

Contents

Prologue	page ix
Acknowledgements	xii
Part I Views of Mars, from the beginning to the present day	1
1 The dawn of Mars exploration	3
1.1 Early observations	3
1.2 Another planet with an atmosphere	5
1.3 The Mountains of Mitchel	6
1.4 The wave of darkening	8
1.5 Lowell and the canals	9
1.6 The detection of water	13
1.7 Carbon dioxide	16
1.8 Prelude to the space age: the von Braun Mars expeditions	17
Further reading	22
2 The first space missions to Mars	23
2.1 Dreams are not enough	23
2.2 The Mars <i>Mariners</i>	26
2.3 Soviet Mars missions	38
2.4 The <i>Vikings</i>	40
2.5 The post- <i>Viking</i> picture of Mars	43
2.6 The legacy of <i>Viking</i>	48
Further reading	49
3 After <i>Viking</i>: the twenty-year hiatus	51
3.1 The mood after <i>Viking</i> : so high, so low	51
3.2 Phantom missions: proposals, working groups and Phase A studies	52
3.3 The NASA Mars Science Working Group (1976–9)	55
3.4 <i>Kepler</i> , <i>Mars Aeronomy Orbiter</i> and <i>Mars Geoscience/Climatology Orbiter</i>	63
3.5 The US-European Joint Working Group on Planetary Exploration (1982–4)	66
3.6 The Joint Committee on US–European Cooperation in Space Science (1995–7)	69

Contents

3.7	<i>Mars Together</i>	77
3.8	Failed missions	77
4	The modern era	84
4.1	Faster, Better, Cheaper	84
4.2	An unexpected bonus: meteorites from Mars	86
4.3	The <i>Mars Surveyor</i> and <i>Discovery</i> programmes	90
4.4	<i>Pathfinder</i> and <i>Sojourner</i>	91
4.5	<i>Global Surveyor</i> : mapping the Martian surface, atmosphere and interior	97
4.6	Faster, Cheaper: <i>Climate Orbiter</i> and <i>Polar Lander</i>	100
4.7	<i>Mars Odyssey</i>	104
4.8	Europe and Japan look to Mars	106
4.9	<i>Mars Express</i>	107
4.10	<i>Beagle 2</i>	109
4.11	The <i>Mars Exploration Rovers: Spirit</i> and <i>Opportunity</i>	114
4.12	<i>Mars Reconnaissance Orbiter</i>	119
	Further reading	131
	Part II The Big Science: motivation to continue the quest	133
5	The origin and evolution of planet Mars	135
5.1	Interior and magnetic field	137
5.2	The core of Mars	139
5.3	The composition of the surface	141
5.4	Determining the ages of regions and features	145
5.5	Towards an absolute chronology	153
5.6	Volcanoes and volcanism	157
5.7	Water on the surface	158
5.8	The polar caps	164
5.9	The moons of Mars	164
	Further reading	166
6	The changing climate of Mars	168
6.1	An introduction to the Martian climate	168
6.2	The orbit and the seasons	172
6.3	Climate models	175
6.4	The present climate	178
6.5	Winds, the general circulation of the atmosphere and the weather	190
6.6	The ancient climate: was it really warm and wet?	195
6.7	Evidence for climate change	197
6.8	Mechanisms for climate change	212
6.9	The Martian climate: a current paradigm	218
	Further reading	220

Contents

7	The search for life	221
7.1	Are we alone in the Universe?	221
7.2	What is life?	223
7.3	Ancient and modern life	225
7.4	Terrestrial vs. Martian life	226
7.5	Habitats	228
7.6	Biosignatures	229
7.7	Astrobiological experiments on Mars	231
7.8	Renewing the search for life on Mars	235
7.9	Zeroing in on habitats from orbit	237
7.10	Astrobiological rovers	238
7.11	Advanced tools in the search for life	240
7.12	Deep drilling to follow the water	243
7.13	Sample return vs. meteorites	245
7.14	Biological sample return	246
7.15	Planetary protection	247
7.16	The importance of human exploration	248
7.17	Epilogue: the prospects for finding life on Mars	248
	Part III Plans and visions for the future	251
8	The future of the unmanned programme	253
8.1	Choosing the way forward	254
8.2	Towards Mars networks	257
8.3	The sample return saga	258
8.4	Developing a new strategy: Mars Exploration Pathways 2010–20	262
8.5	Missions to implement the pathways	266
8.6	Pathways at work: discoveries change the plan	275
8.7	Back on the agenda again: sample return	276
8.8	Europe goes to Mars with <i>Aurora</i>	277
8.9	International collaboration takes a back seat	281
8.10	Return of the Russians: <i>Phobos-Grunt</i>	282
	Further reading	283
9	Towards human expeditions	284
9.1	Finishing the <i>International Space Station</i>	286
9.2	Developing the Moon base	287
9.3	Transportation systems	289
9.4	The danger from radiation and weightlessness	293
9.5	Landing and return vehicles	294
9.6	Setting up the Mars base	296
9.7	Ready to go?	305
	Further reading	307

Contents

10	The first footfall on Mars	308
10.1	The <i>Mayflower 3</i> and its crew	309
10.2	The journey through deep space	310
10.3	On the voyage	311
10.4	Entering the realm of Mars	312
10.5	Preparing to land	314
10.6	Descent to the Martian surface	315
10.7	First Foot	317
10.8	<i>In memoriam</i>	317
10.9	At Meridiani Base	318
10.10	Survival and resources	319
10.11	Science operations	320
10.12	Launch to near Mars orbit and on toward Earth	321
10.13	Quarantining the returning crew	322
	Epilogue: Beyond the horizon	324
	Appendix A Data about Mars	328
	Appendix B Space missions to Mars	330
	Appendix C Mars study groups	332
	Glossary	337
	Index	341

The plates are situated between pages 50 and 51.