

CONTENTS

10 INTRODUCTION

FROM MYTH TO SCIENCE

600 BCE—1550 CE

- 20 It is clear that Earth does not move**
The geocentric model
- 21 Earth revolves around the sun on the circumference of a circle**
Early heliocentric model
- 22 The equinoxes move over time**
Shifting stars
- 23 The moon's brightness is produced by the radiance of the sun**
Theories about the moon
- 24 All matters useful to the theory of heavenly things**
Consolidating knowledge

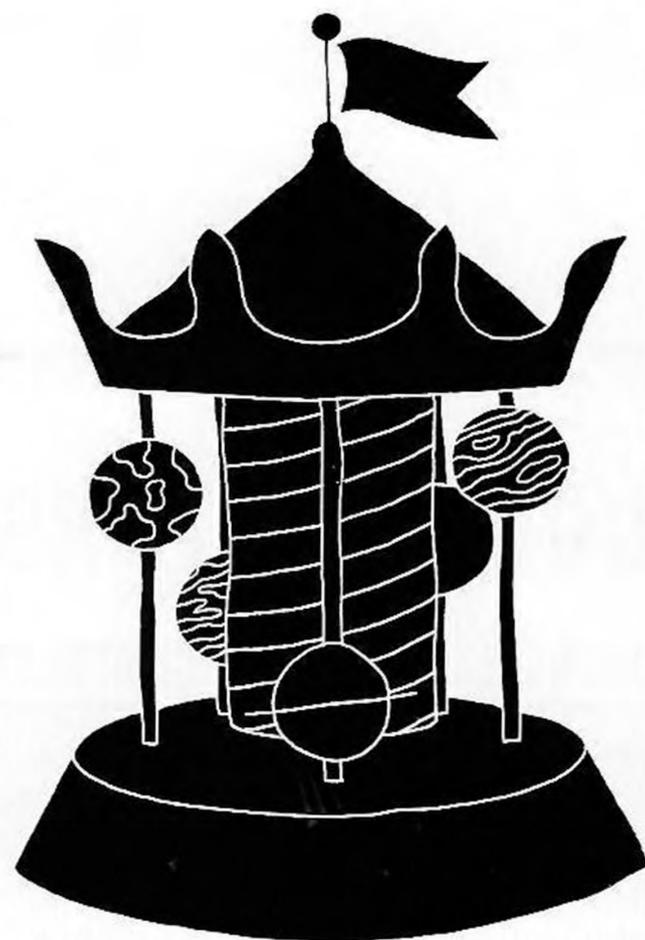


- 26 The unmoving stars go uniformly westward**
Earth's rotation
- 27 A little cloud in the night sky**
Mapping the galaxies
- 28 A new calendar for China**
The solar year
- 30 We have re-observed all of the stars in Ptolemy's catalog**
Improved instruments
- 32 Finally we shall place the sun himself at the center of the universe**
The Copernican model

THE TELESCOPE REVOLUTION

1550—1750

- 44 I noticed a new and unusual star**
The Tycho model
- 48 Mira Ceti is a variable star**
A new kind of star
- 50 The most true path of the planet is an ellipse**
Elliptical orbits
- 56 Our own eyes show us four stars traveling around Jupiter**
Galileo's telescope
- 64 A perfectly circular spot centered on the sun**
The transit of Venus
- 65 New moons around Saturn**
Observing Saturn's rings
- 66 Gravity explains the motions of the planets**
Gravitational theory
- 74 I dare venture to foretell that the comet will return again in the year 1758**
Halley's comet
- 78 These discoveries are the most brilliant and useful of the century**
Stellar aberration
- 79 A catalog of the southern sky**
Mapping southern stars



URANUS TO NEPTUNE 1750–1850

- 84 **I found that it is a comet, for it has changed its place**
Observing Uranus
- 86 **The brightness of the star was altered**
Variable stars
- 87 **Our Milky Way is the dwelling, the nebulae are the cities**
Messier objects
- 88 **On the construction of the heavens**
The Milky Way
- 90 **Rocks fall from space**
Asteroids and meteorites
- 92 **The mechanism of the heavens**
Gravitational disturbances
- 94 **I surmise that it could be something better than a comet**
The discovery of Ceres

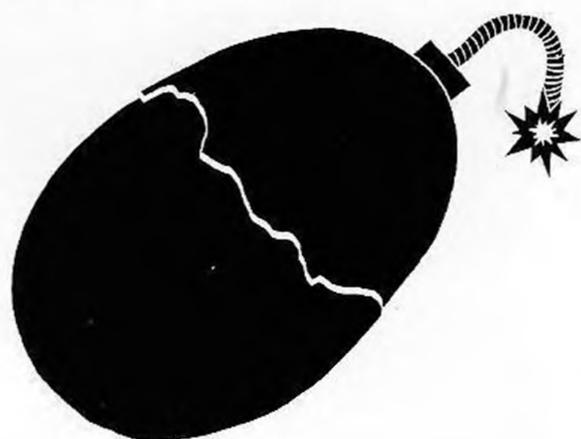


- 100 **A survey of the whole surface of the heavens**
The southern hemisphere
- 102 **An apparent movement of the stars**
Stellar parallax
- 103 **Sunspots appear in cycles**
The surface of the sun
- 104 **A spiral form of arrangement was detected**
Examining nebulae
- 106 **The planet whose position you have pointed out actually exists**
The discovery of Neptune

THE RISE OF ASTROPHYSICS 1850–1915

- 112 **Sodium is to be found in the solar atmosphere**
The sun's spectrum
- 113 **Stars can be grouped by their spectra**
Analyzing starlight
- 114 **Enormous masses of luminous gas**
Properties of nebulae
- 116 **The sun's yellow prominence differs from any terrestrial flame**
The sun's emissions
- 117 **Mars is traversed by a dense network of channels**
Mapping Mars's surface
- 118 **Photographing the stars**
Astrophotography
- 120 **A precise measurement of the stars**
The star catalog
- 122 **Classifying the stars according to their spectra reveals their age and size**
The characteristics of stars
- 128 **There are two kinds of red star**
Analyzing absorption lines
- 129 **Sunspots are magnetic**
The properties of sunspots
- 130 **The key to a distance scale of the universe**
Measuring the universe
- 138 **Stars are giants or dwarfs**
Refining star classification
- 140 **Penetrating radiation is coming from space**
Cosmic rays
- 141 **A white hot star that is too faint**
Discovering white dwarfs



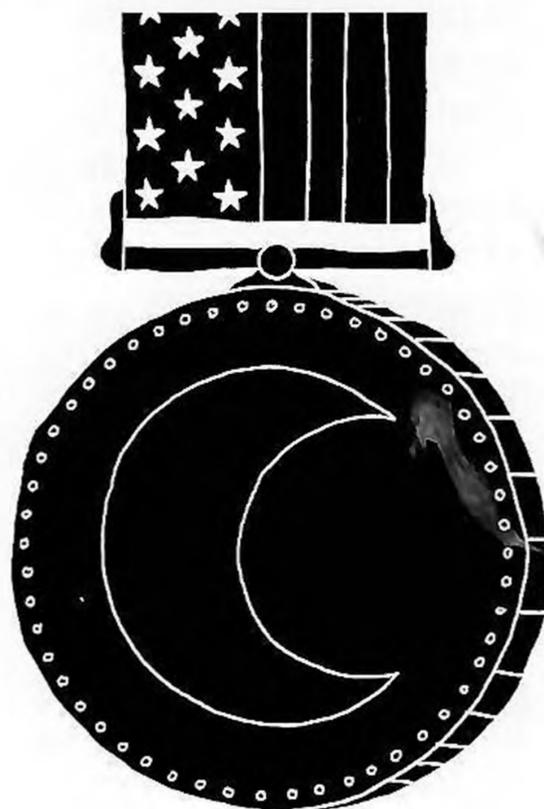


ATOMS, STARS, AND GALAXIES

1915–1950

- 146 Time and space and gravitation have no separate existence from matter**
The theory of relativity
- 154 An exact solution to relativity predicts black holes**
Curves in spacetime
- 156 The spiral nebulae are stellar systems**
Spiral galaxies
- 162 Stars are dominated by hydrogen and helium**
Stellar composition
- 164 Our galaxy is rotating**
The shape of the Milky Way
- 166 A slow process of annihilation of matter**
Nuclear fusion within stars
- 168 A day without yesterday**
The birth of the universe
- 172 The universe is expanding in all directions**
Beyond the Milky Way

- 178 White dwarfs have a maximum mass**
The life cycles of stars
- 179 The radio universe**
Radio astronomy
- 180 An explosive transition to a neutron star**
Supernovae
- 182 The source of energy in stars is nuclear fusion**
Energy generation
- 184 A reservoir of comets exists beyond the planets**
The Kuiper belt
- 185 Some galaxies have active regions at their centers**
Nuclei and radiation
- 186 The match of lunar and Earth material is too perfect**
The origin of the moon
- 188 Important new discoveries will be made with flying telescopes**
Space telescopes



- 196 It took less than an hour to make the atomic nuclei**
The primeval atom
- 198 Stars are factories for the chemical elements**
Nucleosynthesis
- 200 Sites of star formation**
Dense molecular clouds

NEW WINDOWS ON THE UNIVERSE

1950–1975

- 206 A vast cloud surrounds the solar system**
The Oort cloud
- 207 Comets are dirty snowballs**
The composition of comets
- 208 The way to the stars is open**
The launch of Sputnik
- 210 The search for interstellar communications**
Radio telescopes
- 212 Meteorites can vaporize on impact**
Investigating craters
- 213 The sun rings like a bell**
The sun's vibrations
- 214 The data can best be explained as X-rays from sources outside the solar system**
Cosmic radiation
- 218 Brighter than a galaxy, but it looks like a star**
Quasars and black holes

- 222 An ocean of whispers left over from our eruptive creations**
Searching for the Big Bang
- 228 The search for extraterrestrial intelligence is a search for ourselves**
Life on other planets
- 236 It has to be some new kind of star**
Quasars and pulsars
- 240 Galaxies change over time**
Understanding stellar evolution
- 242 We choose to go to the moon**
The Space Race
- 250 The planets formed from a disk of gas and dust**
The nebular hypothesis
- 252 Solar neutrinos can only be seen with a very large detector**
The Homestake experiment
- 254 A star that we couldn't see**
Discovering black holes
- 255 Black holes emit radiation**
Hawking radiation

THE TRIUMPH OF TECHNOLOGY 1975–PRESENT

- 260 A grand tour of the giant planets**
Exploring the solar system



- 268 Most of the universe is missing**
Dark matter
- 272 Negative pressures produce repulsive gravity**
Cosmic inflation
- 274 Galaxies appear to be on the surfaces of bubblelike structures**
Redshift surveys
- 276 Stars form from the inside out**
Inside giant molecular clouds
- 280 Wrinkles in time**
Observing the CMB
- 286 The Kuiper belt is real**
Exploring beyond Neptune
- 288 Most stars are orbited by planets**
Exoplanets
- 296 The most ambitious map of the universe ever**
A digital view of the skies
- 297 Our galaxy harbors a massive central black hole**
The heart of the Milky Way
- 298 Cosmic expansion is accelerating**
Dark energy
- 304 Peering back over 13.5 billion years**
Studying distant stars
- 306 Our mission is to land on a comet**
Understanding comets
- 312 The violent birth of the solar system**
The Nice model
- 314 A close-up view of an oddball of the solar system**
Studying Pluto
- 318 A laboratory on Mars**
Exploring Mars
- 326 The biggest eye on the sky**
Looking farther into space
- 328 Ripples through spacetime**
Gravitational waves
- 332 DIRECTORY**
- 340 GLOSSARY**
- 344 INDEX**
- 352 ACKNOWLEDGMENTS**

