

Table of Contents

INTRODUCTION	1
About This Book	2
Foolish Assumptions	2
Icons Used in This Book	3
Beyond the Book	3
Where to Go from Here	4
PART 1: GETTING STARTED WITH ASTRONOMY	5
CHAPTER 1: Seeing the Light: The Art and Science of Astronomy	7
Astronomy: The Science of Observation	8
What You See: The Language of Light	10
They wondered as they wandered: Understanding planets versus stars	10
If you see a Great Bear, start worrying: Naming stars and constellations	12
The smaller, the brighter: Getting to the root of magnitudes. . . .	19
What do I spy? Spotting the Messier Catalog and other sky objects	20
Looking back on light-years	22
Keep on moving: Figuring the positions of the stars	23
Gravity: A Force to Be Reckoned With	26
Space: A Commotion of Motion	27
CHAPTER 2: Join the Crowd: Skywatching Activities and Resources	29
You're Not Alone: Astronomy Clubs, Websites, Smartphone Apps, and More	30
Joining an astronomy club for star-studded company	30
Checking websites, magazines, software, and apps.	31
Visiting Observatories and Planetariums.	35
Ogling the observatories	35
Popping in on planetariums.	39
Vacationing with the Stars: Star Parties, Eclipse Trips, Dark Sky Parks, and More	39
Party on! Attending star parties	40
Getting festive at an astro fest.	42
Tapping into Astronomy on Tap	42
To the path of totality: Taking eclipse cruises and tours.	42
Motoring to telescope motels	44

CHAPTER 3: Terrific Tools for Observing the Skies	47
Seeing Stars: A Sky Geography Primer.....	48
As Earth turns.....	48
... keep an eye on the North Star.....	51
Beginning with Naked-Eye Observations.....	53
Using Binoculars or a Telescope for a Better View.....	56
Binoculars: Sweeping the night sky.....	56
Telescopes: When closeness counts.....	60
Planning Your First Steps into Astronomy.....	70
CHAPTER 4: Just Passing Through: Meteors, Comets, and Artificial Satellites	73
Meteors: Wishing on a Shooting Star.....	74
Spotting sporadic meteors, fireballs, and bolides.....	75
Watching meteor showers: No umbrella needed.....	77
Comets: Dirty Ice Balls or Icy Dirt Balls?.....	81
Making heads and tails of a comet's structure.....	82
Waiting for the "comets of the century".....	86
Hunting for the next great comet.....	87
Artificial Satellites: Enduring a Love-Hate Relationship.....	90
Skywatching for artificial satellites.....	91
Finding satellite viewing predictions.....	92
UFOs: Could some be aliens?.....	94
PART 2: GOING ONCE AROUND THE SOLAR SYSTEM	95
CHAPTER 5: A Matched Pair: Earth and Its Moon	97
Putting Earth under the Astronomical Microscope.....	98
One of a kind: Earth's unique characteristics.....	98
Spheres of influence: Earth's distinct regions.....	100
Examining Earth's Time, Seasons, and Age.....	102
Orbiting for all time.....	102
Tilting toward the seasons.....	104
Estimating Earth's age.....	106
Making Sense of the Moon.....	107
Get ready to howl: Identifying phases of the Moon.....	108
In the shadows: Watching lunar eclipses.....	110
Cultivating an interest in the occult(at)ions.....	112
Hard rock: Surveying lunar geology.....	113
Quite an impact: Considering a theory about the Moon's origin.....	119

CHAPTER 6:	Earth's Near Neighbors: Mercury, Venus, and Mars	121
	Mercury: Weird, Hot, and Mostly Metal	122
	Dry, Acidic, and Hilly: Piercing the Veil of Venus	123
	Dropping the ball: Probing Venus with <i>DAVINCI+</i> and <i>EnVision</i>	125
	Something in the air: Life in Venus's clouds?	125
	Red, Cold, and Barren: Uncovering the Mysteries of Mars	125
	Where have almost all the air and water gone? (Long time passing)	126
	Does Mars support life?	128
	Differentiating Earth through Comparative Planetology	131
	Observing the Terrestrial Planets with Ease	132
	Understanding elongation, opposition, and conjunction	133
	Viewing Venus and its phases	135
	Watching Mars as it loops around	137
	Outdoing Copernicus by observing Mercury	139
CHAPTER 7:	Rock On: The Asteroid Belt and Near-Earth Objects	141
	Taking a Brief Tour of the Asteroid Belt	141
	Getting the Dirt on (and off) Asteroids	145
	Understanding the Threat That Near-Earth Objects Pose	146
	When push comes to shove: Nudging an asteroid	148
	Forewarned is forearmed: Surveying NEAs to protect Earth	149
	Searching for Small Points of Light	150
	Helping to track an occultation	151
	Timing an asteroidal occultation	152
CHAPTER 8:	Great Balls of Gas: Jupiter and Saturn	153
	The Pressure's On: Journeying Inside Jupiter and Saturn	153
	Almost a Star: Gazing at Jupiter	154
	Scanning for the Great Red Spot	156
	Shooting for Galileo's moons	157
	Our Main Planetary Attraction: Setting Your Sights on Saturn	161
	Ringing around the planet	162
	Storm chasing across Saturn	164
	Monitoring a moon of major proportions	164
	Venting about geysers on Enceladus	166
CHAPTER 9:	Far Out! Uranus, Neptune, Pluto, and Beyond	169
	Breaking the Ice with Uranus and Neptune	169
	Bull's-eye! Tilted Uranus and its features	170
	Against the grain: Neptune and its biggest moon	171

Meeting Pluto, the Amazing Dwarf Planet	173
Defining Pluto the geophysical way	174
Getting to the heart of Pluto	174
Looking at Pluto's makeup	177
The moon chip doesn't float far from the planet	177
Buckling Down to the Kuiper Belt	178
Viewing the Outer Planets	180
Sighting Uranus	180
Distinguishing Neptune from a star	180
Straining to see Pluto	181
Hunting New Planet Number Nine	182

PART 3: STARTING WITH OLD SOL: MEETING STARS AND GALAXIES 185

CHAPTER 10: The Sun: Star of Earth 187

Surveying the Sunscape	188
The Sun's size and shape: A great bundle of gas	189
The Sun's regions: Caught between the core and the corona	189
Solar activity: What's going on out there?	192
Solar wind: Playing with magnets	196
Solar CSI: The mystery of the missing solar neutrinos.	197
Four billion and counting: The life expectancy of the Sun	198
Don't Make a Blinding Mistake: Safe Techniques for Solar Viewing	199
Viewing the Sun by projection	199
Viewing the Sun through front-end filters	204
Fun with the Sun: Solar Observation	206
Tracking sunspots	206
Experiencing solar eclipses	208
Surfing solar observatories	212

CHAPTER 11: Taking a Trip to the Stars 215

Life Cycles of the Hot and Massive	216
Young stellar objects: Taking baby steps	217
Main sequence stars: Enjoying a long adulthood	218
Red giants and supergiants: Big and bigger	219
Closing time: Coming up on the tail end of stellar evolution	220
Star Color, Brightness, and Mass	226
Spectral types: What color is my star?	227
Star light, star bright: Luminosity classifications.	228
The brighter they burn, the bigger they swell: Mass determines class	229
Making sense of the H-R diagram	230

Eternal Partners: Binary and Multiple Stars	232
Binary stars and the Doppler effect	232
Two stars are binary, but three's a crowd: Multiple stars	234
Change Is Good: Variable Stars	235
Go the distance: Pulsating stars	236
Explosive neighbors: Flare stars	238
Nice to nova: Exploding stars.	238
Stellar hide-and-seek: Eclipsing binary stars.	241
Hog the starlight: Microlensing events.	242
Your Stellar Neighbors	242
How to Help Scientists by Observing the Stars	245
CHAPTER 12: Galaxies: The Milky Way and Beyond	247
Unwrapping the Milky Way	248
How and when did the Milky Way form?	249
What shape is the Milky Way?	249
Where can you find the Milky Way?	251
Star Clusters: Meeting Galactic Associates	252
A loose fit: Open clusters	253
A tight squeeze: Globular clusters	255
Fun while it lasted: OB associations	256
Taking a Shine to Nebulas	257
Picking out planetary nebulas	259
Breezing through supernova remnants.	261
Enjoying Earth's best nebular views	261
Getting a Grip on Galaxies	264
Surveying spiral, barred spiral, and lenticular galaxies	265
Examining elliptical galaxies	266
Looking at irregular, dwarf, and low surface brightness galaxies	267
Gawking at great galaxies.	268
Discovering the Local Group of galaxies	271
Checking out clusters of galaxies	272
Sizing up superclusters, cosmic voids, and great walls	272
CHAPTER 13: Falling for Black Holes and Quasars.	275
Black Holes: Keeping Your Distance	275
Looking over the black hole roster	276
Poking around the black hole interior	277
Surveying a black hole's surroundings.	280
Warping space and time.	281
Detecting black hole collisions.	283
Watching stars get swallowed by black holes	284

Quasars: Defying Definitions	285
Measuring the size of a quasar	286
Getting up to speed on jets	287
Exploring quasar spectra	287
Active Galactic Nuclei: Welcome to the Quasar Family	288
Sifting through different types of AGN.	288
Examining the power behind AGN	290
Questioning what ORCs are.	291
PART 4: PONDERING THE REMARKABLE UNIVERSE	293
CHAPTER 14: Planets of Other Suns: Is Anybody Out There?	295
Discovering Alien Worlds	296
Changing ideas on exoplanets.	296
Finding exoplanets	298
Meeting the (exo)planets	302
Catching Proxima fever: Focusing on red dwarfs	305
Finding Earth-class planets orbiting TRAPPIST-1	307
Checking out planets for fun and science	308
Astrobiology: How's Life on Other Worlds?	309
Extremophiles: Living the hard way	309
Seeking life in the solar system	310
Using Drake's Equation to Discuss SETI	313
SETI Projects: Listening for E.T.	316
The flight of Project Phoenix	317
Space scanning with other SETI projects	318
Hot targets for SETI	320
SETI@home.	321
CHAPTER 15: Delving into Dark Matter and Antimatter	323
Dark Matter: Understanding the Universal Glue	323
Gathering the evidence for dark matter	324
Debating the makeup of dark matter.	328
Taking a Shot in the Dark: Searching for Dark Matter	329
Looking for WIMPs and other microscopic dark matter	329
MACHOs: Making a brighter image.	331
Mapping dark matter with gravitational lensing.	331
Dueling Antimatter: Proving That Opposites Attract	333

CHAPTER 16: The Big Bang and the Evolution of the Universe	335
Evidence for the Big Bang	336
Inflation: A Swell Time in the Universe	337
Something from nothing: Inflation and the vacuum	339
Falling flat: Inflation and the shape of the universe	339
Dark Energy: The Universal Accelerator	340
Universal Info Pulled from the Cosmic Microwave Background	341
Finding the lumps in the cosmic microwave background	342
Mapping the universe with the cosmic microwave background	342
In a Galaxy Far Away: Standard Candles and the Hubble Constant	344
Standard candles: How do scientists measure galaxy distances?	344
The Hubble constant: How fast do galaxies really move?	345
The Fate of the Universe	346
PART 5: THE PART OF TENS	347
CHAPTER 17: Ten Strange Facts about Astronomy and Space	349
You Have Tiny Meteorites in Your Hair	349
A Comet's Tail Often Leads the Way	350
Earth Is Made of Rare and Unusual Matter	350
High Tide Comes on Both Sides of Earth at the Same Time	350
On Venus, the Rain Never Falls on the Plain	350
Rocks from Mars Dot Earth	351
Pluto Was Discovered from the Predictions of a Wrong Theory	351
Sunspots Aren't Dark	351
A Star in Plain View May Have Exploded, But No One Knows	352
The Same Supernova or Quasar May Be Seen in Different Places	352
CHAPTER 18: Ten Common Errors about Astronomy and Space	353
"The Light from That Star Took 1,000 Light-Years to Reach Earth"	353
There's No Gravity in Space	354
Summer Comes When Earth Is Closest to the Sun	354
The Back of the Moon Is Dark	354

The “Morning Star” or “Evening Star” Is a Star	355
The Asteroid Belt Is Crowded	355
Nuking a “Killer Asteroid” on a Collision Course for Earth Will Save Us	355
The Sun Is an Average Star.	356
The <i>Hubble Space Telescope</i> Gets Up Close and Personal	356
The Big Bang Is Dead	356
PART 6: APPENDIXES	357
APPENDIX A: Star Maps	359
APPENDIX B: Glossary	367
INDEX	373