
Contents

Introduction to Neurons

<i>Avner Friedman</i>	1
1 The Structure of Cells	1
2 Nerve Cells	6
3 Electrical Circuits and the Hodgkin-Huxley Model	9
4 The Cable Equation	15
References	20

An Introduction to Dynamical Systems and Neuronal Dynamics

<i>David Terman</i>	21
1 Introduction	21
2 One Dimensional Equations.....	23
2.1 The Geometric Approach.....	23
2.2 Bifurcations	24
2.3 Bistability and Hysteresis	26
3 Two Dimensional Systems	28
3.1 The Phase Plane	28
3.2 An Example	29
3.3 Oscillations	31
3.4 Local Bifurcations	31
3.5 Global Bifurcations	33
3.6 Geometric Singular Perturbation Theory	34
4 Single Neurons	36
4.1 Some Biology	37
4.2 The Hodgkin-Huxley Equations	38
4.3 Reduced Models	39
4.4 Bursting Oscillations	43
4.5 Traveling Wave Solutions	47

VIII Contents

5	Two Mutually Coupled Cells	50
5.1	Introduction	50
5.2	Synaptic Coupling	50
5.3	Geometric Approach	51
5.4	Synchrony with Excitatory Synapses	53
5.5	Desynchrony with Inhibitory Synapses	57
6	Activity Patterns in the Basal Ganglia	61
6.1	Introduction	61
6.2	The Basal Ganglia	61
6.3	The Model	62
6.4	Activity Patterns	63
6.5	Concluding Remarks	65
	References	66

Neural Oscillators

	<i>Bard Ermentrout</i>	69
1	Introduction	69
2	How Does Rhythmicity Arise	70
3	Phase-Resetting and Coupling Through Maps	73
4	Doublets, Delays, and More Maps	78
5	Averaging and Phase Models	80
5.1	Local Arrays	84
6	Neural Networks	91
6.1	Slow Synapses	91
6.2	Analysis of the Reduced Model	94
6.3	Spatial Models	96
	References	103

Physiology and Mathematical Modeling of the Auditory System

	<i>Alla Borisyuk</i>	107
1	Introduction	107
1.1	Auditory System at a Glance	108
1.2	Sound Characteristics	110
2	Peripheral Auditory System	113
2.1	Outer Ear	113
2.2	Middle Ear	114
2.3	Inner Ear. Cochlea. Hair Cells.	115
2.4	Mathematical Modeling of the Peripheral Auditory System	117
3	Auditory Nerve (AN)	124
3.1	AN Structure	124
3.2	Response Properties	124
3.3	How Is AN Activity Used by Brain?	127
3.4	Modeling of the Auditory Nerve	130

4	Cochlear Nuclei	130
4.1	Basic Features of the CN Structure	131
4.2	Innervation by the Auditory Nerve Fibers	132
4.3	Main CN Output Targets	133
4.4	Classifications of Cells in the CN	134
4.5	Properties of Main Cell Types	135
4.6	Modeling of the Cochlear Nuclei	141
5	Superior Olive. Sound Localization, Jeffress Model	142
5.1	Medial Nucleus of the Trapezoid Body (MNTB)	142
5.2	Lateral Superior Olivary Nucleus (LSO)	143
5.3	Medial Superior Olivary Nucleus (MSO)	143
5.4	Sound Localization. Coincidence Detector Model	144
6	Midbrain	150
6.1	Cellular Organization and Physiology of Mammalian IC	151
6.2	Modeling of the IPD Sensitivity in the Inferior Colliculus	151
7	Thalamus and Cortex	161
	References	162
	Index	169