

# Contents

<b>List of Tables</b> .....	xiii
<b>1 Habitable Zones</b> .....	1
1.1 Definition of Habitability .....	1
1.1.1 Basic Considerations .....	1
1.1.2 Definitions of Habitable Zones .....	3
1.1.3 HZ and Planetary Atmospheres .....	6
1.1.4 Tidal Locking .....	7
1.1.5 Tidal Heating .....	11
1.1.6 The Galactic Habitable Zone .....	15
1.2 The Earth – Protector of Life .....	16
1.2.1 The Atmosphere .....	16
1.2.2 The Magnetosphere .....	19
1.2.3 Stability of Atmosphere and Magnetosphere .....	21
1.3 The Habitable Zone in the Solar System .....	25
1.3.1 Mean Surface Temperatures .....	25
1.3.2 Habitable Zone Around Giant Planets .....	26
<b>2 Properties and Environments of Life</b> .....	29
2.1 Organic Compounds in Space .....	29
2.1.1 Interstellar Medium .....	29
2.1.2 Organic Material Around Stars .....	31
2.2 Life .....	31
2.2.1 What Is Life? .....	32
2.2.2 From Nonliving to Living .....	32
2.2.3 Cells .....	37
2.2.4 RNA-Based Life .....	43
2.3 How Do Organisms Produce Energy? .....	43
2.3.1 Oxidation–Reduction .....	43
2.3.2 Photosynthesis .....	44
2.3.3 Respiration .....	47
2.3.4 Digestion and Assimilation .....	49

2.4	Biological Classification . . . . .	49
2.4.1	Bacteria . . . . .	50
2.4.2	Viruses, Viroids, and Prions . . . . .	53
2.4.3	The Kingdom Protista . . . . .	54
2.4.4	The Evolution of Complex Life, Cosmic Catastrophes . . . . .	54
<b>3</b>	<b>Stars and Galaxies . . . . .</b>	<b>55</b>
3.1	Stars: Evolution and Formation . . . . .	55
3.1.1	Physical Parameters of Stars . . . . .	55
3.1.2	Spectral and Luminosity Classes . . . . .	55
3.1.3	Main Sequence Lifetime . . . . .	57
3.1.4	Stellar Evolution . . . . .	58
3.2	Stellar Evolution and Habitability . . . . .	61
3.2.1	Main Sequence Stars . . . . .	61
3.2.2	Habitable Zones and Stellar Evolution . . . . .	62
3.3	Galaxies . . . . .	64
3.3.1	Our Galaxy . . . . .	64
3.3.2	Galaxies . . . . .	67
3.4	The Sun – Our Star . . . . .	70
3.4.1	Overview . . . . .	70
3.4.2	Solar Observations . . . . .	73
3.4.3	The Variable Sun . . . . .	75
3.4.4	Solar Activity Cycles . . . . .	78
<b>4</b>	<b>Planetary Systems . . . . .</b>	<b>81</b>
4.1	The Solar System: Overview and Formation . . . . .	81
4.1.1	Planets — How Are They Defined? . . . . .	81
4.1.2	Overview and Formation of the Solar System . . . . .	82
4.1.3	Unstable Interstellar Clouds . . . . .	84
4.2	Main Objects in the Solar System . . . . .	88
4.2.1	Planets . . . . .	88
4.2.2	Dwarf Planets . . . . .	89
4.2.3	Comets . . . . .	90
4.2.4	Asteroids . . . . .	95
4.2.5	Small Solar System Bodies and Habitability . . . . .	97
4.3	Extrasolar Planetary Systems . . . . .	97
4.3.1	Some Considerations . . . . .	97
4.3.2	Detection Methods . . . . .	98
4.3.3	Examples of Extrasolar Planets . . . . .	103
4.3.4	Planet Formation around Pulsars . . . . .	109
4.4	Stability of Planetary Systems . . . . .	110
4.4.1	What does Stability Mean? . . . . .	110
4.4.2	The Earth: Perturbations by the Moon and Planets . . . . .	112
4.4.3	Is the Solar System Stable? . . . . .	117
4.4.4	Pluto—Charon and Triton . . . . .	118

4.5	Extrasolar Planetary Systems . . . . .	119
4.5.1	Stability of Orbits in Binary Stars . . . . .	120
4.5.2	Migration of Planets . . . . .	121
<b>5</b>	<b>Catastrophes in Our Solar System? . . . . .</b>	<b>123</b>
5.1	Catastrophes by Particles and Radiation Hazards . . . . .	123
5.1.1	Major Solar Events . . . . .	123
5.1.2	The T Tauri Phase of the Early Sun . . . . .	129
5.2	Catastrophes in the Early Solar System . . . . .	129
5.2.1	Planetesimals . . . . .	129
5.2.2	Heavy Bombardment Phase . . . . .	130
5.2.3	The Formation of the Moon . . . . .	130
5.2.4	Collisions in the Early Solar System . . . . .	131
5.3	Collisions in the Solar System . . . . .	134
5.3.1	Case Study: Meteor Crater, Arizona . . . . .	134
5.3.2	The K-T Event . . . . .	136
5.3.3	Controversy about the K-T Impact Theory . . . . .	140
5.3.4	The Permian-Triassic Event, P-T Event . . . . .	140
5.3.5	Mass Extinctions by Flood Basalt Volcanism . . . . .	141
5.4	NEOs . . . . .	143
5.4.1	Classification and Definition . . . . .	143
5.4.2	Orbit Instabilities . . . . .	144
5.5	Impact Risk Scale . . . . .	145
5.5.1	Surveillance Systems . . . . .	145
5.5.2	Torino Impact Scale . . . . .	147
5.5.3	Palermo Technical Impact Hazard Scale . . . . .	148
5.6	Collisions and Habitability . . . . .	149
5.6.1	Impacts of Comets . . . . .	149
5.6.2	Probability of Cometary Impacts . . . . .	152
5.6.3	Impacts and Their Consequences . . . . .	153
5.6.4	The Tunguska Event . . . . .	155
<b>6</b>	<b>Catastrophes in Extrasolar Planetary Systems? . . . . .</b>	<b>157</b>
6.1	Collisions in Extrasolar Planetary Systems . . . . .	157
6.1.1	Stability Catalogues . . . . .	157
6.1.2	Collision and X-ray Flashes . . . . .	158
6.1.3	Small Body Collisions . . . . .	160
6.2	Case Studies: Late Type Stars . . . . .	162
6.2.1	General Properties . . . . .	162
6.2.2	G, K Stars . . . . .	162
6.2.3	M Type Stars . . . . .	164
6.2.4	Proxima Centauri . . . . .	165
6.3	Early Type Stars . . . . .	167
6.3.1	Properties of Early Type Stars . . . . .	167
6.3.2	Planetary Systems in Early Type Stars . . . . .	167

<b>7</b>	<b>The Solar Neighborhood</b>	169
7.1	The Sun in the Galaxy	169
7.1.1	Interstellar Matter	169
7.1.2	The Local Bubble	170
7.2	Nearby Stars	171
7.2.1	Definition of the Solar Neighborhood	171
7.2.2	Nemesis	172
7.2.3	Mass Extinctions by Galactic Clouds	173
7.3	Habitable Zones in Galaxies	173
7.3.1	Supernova Explosions	173
7.3.2	Gamma-Ray Bursts, GRB	177
7.4	Catastrophes and Habitability in Galaxies	179
7.4.1	Galactic Collisions, Starburst Galaxies	179
7.4.2	Active Galactic Nuclei and Habitability	182
<b>8</b>	<b>The Search for Extraterrestrial Life</b>	187
8.1	Life Based on Elements other than Carbon	187
8.1.1	Silicon-Based Life	187
8.1.2	Life Based on Ammonia	188
8.1.3	The Role of Solvents	188
8.1.4	Boron-Based Life	189
8.1.5	Nitrogen- and Phosphorus-Based Life	190
8.1.6	Sulfur-Based Life	190
8.2	The Gaia Hypothesis	191
8.2.1	Biota and Their Influences on the Environment	191
8.2.2	Gaia	191
8.2.3	How to Test Gaia?	192
8.3	The Future of Extrasolar Planet Finding	193
8.3.1	Planned Satellite Missions	193
8.3.2	Biomarkers	196
8.3.3	In Situ Search for Biomarkers: Mars	197
8.4	Some Case Studies of Habitability	198
8.4.1	Mars	198
8.4.2	Venus	199
8.4.3	Europa	200
8.4.4	Life on Jupiter and Other Gas Giants	200
8.4.5	Life in Interstellar Medium	201
8.5	Comparison of Cosmic Catastrophes and Habitability	202
8.5.1	Impacts	202
8.5.2	Radiation Hazards	203
8.5.3	Summary: Habitability and Cosmic Catastrophes	203
8.6	The Drake Equation	204
8.6.1	The Fermi Paradox	204
8.6.2	The Drake Equation	205
8.6.3	Cosmic Catastrophes and Drake's Equation	206

<b>9</b>	<b>Appendix</b>	209
9.1	Life and Chemistry	209
9.1.1	Atoms and Bonds	209
9.1.2	Acids, Bases, and Salts	210
9.1.3	Important Elements for Life	211
9.1.4	The Element Carbon	211
9.1.5	Hydrocarbons	213
9.1.6	Alcohols and Organic Acids	215
9.1.7	Organic Compounds of Life	215
9.2	Stars and Radiation	219
9.2.1	Electromagnetic Radiation	219
9.2.2	Spectral Lines	221
9.2.3	Stellar Parameters	221
9.2.4	Stellar Spectra, the Hertzsprung-Russell Diagram	223
	<b>Bibliography</b>	227
	<b>Index</b>	241





<http://www.springer.com/978-3-540-76944-6>

Habitability and Cosmic Catastrophes

Hanslmeier, A.

2009, XIV, 248 p., Hardcover

ISBN: 978-3-540-76944-6