CONTENTS

Preface	xiii
1. Power Laws in Biological Networks	1
<i>Eivind Almaas and Albert-László Barabási</i>	
Power Laws in Network Topology	2
Network Models	3
Power Laws in Network Utilization	6
2. Graphical Analysis of Biocomplex Networks and Transport Phenomena	12
<i>Kwang-Il Goh, Byungnam Kahng and Doohul Kim</i>	
The Degree Distribution, the Degree Correlation Function and the Clustering Coefficient	13
Graph Theoretic Analysis of the Yeast Protein Interaction Network	14
Classification of Scale-Free Networks	16
3. Large-Scale Topological Properties of Molecular Networks	25
<i>Sergei Maslov and Kim Sneppen</i>	
Topological Properties of Protein Networks	26
Multi-Node Properties: Correlation Profile	33
Robustness of the Correlation Profile with Respect to Potential Errors in the Data	36
Discussion: What It May All Mean?	37
4. The Connectivity of Large Genetic Networks: Design, History, or Mere Chemistry?	40
<i>Andreas Wagner</i>	
Metabolic Networks and Planetary Atmospheres	42
Protein Interaction Networks	44
Connectivity and Protein Age	46
5. The <i>Drosophila</i> Protein Interaction Network May Be neither Power-Law nor Scale-Free	53
<i>J.S. Bader</i>	
Observed Vertex Degree Distribution	55
Vertex Degree Distributions and Power-Law Fits	56
Bait and Prey Distributions Reconciled	58
Determining the Length Scale of the Network	59

6. Birth and Death Models of Genome Evolution	65
<i>Georgy P. Karev, Yuri I. Wolf and Eugene V. Koonin</i>	
Power Laws, Scale-Free Networks, and Models of Genome Evolution	65
Definitions, Assumptions and Empirical Data	67
Asymptotic Behaviors of the Ergodic Distribution of the Model	69
Linear Stochastic BDIM and Its Applications	71
Nonlinear Modifications of the Model: Polynomial BDIM	73
Nonlinear Rational BDIM	75
Simulation of Gene Family Evolution under BDIMs of Different Degrees	79
The Mean Number of Elementary Events before Family Extinction and Formation	79
7. Scale-Free Evolution: From Proteins to Organisms	86
<i>Nikolay V. Dokholyan and Eugene I. Shakhnovich</i>	
Protein Evolutionary Relationships from Structure Similarities	88
Protein Structure-Function Relations from an Evolutionary Perspective	89
Protein Evolutionary Relations within and between Individual Proteomes	89
Sequence Divergence	90
Why It May Be Impossible to Reconstruct Hereditary Relations between Proteins Based Solely on Their Sequence Similarity?	91
The Underlying Scenario of Protein Evolution	92
Reconstructing Evolutionary Relations between Proteins	93
Properties of the Protein Domain Universe Graphs	94
Evolution of Proteins and Organisms	97
Reconstruction of Protein Structure-Function Relations	98
The Importance of Independent Functional Hierarchical Description	99
Divergent Evolution Observed	100
8. Gene Regulatory Networks	106
<i>T. Gregory Dewey and David J. Galas</i>	
Inferring Gene Expression Networks from Microarray Data	107
Global Properties of Gene Expression Networks	111
Gene Duplication Model of Expression Networks	113
Transcription Factor Networks	115

9. Power Law Correlations in DNA Sequences	123
<i>Sergey V. Buldyrev</i>	
Critical Phenomena and Long Range Correlations	124
One-Dimensional Ising Model	125
Markovian Processes	126
Exponential versus Power Law Correlations	128
Correlation Analysis of DNA Sequences	131
Correlation Function	132
Fourier Power Spectrum	136
Discrete Fourier Transform	137
Detrended Fluctuation Analysis (DFA)	140
A Relation between DFA and Power Spectrum	141
Duplication-Mutation Model of DNA Evolution	144
Alternation of Nucleotide Frequencies	145
Models of Long Range Anti-Correlations	149
Analysis of DNA Sequences	151
Distribution of Simple Repeats	154
10. Analytical Evolutionary Model for Protein Fold Occurrence in Genomes, Accounting for the Effects of Gene Duplication, Deletion, Acquisition and Selective Pressure	165
<i>Michael Kamal, Nicholas M. Luscombe, Jiang Qian and Mark Gerstein</i>	
Minimal Model: Gene Duplication and New Fold Acquisition	167
Extended Model: Including the Effects of Random Gene Deletion	170
The Effects of Selection Pressure	174
Fitting the Models to Genomic Data	176
Appendix A: Analytic Solution of the Minimal Model	180
Appendix B: Crossover Behavior	182
Appendix C: Arbitrary Initial Distribution	184
Appendix D: Solution to the Extended Model When $0 < Q < 1$ and $R \approx 0$	184
Appendix E: Analytical Results for Higher Moments	185
Appendix F: Perturbation Theory Approximation for the Extended Model	186
Appendix G: The Effects of Selection Pressure	189
Appendix H: A Useful Normalization Identity	192
11. The Protein Universes: Some Informatic Issues in Protein Classification	194
<i>S. Rackovsky</i>	
General Methodology	195
Protein Sequences	196
Protein Structures	198

12. The Role of Computation in Complex Regulatory Networks	206
<i>Pau Fernández and Ricard V. Solé</i>	
The Evidence for Computing Networks	208
Modeling	209
Irreducibility	211
The Boolean Idealization	212
The Evolutionary Point of View	216
Redundancy	218
Degeneracy	219
Evolvability	220
Modularity	221
13. Neutrality and Selection in the Evolution of Gene Families	226
<i>Itai Yanai</i>	
Gene Family Sizes (GFS) Distributions	226
Modeling Genome Evolution	227
Comparative Deconstruction of the Gene Family	
Sizes Distribution	228
Pleiotropy → Duplication → Subfunctionalization	232
14. Scaling Laws in the Functional Content of Genomes:	
Fundamental Constants of Evolution?	236
<i>Erik van Nimwegen</i>	
Power Laws in Genomic Quantities	236
Comparing Genomic Features across Genomes	236
Scaling in Functional Gene-Content Statistics	237
Principle Component Analysis	243
Evolutionary Interpretation	247
Methods	251
Index	255