

Contents

<i>Preface</i>	ix
1 Molecular Biology of the Cell	1
1.1 The Central Dogma of Molecular Biology	1
1.2 A Journey through the Cell Nucleus	8
2 Statistical Physics	19
2.1 The Partition Function	19
2.2 Applications	33
2.3 The Entropy	36
2.4 Particles with Interactions and Phase Transitions	45
3 Polymer Physics	63
3.1 Random Walks	64
3.2 Freely Jointed and Freely Rotating Chains	68
3.3 Polymers in Good Solvents	73
3.4 Polymers in Poor Solvents	82
3.5 Internal Structure of Polymers	87
4 DNA	93
4.1 The Discovery of the DNA Double Helix	93
4.2 DNA on the Base Pair Level	98
4.3 DNA as a Wormlike Chain	110
4.4 DNA Melting	140
5 Stochastic Processes	153
5.1 Introduction	153
5.2 Markov Processes	158

5.3	Master Equation	163
5.4	Fokker–Planck Equation	164
5.5	Application: Escape over a Barrier	173
5.6	Application: Dynamic Force Spectroscopy	177
5.7	Langevin Equation	183
5.8	Application: Polymer Dynamics	187
6	RNA and Protein Folding	203
6.1	RNA Folding	203
6.2	Protein Folding	209
7	Electrostatics Inside the Cell	223
7.1	Poisson–Boltzmann Theory	223
7.2	Electrostatics of Charged Surfaces	227
7.3	Electrostatics of Cylinders and Spheres	236
7.4	Debye–Hückel Theory	241
7.5	Breakdown of Mean Field Theory	250
8	DNA-Protein Complexes	257
8.1	Protein Target Search	257
8.2	RNA Polymerase	274
8.3	Nucleosome Dynamics	285
8.3.1	Site Exposure Mechanism	285
8.3.2	Force Induced Nucleosome Unwrapping	295
8.3.3	Nucleosome Sliding	312
8.4	Chromatin Fibers	330
8.4.1	Two-Angle Model	332
8.4.2	Solenoid-Type Models	341
8.5	Large-Scale Properties of Chromatin	350
	<i>Appendix A Probability Theory</i>	361
	<i>Appendix B The Distribution of Magnetization and the Central Limit Theorem</i>	367
	<i>Appendix C Hamilton’s Principle and the Pendulum</i>	369
	<i>Appendix D Fourier Series</i>	377
	<i>Appendix E The Pre-Averaging Approximation</i>	381

<i>Appendix F Interaction between two Equally Charged Plates at Zero Temperature</i>	387
<i>Appendix G Geometries of Chromatin Fiber Models</i>	391
<i>References</i>	395
<i>Index</i>	403