

Table of Contents

Foreword	v
Preface.....	vii
1 Introduction to Space Life Sciences	1
1.1. Space life sciences: what is it?	1
1.1.1. Objectives.....	1
1.1.2. The space environment.....	4
1.1.3. Justification for human spaceflight.....	7
1.1.4. Where we are.....	10
1.2. How we got there	12
1.2.1. Major space life sciences events	12
1.2.2. Surviving the Odyssey	24
1.2.3. Life support systems	27
1.3. Challenges facing humans in space.....	28
1.3.1. Astronauts' health maintenance	28
1.3.2. Environmental health during space missions	31
1.3.3. Human Mars mission	32
1.3.4. Countermeasures	35
1.3.5. Artificial gravity	37
1.3.6. A new science is born.....	40
References	43
2 Space Biology	45
2.1. What is life?.....	45
2.1.1. Life on Earth	45
2.1.2. Life on Mars	50
2.2. Gravitational biology.....	51
2.2.1. Questions.....	51
2.2.2. Results of space experiments	55
2.2.3. Bioprocessing in space.....	61
2.3. Development biology	63
2.3.1. Questions.....	63
2.3.2. Results of space experiments	66

2.4.	Plant biology	75
2.4.1.	Questions.....	75
2.4.2.	Results of space experiments	76
2.5.	Radiation biology	82
2.5.1.	Ionized radiation in space.....	82
2.5.2.	Biological effects of radiation	84
2.6.	Facilities for space biology.....	86
2.6.1.	Laboratories on board the ISS.....	86
2.6.2.	Bioprocessing.....	88
2.6.3.	Storage and operations	88
	References	90
3	The Neuro-Sensory System in Space.....	95
3.1.	The problem: space motion sickness.....	95
3.2.	Vestibular function	99
3.2.1.	The vestibular system.....	99
3.2.2.	The other senses	104
3.3.	Posture and movement	113
3.3.1.	Rest posture	113
3.3.2.	Vestibulo-spinal reflexes.....	114
3.3.3.	Locomotion	115
3.3.4.	Body movement	118
3.3.5.	Eye movement.....	119
3.4.	Spatial orientation	124
3.4.1.	Visual orientation	124
3.4.2.	Cognition.....	126
3.5.	What do we know?	132
3.5.1.	Space motion sickness experience	132
3.5.2.	Theories for space motion sickness.....	133
3.5.3.	Countermeasures	135
	References	139
4	The Cardio-Vascular System in Space.....	143
4.1.	The problem: postflight orthostatic intolerance.....	143
4.2.	Cardio-vascular system physiology.....	147
4.2.1.	Basics	147
4.2.2.	Control mechanisms.....	149
4.3.	Effects of spaceflight.....	153
4.3.1.	Launch position.....	153
4.3.2.	Early on-orbit	155
4.3.3.	Later on-orbit	158
4.3.4.	Postflight	164
4.4.	What do we know?	166
4.4.1.	Orthostatic intolerance	166
4.4.2.	Pulmonary function.....	168
4.4.3.	Bed rest.....	169

4.5.	Countermeasures	171
4.5.1.	In-flight.....	171
4.5.2.	End of mission.....	175
	References	178
5	The Musculo-Skeletal System in Space.....	181
5.1.	The problem: muscle atrophy and bone loss	181
5.1.1.	Muscle atrophy.....	181
5.1.2.	Bone loss	182
5.2.	Muscle and bone physiology	184
5.2.1.	Muscle physiology	184
5.2.2.	Bone physiology.....	188
5.3.	Effects of spaceflight on muscle.....	191
5.3.1.	Decrease in body mass	191
5.3.2.	Decrease in muscle volume and strength.....	191
5.3.3.	Changes in muscle structure.....	193
5.4.	Effects of spaceflight on bone	195
5.4.1.	Human studies.....	196
5.4.2.	Animal studies.....	198
5.5.	What do we know?	200
5.5.1.	Muscle atrophy.....	200
5.5.2.	Bone demineralization	201
5.6.	Countermeasures	203
5.6.1.	Muscle	204
5.6.2.	Bone	208
5.6.3.	Aging and Space	212
	References	213
6	Psychological Issues of Spaceflight.....	217
6.1.	The problem: reaction to stress	217
6.1.1.	Analogs	221
6.1.2.	Space simulators.....	224
6.1.3.	Space missions	226
6.1.4.	Rules.....	227
6.2.	Individual selection	228
6.2.1.	Select-out criteria	228
6.2.2.	Select-in criteria	229
6.2.3.	Psychological profiles of astronauts and cosmonauts.....	231
6.3.	Crew selection	234
6.3.1.	Sociological issues	234
6.3.2.	Selection issues	240
6.4.	Crew behavior and performance	244
6.5.	Psychological training and support	246
6.5.1.	Training	246
6.5.2.	Support.....	247
	References	253

7	Operational Space Medicine	257
7.1.	Space medicine: what is it?	257
7.1.1.	Objectives	259
7.1.2.	Risk assessment.....	259
7.2.	Astronaut selection and training.....	261
7.2.1.	Crew position	261
7.2.2.	Physical requirements for astronaut selection.....	263
7.2.3.	Selection process.....	266
7.2.4.	Astronaut training.....	268
7.3.	Prevention: health hazards in space.....	273
7.3.1.	Medical events during spaceflight.....	274
7.3.2.	Sleep.....	277
7.3.3.	Immune system	279
7.3.4.	Medical aspects of extra-vehicular activity.....	281
7.3.5.	Conclusion on space health hazards.....	285
7.4.	Treatment: space medical facilities	285
7.4.1.	Crew health care system.....	287
7.4.2.	Telemedicine	294
7.4.3.	Emergency and rescue.....	295
7.5.	Challenges for exploration missions	301
	References	302
8	Life Support Systems.....	305
8.1.	Human needs for space missions.....	305
8.1.1.	Environment	305
8.1.2.	So, how long will we live?	306
8.1.3.	Human needs	307
8.2.	Contamination	308
8.3.	Major life support system functions.....	311
8.3.1.	Atmosphere management.....	311
8.3.2.	Water management.....	312
8.3.3.	Food management	313
8.3.4.	Hygiene	318
8.3.5.	Radiation shielding.....	318
8.4.	Methods for life support systems	330
8.4.1.	Open loop and closed loop.....	330
8.4.2.	Physical-chemical or biological (bioregenerative).....	331
8.5.	Closed ecological life support system.....	333
8.5.1.	CELSS for exploratory missions.....	333
8.5.2.	Terraforming	335
	References	338

9 An Investigator’s Guide 341

9.1. Resources and constraints 341

9.1.1. Opportunities for space life sciences experiments 341

9.1.2. Constraints..... 347

9.2. How to “fly” an experiment..... 353

9.2.1. Flight experiment selection 353

9.2.2. Experiment design..... 355

9.2.3. Hardware selection..... 356

9.2.4. Feasibility 357

9.2.5. Experiment integration..... 359

9.2.6. Crew science training 360

9.2.7. In-flight science operations 362

9.2.8. Data analysis 367

9.3. Benefits to life on Earth..... 368

References 369

Index 371



<http://www.springer.com/978-1-4419-9904-7>

Fundamentals of Space Medicine

Clément, G.

2011, XVII, 381 p. 206 illus., Hardcover

ISBN: 978-1-4419-9904-7