

Contents

1	Nature and Subject of Biophysics	1
2	Molecular Structure of Biological Systems	5
2.1	Intramolecular Bonds	6
2.1.1	Some Properties of Atomic Orbitals	7
2.1.2	Covalent Bonds, Molecular Orbitals	9
2.1.3	Ionic Bonds	13
2.1.4	Coordinative Bonds, Metallo-Organic Complexes	15
2.1.5	Hydrogen Bond	17
2.2	Molecular Excitation and Energy Transfer	18
2.2.1	Mechanisms of Photon-Induced Molecular Excitation .	18
2.2.2	Mechanisms of Molecular Energy Transfer	19
2.2.3	Photosynthesis as Process of Energy Transfer and Energy Transformation	23
2.3	Thermal Molecular Movement, Order and Probability .	26
2.3.1	Thermodynamic Probability and Entropy	26
2.3.2	Information and Entropy	29
2.3.3	Biological Structures: General Aspects	33
2.3.4	Distribution of Molecular Energy and Velocity at Equilibrium	36
2.3.5	Energy of Activation, Theory of Absolute Reaction Rate	39
2.3.6	Thermal Molecular Movement	45
2.4	Molecular and Ionic Interactions as the Basis for the Formation of Biological Structures	51
2.4.1	Some Foundations of Electrostatics	52
2.4.2	The Water Structure, Effects of Hydration	57
2.4.3	Ions in Aqueous Solutions, the Debye-Hückel Radius .	64
2.4.4	Intermolecular Interactions	67
2.4.5	Structure Formation of Biomacromolecules	73
2.4.6	Ampholytes in Solution, the Acid-Base Equilibrium ...	77
2.5	Interfacial Phenomena and Membranes	80
2.5.1	Surface and Interfacial Tensions	81
2.5.2	Self Assembly and the Molecular Structure of Membranes	83
2.5.3	Mechanical Properties of Biological Membranes	87

2.5.4	Electrical Double Layers and Electrokinetic Phenomena	91
2.5.5	The Electrostatic Structure of the Membrane	99
3	Energetics and Dynamics of Biological Systems	105
3.1	Some Fundamental Concepts of Thermodynamics	105
3.1.1	Systems, Parameters and State Functions	106
3.1.2	Gibb's Fundamental Equation	109
3.1.3	Force and Motion	115
3.1.4	Entropy and Stability	121
3.1.5	Thermodynamic Basis of Biochemical Reactions	129
3.2	The Aqueous and Ionic Equilibrium of the Living Cell	132
3.2.1	Osmotic Pressure	133
3.2.2	Electrochemical Equilibrium – The Nernst Equation ...	141
3.2.3	The Donnan Equilibrium	146
3.3	The Thermodynamic Analysis of Fluxes	152
3.3.1	The Flux of Uncharged Substances	152
3.3.2	Fluxes of Electrolytes	159
3.3.3	The Diffusion Potential	163
3.4	The Nonequilibrium Distribution of Ions in Cells and Organelles	165
3.4.1	Ion Transport in Biological Membranes	166
3.4.2	The Network of Cellular Transporters. The Cell as an Accumulator of Electrochemical Energy	171
3.4.3	The Action Potential	177
3.5	Electric Fields in Cells and Organism	182
3.5.1	The Electric Structure of the Living Organism	182
3.5.2	Electric Fields in the Extracellular Space	183
3.5.3	Passive Electrical Properties of Tissue and Cell-Suspensions	187
3.5.4	Single Cells in External Electric Fields	193
3.5.5	Manipulation of Cells by Electric Fields	197
3.6	Mechanical Properties of Biological Materials	203
3.6.1	Some Basic Properties of Fluids	204
3.6.2	The Viscosity of Biological Fluids	208
3.6.3	Viscoelastic Properties of Biomaterials	210
3.6.4	The Biomechanics of the Human Body	215
3.7	Biomechanics of Fluid Behavior	219
3.7.1	Laminar and Turbulent Flows	220
3.7.2	Biomechanics of Blood Circulation	223
3.7.3	Swimming and Flying	228
4	Physical Factors of the Environment	235
4.1	Temperature	236
4.2.	Pressure	239
4.3	Mechanical Oscillations	240
4.3.1	Vibration	240

4.3.2	Sound	243
4.3.3	The Biophysics of Hearing	245
4.3.4	Infrasound	250
4.3.5	Biophysics of Sonar Systems	251
4.3.6	The Effects of Ultrasound	254
4.4.	Static and Electromagnetic Fields	256
4.4.1	The Static Magnetic Field	256
4.4.2	The Electrostatic Field	262
4.4.3	Electromagnetic Fields in the Human Environment	266
4.4.4	Biological Effects of Electromagnetic Fields	270
4.5	Ionizing Radiation	275
4.5.1	Nature, Properties and Dosimetry of Radiation	275
4.5.2	Primary Processes of Radiation Chemistry	277
4.5.3	Radiobiological Reactions	282
4.5.4	Some Aspects of Radiation Protection	284
4.5.5	Mathematical Models of Primary Radiobiological Effects	286
5	The Kinetics of Biological Systems	291
5.1	Some Foundations of Systems Theory	291
5.1.1	Problems and Approaches of System Analysis	291
5.1.2	General Features of System Behavior	293
5.1.3	Cybernetic Approaches to System Analysis	300
5.2	Systems of Metabolism and Transport	304
5.2.1	Introduction to Compartmental Analysis	305
5.2.2	Models of Biochemical Reactions	312
5.2.3	Pharmacokinetic Models	318
5.3	Model Approaches to Some Complex Biological Processes	319
5.3.1	Models of Propagation and Ecological Interactions	320
5.3.2	Models of Growth and Differentiation	324
5.3.3	Models of Evolution	327
5.3.4	Models of Neural Processes	330
	References	335
	Subject Index	345