

Contents

Chapter 1 Introduction	1
1.1 Historical remarks	1
1.1.1 Gravitational research.....	1
1.2 Excitable media and their control by small external forces.....	2
1.3 Waves and oscillations in biological systems.....	3
1.4 Book layout	4
References	5
Chapter 2 Gravity	7
2.1 Physical remarks	7
2.2 Perception of gravity by living systems.....	8
References	9
Chapter 3 Basic Structure of Neuronal Systems	11
References	18
Chapter 4 Platforms for Gravitational Research	19
4.1 Microgravity platforms	20
4.1.1 Short term platforms.....	21
4.1.2 Long term platforms.....	31
4.1.3 Magnetic levitation.....	34
4.2 Removing orientation.....	36
4.2.1 Clinostats	37
4.2.2 Random positioning machine.....	37
4.3 Macro-gravity platforms	38
4.3.1 Centrifuge	39
References	41
Chapter 5 A Model Systems for Gravity Research:	
The Belousov-Zhabotinsky Reaction	43
5.1 Setup for the Belousov-Zhabotinsky experiments.....	44
5.2 Preparation of gels for the Belousov-Zhabotinsky reaction	46
5.3 Data evaluation.....	46
References	55

Chapter 6 Interaction of Gravity with Molecules and Membranes	57
6.1 Bilayer experiments.....	58
6.1.1 Hardware for the Microba mission.....	60
6.1.2 Hardware for the drop-tower	62
6.1.3 Hardware for parabolic flights.....	62
6.1.4 Hardware for laboratory centrifuge	64
6.1.5 Experimental results	64
6.2 Patch-clamp experiments	69
6.2.1 Principles of patch-clamp experiments	69
6.2.2 Hardware for the drop-tower	71
6.2.3 First hardware for parabolic flights	75
6.2.4 For the drop-tower.....	76
6.2.5 First parabolic flight experiment	77
6.2.6 Second hardware for parabolic flights.....	78
6.2.7 Second parabolic flight experiment.....	86
6.2.8 First results and future perspectives	89
References	92
 Chapter 7 Behavior of Action Potentials Under Variable Gravity Conditions	 95
7.1 Introductory remarks	95
7.2 Materials and methods	99
7.3 Isolated leech neuron experiments	100
7.4 Earthworm and nerve fiber experiments (rats and worms).....	102
7.5 Discussion	105
References	108
 Chapter 8 Fluorescence and Light Scatter Experiments to Investigate Cell Properties at Microgravity.....	 111
8.1 Fluorescence measurements to determine calcium influx and membrane potential changes	111
8.1.1 Intracellular calcium concentration experiments	112
8.1.2 Membrane potential experiments	113
8.2 Light scatter experiments to determine changes in cell size.....	114
8.2.1 Static light scatter	115
8.2.2 Dynamic light scatter.....	118
References	121
 Chapter 9 Spreading Depression: A Self-organized Excitation Depression Wave in Different Gravity Conditions	 123
9.1 The retinal spreading depression.....	124
9.2 Gravity platforms used for retinal spreading depression experiments	126
9.2.1 Methods	127

9.2.2 Experiment setup and protocol for spreading depression experiments in parabolic flights	128
9.2.3 Experiment setup and protocol for spreading depression experiments on TEXUS sounding rocket	129
9.2.4 Setup and protocol for spreading depression experiments in the centrifuge	132
9.2.5 Data analysis	132
9.3 Results	134
9.3.1 Spreading depression experiments in parabolic flights and in the centrifuge	134
9.3.2 Spreading depression experiments on sounding rockets and in the centrifuge	136
9.3.3 Determination of latency of spreading depression waves in the centrifuge	138
9.3.4 Summary of all spreading depression experiments on different gravity platforms	139
9.4 Discussion	140
9.4.1 Comment on different gravity platforms	141
References	142
Chapter 10 The Brain Itself in Zero-g	145
10.1 Methods	147
10.1.1 Slow cortical potentials (SCP)	148
10.1.2 Classical frequency bands in EEG	149
10.1.3 Peripheral psycho physiological parameters	150
10.1.4 Protocol and data analysis	150
10.1.5 Subjects	152
10.1.6 Ethic	153
10.2 Results	153
10.2.1 Slow Cortical Potentials (SCP)	154
10.2.2 Frequency band EEG	157
10.2.3 Peripheral stress parameters	159
10.3 Discussion	161
10.3.1 Slow cortical potentials	161
10.3.2 Frequency band EEG	162
10.3.3 Peripheral parameters	163
10.4 Conclusion	163
References	164
Chapter 11 Effects of Altered Gravity on the Actin and Microtubule Cytoskeleton, Cell Migration and Neurite Outgrowth	167
11.1 Summary	167
11.2 Introductory remarks	168
11.3 Material and methods	169
11.3.1 Cell transfection	169

11.3.2 Cell culture and experiments with SH-SY5Y neuroblastoma cells.....	169
11.3.3 Cell migration experiments- Human carcinoma cell lines	170
11.3.4 Scratch Migration Assay (SMA)	170
11.3.5 Neurite outgrowth experiments-Primary cell culture of embryonic chicken spinal cord neurons	170
11.3.6 Immunostaining of cells.....	171
11.3.7 Staining of F-actin	171
11.3.8 Microscopy and live imaging	171
11.4 Results and discussion.....	172
11.4.1 Effects of altered gravity on actin-driven lamellar protrusion of SH-SY5Y neuroblastoma cells.....	172
11.4.2 Effect of altered gravity on the microtubule cytoskeleton of SH-SY5Y neuroblastoma cells	177
11.4.3 Effects of altered gravity on cell migration.....	181
11.4.4 Effects of altered gravity on the intensity and direction of neurite outgrowth	182
References	184
Chapter 12 Discussion and Perspectives.....	187
References	192
Index	193