elements: Defined by Their Number of Protons

GEO GRAPHICS | Gold

Why Atoms Bond

The Octet Rule and Chemical Bonds

Ionic Bonds: Electrons Transferred

Covalent Bonds: Electron Sharing

Metallic Bonds: Electrons Free to Move

EYE ON EARTH

Properties of a Mineral

Optical Properties

Crystal Shape, or Habit

Mineral Strength

Density and Specific Gravity

Other Properties of Minerals

Mineral Groups

Silicate Minerals

EYE ON EARTH

Important Nonsilicate Minerals

Natural Resources

Renewable Versus Nonrenewable Resources

Mineral Resources

GEO GRAPHICS | Gemstones

Concepts in Review

Give It Some Thought

3 Rocks: Materials of the Solid Earth

FOCUS ON CONCEPTS

Earth as a System: The Rock Cycle

The Basic Cycle



Alternative Paths

Igneous Rocks: Formed by Fire

From Magma to Crystalline Rock

Igneous Compositions

What Can Igneous Textures Tell Us?

Common Igneous Rocks

How Different Igneous Rocks Form

EYE ON EARTH

Sedimentary Rocks: Compacted and Cemented Sediment

Classifying Sedimentary Rocks

Lithification of Sediment

Features of Sedimentary Rocks

Metamorphic Rocks: New Rock from Old

What Drives Metamorphism?

EYE ON EARTH

Metamorphic Textures

Common Metamorphic Rocks

Resources from Rocks and Minerals

Metallic Mineral Resources

GEO GRAPHICS | Marble

Nonmetallic Mineral Resources

Energy Resources: Fossil Fuels

EYE ON EARTH

Concepts in Review

Give It Some Thought

UNIT TWO | SCULPTING EARTHS SURFACE

4 Weathering, Soil, and Mass Wasting

FOCUS ON CONCEPTS

Earths External Processes

Weathering

GEO GRAPHICS | Some Everyday Examples of Weathering

Mechanical Weathering

Chemical Weathering

EYE ON EARTH

GEO GRAPHICS | The Old Man of the Mountain

Rates of Weathering

Rock Characteristics

Climate

Differential Weathering

Soil

An Interface in the Earth System

What Is Soil?

Soil Texture and Structure



Controls of Soil Formation Parent Material Time Climate Plants and Animals Topography The Soil Profile Classifying Soils EYE ON EARTH Soil Erosion: Losing a Vital Resource Mass Wasting: The Work of Gravity Landslides as Geologic Hazards The Role of Mass Wasting in Landform Development Slopes Change Through Time GEO GRAPHICS | Landslides as Natural Disasters Controls and Triggers of Mass Wasting The Role of Water Oversteepened Slopes Removal of Vegetation Earthquakes as Triggers Classifying Mass-Wasting Processes Type of Motion Rate of Movement **EYE ON EARTH** Rapid Forms of Mass Wasting Slump Rockslide Debris Flow Earthflow Slow Forms of Mass Wasting Creep Solifluction Concepts in Review Give It Some Thought

5 Running Water and Groundwater

FOCUS ON CONCEPTS

Earth as a System: The Hydrologic Cycle

Earths Water
Waters Paths
Storage in Glaciers



Water Balance

Running Water

Drainage Basins

River Systems

Drainage Patterns

Streamflow

Factors Affecting Flow Velocity

Changes from Upstream to Downstream

The Work of Running Water

Stream Erosion

EYE ON EARTH

GEO GRAPHICS | What Are the Largest Rivers?

Transportation of Sediment

Deposition of Sediment

Stream Channels

Bedrock Channels

Alluvial Channels

Shaping Stream Valleys

Base Level and Stream Erosion

Valley Deepening

Valley Widening

Changing Base Level and Incised Meanders

Depositional Landforms

Deltas

EYE ON EARTH

Natural Levees

Alluvial Fans

Floods and Flood Control

Causes of Floods

Flood Control

GEO GRAPHICS | Flash Floods

Groundwater: Water Beneath the Surface

The Importance of Groundwater

Groundwaters Geologic Roles

Distribution of Groundwater

EYE ON EARTH

Factors Influencing the Storage and Movement of Groundwater

Groundwater Movement

Springs, Wells, and Artesian Systems

Springs

Artesian Systems

EYE ON EARTH

Environmental Problems of Groundwater

Treating Groundwater as a Nonrenewable Resource

Land Subsidence Caused by Groundwater Withdrawal

Groundwater Contamination



The Geologic Work of Groundwater

Caverns

Karst Topography

Concepts in Review

Give It Some Thought

6 Glaciers, Deserts, and Wind FOCUS ON CONCEPTS

Glaciers and the Earth System

Glaciers: A Part of Two Basic Cycles

Valley (Alpine) Glaciers

Ice Sheets

Other Types of Glaciers

How Glaciers Move

Observing and Measuring Movement

GEO GRAPHICS | Antarctica Fact File

Budget of a Glacier: Accumulation Versus Wastage

Glacial Erosion

How Glaciers Erode

Landforms Created by Glacial Erosion

Glacial Deposits

Types of Glacial Drift

EYE ON EARTH

Moraines, Outwash Plains, and Kettles

Drumlins, Eskers, and Kames

Other Effects of Ice Age Glaciers

Changing Rivers

Crustal Subsidence and Rebound

Proglacial Lakes Created by Ice Dams

Sea-Level Changes

Pluvial Lakes

Extent of Ice Age Glaciation

Causes of Ice Ages

Plate Tectonics

Variations in Earths Orbit

Other Factors

Deserts

Distribution and Causes of Dry Lands

Geologic Processes in Arid Climates

Basin and Range: The Evolution of a Mountainous Desert Landscape

EYE ON EARTH

Wind Erosion

Deflation, Blowouts, and Desert Pavement

Wind Abrasion

Wind Deposits

Loess



Sand Dunes

Types of Sand Dunes

EYE ON EARTH

Concepts in Review

Give It Some Thought

UNIT THREE | FORCES WITHIN

7 Plate Tectonics: A Scientific Revolution Unfolds

FOCUS ON CONCEPTS

From Continental Drift to Plate Tectonics

Continental Drift: An Idea Before Its Time

Evidence: The Continental Jigsaw Puzzle

Evidence: Fossils Matching Across the Seas

Evidence: Rock Types and Geologic Features

Evidence: Ancient Climates

The Great Debate

Rejection of the Drift Hypothesis

The Theory of Plate Tectonics

Rigid Lithosphere Overlies Weak Asthenosphere

Earths Major Plates

Plate Boundaries

Divergent Plate Boundaries and Seafloor Spreading

Oceanic Ridges and Seafloor Spreading

Continental Rifting

Convergent Plate Boundaries and Subduction

OceanicContinental Convergence

OceanicOceanic Convergence

ContinentalContinental Convergence

Transform Plate Boundaries

How Do Plates and Plate Boundaries Change?

The Breakup of Pangaea

EYE ON EARTH

Plate Tectonics in the Future

Testing the Plate Tectonics Model

Evidence: Ocean Drilling

Evidence: Mantle Plumes and Hot Spots

Evidence: Paleomagnetism

How Is Plate Motion Measured

Geologic Evidence for Plate Motion

Measuring Plate Motion from Space

What Drives Plate Motions?

Forces That Drive Plate Motion

Models of PlateMantle Convection

EYE ON EARTH

Concepts in Review

Give It Some Thought



8 Earthquakes and Earths Interior

FOCUS ON CONCEPTS

What Is an Earthquake?

Discovering the Causes of Earthquakes

Aftershocks and Foreshocks

Faults and Large Earthquakes

EYE ON EARTH

Seismology: The Study of Earthquake Waves

Instruments That Record Earthquakes

Seismic Waves

Determining the Size of Earthquakes

Intensity Scales

Magnitude Scales

GEO GRAPHICS | Finding the Epicenter of an Earthquake

Earthquake Destruction

Destruction from Seismic Vibrations

Landslides and Ground Subsidence

Fire

EYE ON EARTH

What Is a Tsunami?

Earthquake Belts and Plate Boundaries

GEO GRAPHICS | Historic Earthquakes East of the Rockies

Can Earthquakes Be Predicted?

Short-Range Predictions

Long-Range Forecasts

GEO GRAPHICS | Seismic Risks on the San Andreas Fault System

Earths Interior

Formation of Earths Layered Structure

Probing Earths Interior: Seeing Seismic Waves

Earths Layers

Crust

Mantle

Core

Concepts in Review

Give It Some Thought

9 Volcanoes and Other Igneous Activity

FOCUS ON CONCEPTS

Mount St. Helens Versus Kilauea

The Nature of Volcanic Eruptions

Factors Affecting Viscosity

Quiescent Versus Explosive Eruptions

Materials Extruded During an Eruption

Lava Flows

Gases



Pyroclastic Materials

Anatomy of a Volcano

GEO GRAPHICS | Comparison of Three Types of Volcanic Cones

Shield Volcanoes

Mauna Loa: Earths Largest Shield Volcano

Kilauea, Hawaii: Eruption of a Shield Volcano

GEO GRAPHICS | Kilaueas East Rift Zone Eruption

Cinder Cones

Parícutin: Life of a Garden-Variety Cinder Cone

Composite Volcanoes

GEO GRAPHICS | Eruption of Mount Vesuvius, ad 79

Volcanic Hazards

Pyroclastic Flow: A Deadly Force of Nature

Lahars: Mudflows on Active and Inactive Cones

Other Volcanic Hazards

Other Volcanic Landforms

Calderas

Fissure Eruptions and Basalt Plateaus

EYE ON EARTH

Volcanic Necks and Pipes

Intrusive Igneous Activity

Nature of Intrusive Bodies

EYE ON EARTH

Tabular Intrusive Bodies: Dikes and Sills

Massive Intrusive Bodies: Batholiths, Stocks, and Laccoliths

Partial Melting and the Origin of Magma

Partial Melting

Generating Magma from Solid Rock

Decrease in Pressure: Decompression Melting

Plate Tectonics and Volcanic Activity

Volcanism at Convergent Plate Boundaries

Volcanism at Divergent Plate Boundaries

Intraplate Volcanism

Concepts in Review

Give It Some Thought

10 Crustal Deformation and Mountain Building FOCUS ON CONCEPTS

Crustal Deformation

What Causes Rocks to Deform?

Types of Deformation

Factors That Affect Rock Strength

Folds: Rock Structures Formed by Ductile Deformation

Anticlines and Synclines

EYE ON EARTH

Domes and Basins



Monoclines

Faults and Joints: Rock Structures Formed by Brittle Deformation

Dip-Slip Faults

Strike-Slip Faults

Joints

Mountain Building

Subduction and Mountain Building

Island ArcType Mountain Building

Andean-Type Mountain Building

EYE ON EARTH

Sierra Nevada, Coast Ranges, and Great Valley

Collisional Mountain Belts

Cordilleran-Type Mountain Building

Alpine-Type Mountain Building: Continental Collisions

The Himalayas

The Appalachians

What Causes Earths Varied Topography?

GEO GRAPHICS | The Laramide Rockies

The Principle of Isostasy

How High Is Too High?

Concepts in Review

Give It Some Thought

UNIT FOUR | DECIPHERING EARTHS HISTORY

11 Geologic Time

FOCUS ON CONCEPTS

A Brief History of Geology

Catastrophism

The Birth of Modern Geology

Geology Today

Creating a Time Scale: Relative Dating Principle

The Importance of a Time Scale

Numerical and Relative Dates

Principle of Superposition

Principle of Original Horizontality

Principle of Lateral Continuity

Principle of Cross-Cutting Relationships

EYE ON EARTH

Principle of Inclusions

Unconformities

Applying Relative Dating Principles

EYE ON EARTH

Fossils: Evidence of Past Life

Types of Fossils

GEO GRAPHICS | How is Paleontology Different from Archaeology?

Conditions Favoring Preservation



Correlation of Rock Layers

Correlation Within Limited Areas

Fossils and Correlation

Dating with Radioactivity

Reviewing Basic Atomic Structure

Radioactivity

Half-Life

Using Various Isotopes

Dating with Carbon-14

The Geologic Time Scale

Structure of the Time Scale

Precambrian Time

EYE ON EARTH

Terminology and the Geologic Time Scale

Determining Numerical Dates for Sedimentary Strata

EYE ON EARTH

GEO GRAPHICS | Did Humans and Dinosaurs Ever Coexist?

Concepts in Review

Give It Some Thought

12 Earths Evolution Through Geologic Time FOCUS ON CONCEPTS

Is Earth Unique?

The Right Planet

The Right Location

The Right Time

Viewing Earths History

Birth of a Planet

From the Big Bang to Heavy Elements

From Planetesimals to Protoplanets

Earths Early Evolution

Origin and Evolution of the Atmosphere and Oceans

Earths Primitive Atmosphere

Oxygen in the Atmosphere

Evolution of the Oceans

Precambrian History: The Formation of Earths Continents

Earths First Continents

EYE ON EARTH

The Making of North America

Supercontinents of the Precambrian

Geologic History of the Phanerozoic: The Formation of Earths Modern Continents

Paleozoic History

Mesozoic History

Cenozoic History

Earths First Life

Origin of Life



Earths First Life: Prokaryotes

Paleozoic Era: Life Explodes

Early Paleozoic Life-Forms

GEO GRAPHICS | Evolution of Life Through Geologic Time

EYE ON EARTH

Vertebrates Move to Land

Reptiles: The First True Terrestrial Vertebrates

The Great Permian Extinction

GEO GRAPHICS | Demise of the Dinosaurs

Mesozoic Era: Age of the Dinosaurs

Gymnosperms: The Dominant Mesozoic Trees Reptiles: Dominating the Land, Sea, and Sky

Cenozoic Era: Age of Mammals

From Reptiles to Mammals

Marsupial and Placental Mammals

Humans: Mammals with Large Brains and Bipedal Locomotion

Large Mammals and Extinction

Concepts in Review

Give It Some Thought

UNIT FIVE | THE GLOBAL OCEAN

13 The Ocean Floor

FOCUS ON CONCEPTS

The Vast World Ocean

Geography of the Oceans

Comparing the Oceans to the Continents

An Emerging Picture of the Ocean Floor

Mapping the Seafloor

Provinces of the Ocean Floor

Continental Margins

Passive Continental Margins

EYE ON EARTH

Active Continental Margins

Features of Deep-Ocean Basins

Deep-Ocean Trenches

GEO GRAPHICS | Explaining Coral Atolls: Darwins Hypothesis

Abyssal Plains

Volcanic Structures on the Ocean Floor

The Oceanic Ridge

Anatomy of the Oceanic Ridge

Why Is the Oceanic Ridge Elevated?

Seafloor Sediments

Types of Seafloor Sediments

Seafloor SedimentA Storehouse of Climate Data

Resources from the Seafloor



Energy Resources

Other Resources

EYE ON EARTH

Concepts in Review

Give It Some Thought

14 Ocean Water and Ocean Life

FOCUS ON CONCEPTS

Composition of Seawater

Salinity

Sources of Sea Salts

Processes Affecting Seawater Salinity

Recent Increase in Ocean Acidity

Variations in Temperature and Density with Depth

Temperature Variations

Density Variations

EYE ON EARTH

Ocean Layering

The Diversity of Ocean Life

Classification of Marine Organisms

Marine Life Zones

GEO GRAPHICS | Deep-Sea Hydrothermal Vents

EYE ON EARTH

Ocean Productivity

Productivity in Polar Oceans

Productivity in Tropical Oceans

Productivity in Midlatitude Oceans

Oceanic Feeding Relationships

Trophic Levels

Transfer Efficiency

Food Chains and Food Webs

Concepts in Review

Give It Some Thought

15 The Dynamic Ocean

FOCUS ON CONCEPTS

The Oceans Surface Circulation

The Pattern of Ocean Currents

Upwelling and Deep-Ocean Circulation

Coastal Upwelling

Deep-Ocean Circulation

The Shoreline: A Dynamic Interface

The Coastal Zone

Basic Features

Beaches

Ocean Waves

Wave Characteristics



EYE ON EARTH

Circular Orbital Motion

Waves in the Surf Zone

The Work of Waves

Wave Erosion

Sand Movement on the Beach

Shoreline Features

Erosional Features

Depositional Features

The Evolving Shore

Stabilizing the Shore

Hard Stabilization

Alternatives to Hard Stabilization

EYE ON EARTH

Contrasting Americas Coasts

Atlantic and Gulf Coasts

Pacific Coast

Coastal Classification

EYE ON EARTH

GEO GRAPHICS | A Brief Tour of Americas Coasts

Tides

Causes of Tides

Monthly Tidal Cycle

Tidal Patterns

Tidal Currents

Concepts in Review

Give It Some Thought

UNIT SIX | EARTHS DYNAMICAT MOSPHERE

16 The Atmosphere: Composition, Structure, and Temperature

FOCUS ON CONCEPTS Focus on the Atmosphere

Weather in the United States

Weather and Climate

EYE ON EARTH

Composition of the Atmosphere

Major Components

Carbon Dioxide (CO2)

Variable Components

Ozone Depletion: A Global Issue

GEO GRAPHICS | Acid Precipitation

Vertical Structure of the Atmosphere

Pressure Changes

Temperature Changes

EarthSun Relationships

Earths Motions



What Causes the Seasons?

Earths Orientation

Solstices and Equinoxes

EYE ON EARTH

Energy, Heat, and Temperature

Mechanism of Heat Transfer: Conduction

EYE ON EARTH

Mechanism of Heat Transfer: Convection

Mechanism of Heat Transfer: Radiation

Heating the Atmosphere

What Happens to Incoming Solar Radiation?

Reflection and Scattering

Absorption

Heating the Atmosphere: The Greenhouse Effect

For the Record: Air Temperature Data

Why Temperatures Vary: The Controls of Temperature

Land and Water

Altitude

Geographic Position

Cloud Cover and Albedo

EYE ON EARTH

World Distribution of Temperature

Concepts in Review

Give It Some Thought

17 Moisture, Clouds, and Precipitation

FOCUS ON CONCEPTS

Waters Changes of State

Ice, Liquid Water, and Water Vapor

Latent Heat

EYE ON EARTH

Humidity: Water Vapor in the Air

Saturation

Mixing Ratio

Relative Humidity

Dew-Point Temperature

Measuring Humidity

The Basis of Cloud Formation: Adiabatic Cooling

Fog and Dew Versus Cloud Formation

Adiabatic Temperature Changes

Adiabatic Cooling and Condensation

Processes That Lift Air

Orographic Lifting

Frontal Wedging

Convergence

Localized Convective Lifting

The Weathermaker: Atmospheric Stability



Types of Stability Stability and Daily Weather Condensation and Cloud Formation Types of Clouds EYE ON EARTH Fog Fogs Caused by Cooling **Evaporation Fogs** How Precipitation Forms Precipitation from Cold Clouds: The Bergeron Process Precipitation from Warm Clouds: The CollisionCoalescence Process Forms of Precipitation Rain Snow Sleet and Glaze GEO GRAPHICS | Our Water Supply Rime Measuring Precipitation Measuring Snowfall Precipitation Measurement by Weather Radar Concepts in Review Give It Some Thought 18 Air Pressure and Wind **FOCUS ON CONCEPTS** Understanding Air Pressure Visualizing Air Pressure Measuring Air Pressure Factors Affecting Wind Pressure Gradient Force Coriolis Effect Friction with Earths Surface Highs and Lows Cyclonic and Anticyclonic Winds Weather Generalizations About Highs and Lows General Circulation of the Atmosphere Circulation on a Nonrotating Earth Idealized Global Circulation Influence of Continents EYE ON EARTH The Westerlies Local Winds Land and Sea Breezes

Mountain and Valley Breezes
Chinook and Santa Ana Winds

Measuring Wind



EYE ON EARTH

El Niño and La Niña and the Southern Oscillation

Impact of El Niño

Impact of La Niña

GEO GRAPHICS | The 1930s Dust Bowl

Southern Oscillation

Global Distribution of Precipitation

The Influence of Pressure and Wind Belts

Other Factors

EYE ON EARTH

Concepts in Review

Give It Some Thought

19 Weather Patterns and Severe Storms FOCUS ON CONCEPTS

Air Masses

What Is an Air Mass?

Source Regions

Weather Associated with Air Masses

EYE ON EARTH

Fronts

Warm Fronts

Cold Fronts

Stationary Fronts and Occluded Fronts

Midlatitude Cyclones

Idealized Weather of a Midlatitude Cyclone

The Role of Airflow Aloft

EYE ON EARTH

Thunderstorms

Whats in a Name?

Thunderstorm Occurrence

Stages of Thunderstorm Development

Tornadoes

Tornado Occurrence and Development

Tornado Destruction and Loss of Life

EYE ON EARTH

Tornado Forecasting

Hurricanes

Profile of a Hurricane

GEO GRAPHICS | Hurricane Katrina from Space

Hurricane Formation and Decay

Hurricane Destruction

Tracking Hurricanes

Concepts in Review

Give It Some Thought

20 World Climates and Global Climate Change



FOCUS ON CONCEPTS

The Climate System

World Climates

EYE ON EARTH

Climate Classification

The Köppen Classification

Humid Tropical (A) Climates

The Wet Tropics

Tropical Wet and Dry

Dry (B) Climates

Low-Latitude Deserts and Steppes

Middle-Latitude Deserts and Steppes

EYE ON EARTH

Humid Middle-Latitude Climates (C and D Climates)

Humid Middle-Latitude Climates with Mild Winters (C Climates)

Humid Middle-Latitude Climates with Severe Winters (D Climates)

Polar (E) Climates

Highland Climates

Human Impact on Global Climate

Rising CO2 Levels

EYE ON EARTH

The Atmospheres Response

The Role of Trace Gases

GEO GRAPHICS | Greenhouse Gas (GHG) Emissions

Climate-Feedback Mechanisms

Types of Feedback Mechanisms

Computer Models of Climate: Important yet Imperfect Tools

How Aerosols Influence Climate

Some Possible Consequences of Global Warming

Sea-Level Rise

The Changing Arctic

The Potential for Surprises

Concepts in Review

Give It Some Thought

UNIT SEVEN | EARTHS PLACE IN THE UNIVERSE

21 Origins of Modern Astronomy

FOCUS ON CONCEPTS

Ancient Astronomy

The Golden Age of Astronomy

Ptolemys Model

The Birth of Modern Astronomy

Nicolaus Copernicus

Tycho Brahe

Johannes Kepler

Galileo Galilei



Sir Isaac Newton

Positions in the Sky

Constellations

GEO GRAPHICS | Orion the Hunter

The Equatorial System

The Motions of Earth

Rotation

Revolution

EYE ON THE UNIVERSE

Precession

Motions of the EarthMoon System

Lunar Motions

Phases of the Moon

Eclipses of the Sun and Moon

Concepts in Review

Give It Some Thought

22 Touring Our Solar System

FOCUS ON CONCEPTS

Our Solar System: An Overview

Nebular Theory: Formation of the Solar System

The Planets: Internal Structures and Atmospheres

Planetary Impacts

Earths Moon: A Chip Off the Old Block

How Did the Moon Form?

EYE ON THE UNIVERSE

Terrestrial Planets

Mercury: The Innermost Planet

EYE ON THE UNIVERSE

Venus: The Veiled Planet

Mars: The Red Planet

GEO GRAPHICS | Mars Exploration

Jovian Planets

Jupiter: Lord of the Heavens

Saturn: The Elegant Planet

Uranus and Neptune: Twins

Small Solar System Bodies

Asteroids: Leftover Planetesimals

Comets: Dirty Snowballs

Meteoroids: Visitors to Earth

Dwarf Planets

Concepts in Review

Give It Some Thought

23 Light, Astronomical Observations, and the Sun FOCUS ON CONCEPTS



Signals from Space Nature of Light Light as Evidence of Events and Processes Spectroscopy Continuous Spectrum Dark-Line Spectrum Bright-Line Spectrum The Doppler Effect Collecting Light Using Optical Telescopes Refracting Telescopes Reflecting Telescopes Light Collection Radio-and Space-Based Astronomy Radio Telescopes Orbiting Observatories The Sun Photosphere Chromosphere Corona The Active Sun Sunspots Prominences Solar Flares EYE ON THE UNIVERSE GEO GRAPHICS | Hubble Space Telescope The Source of Solar Energy Concepts in Review Give It Some Thought 24 Beyond Our Solar System **FOCUS ON CONCEPTS** The Universe How Large Is It? A Brief History of the Universe Interstellar Matter: Nursery of the Stars Bright Nebulae Dark Nebulae Classifying Stars: HertzsprungRussell Diagrams (H-R Diagrams) Stellar Evolution Stellar Birth Protostar Stage Main-Sequence Stage



Red Giant Stage

EYE ON THE UNIVERSE

Burnout and Death

Stellar Remnants

White Dwarfs

Neutron Stars

Black Holes

Galaxies and Galactic Clusters

GEO GRAPHICS | The Milky Way

Types of Galaxies

Galactic Clusters

Galactic Collisions

The Big Bang Theory

Evidence for an Expanding Universe

Predictions of the Big Bang Theory

What Is the Fate of the Universe?

Concepts in Review

Give It Some Thought

APENDIX A Metric and English Units Compared
APENDIX B Relative Humidity and Dew-Point Tables
APENDIX C Stellar Properties
GLOSSARY
INDEX