

Part I	How Does Bioinformatics Work?	1
1	Sequence Analysis: Deciphering the Language of Life	3
1.1	How Do I Start My Bioinformatics Analysis? Useful Links and Tools. . . .	7
1.2	Protein Analysis Is Easy with the Right Tool	13
1.3	Exercises for Chap. 1	18
	Literature.	21
2	Magic RNA	23
2.1	RNA Sequences Are Biologically Active.	23
2.2	Analysis of RNA Sequence, Structure and Function.	25
2.3	Exercises for Chap. 2	28
	Literature.	32
3	Genomes: Molecular Maps of Living Organisms	35
3.1	Sequencing Genomes: Spelling Genomes	35
3.2	Deciphering the Human Genome.	38
3.3	A Profile of the Human Genome	39
3.4	Exercises for Chap. 3	41
	Literature.	44
4	Modeling Metabolism and Finding New Antibiotics	47
4.1	How Can I Model Metabolism Bioinformatically?	48
4.2	Useful Tools for Metabolic Modelling.	51
4.3	Exercises for Chap. 4	53
	Literature.	54
5	Systems Biology Helps to Discover Causes of Disease	57
5.1	Application Example: How Does Phosphorylation Cause Heart Failure? .	58
5.2	Generalization: How to Build a Systems Biology Model?	63
5.3	Exercises for Chap. 5	68
	Literature.	72

Part II	How Do I Understand Bioinformatics?	75
6	Extremely Fast Sequence Comparisons Identify All the Molecules That Are Present in the Cell	77
6.1	Fast Search: BLAST as an Example for a Heuristic Search	78
6.2	Maintenance of Databases and Acceleration of Programs.	79
6.3	Exercises for Chap. 6.	83
	Literature.	84
7	How to Better Understand Signal Cascades and Measure the Encoded Information	85
7.1	Coding with Bits	85
7.2	The Different Levels of Coding.	86
7.3	Understanding Coding Better	87
7.4	Exercises for Chap. 7	90
	Literature.	91
8	When Does the Computer Stop Calculating?	93
8.1	When Does It Become a Challenge for the Computer?	94
8.2	Complexity and Computing Time of Some Algorithms	95
8.3	Informatic Solutions for Computationally Intensive Bioinformatics Problems	97
8.4	NP Problems Are Not Easy to Grasp.	99
8.5	Exercises for Chap. 8.	101
	Literature.	102
9	Complex Systems Behave Fundamentally in a Similar Way	103
9.1	Complex Systems and Their Behaviour.	103
9.2	Opening Up Complex Systems Using Omics Techniques.	107
9.3	Typical Behaviour of Systems	110
9.4	System Credentials: Emergence, Modular Construction, Positive and Negative Signal Return Loops.	112
9.5	Pioneers of Systems Science	114
9.6	Which Systems Biology Software Can I Use?	117
9.7	Exercises for Chap. 9.	119
	Literature.	120
10	Understand Evolution Better Applying the Computer	123
10.1	A Brief Overview of Evolution from the Origin of Life to the Present Day	124
10.2	Considering Evolution: Conserved and Variable Areas	128
10.3	Measuring Evolution: Sequence and Secondary Structure	128
10.4	Describing Evolution: Phylogenetic Trees.	130
10.5	Protein Evolution: Recognizing Domains	132

10.6 Exercises for Chap. 10.....	135
Literature.....	136
11 Design Principles of a Cell	139
11.1 Bioinformatics Provides an Overview of the Design of a Cell	140
11.2 Bioinformatics Provides Detailed Insights into the Molecular Biology of the Cell.....	140
11.3 Exercises for Chap. 11.....	147
Literature.....	152
Part III What Is Catching and Fascinating About Bioinformatics?	155
12 Life Continuously Acquires New Information in Dialogue with the Environment	159
12.1 Molecular Words Only Ever Make Sense in the Context of the Cell	160
12.2 Printing Errors Are Constantly Selected Away in the Cell	164
12.3 Exercises for Chap. 12.....	169
Literature.....	169
13 Life Invents Ever New Levels of Language	171
13.1 The Different Languages and Codes in a Cell	172
13.2 New Molecular, Cellular and Intercellular Levels and Types of Language Are Emerging All the Time.....	174
13.3 Innovation: Synthetic Biology.....	177
13.4 New Levels of Communication Through Technology.....	178
13.5 The Internet – A New Level of Communication	179
13.6 A Parallel Language Level: Natural and Analogue Computation	181
13.7 Future Level of Communication: The Nanocellulose Chip.....	182
13.8 Using the Language of Life Technically with the Help of Synthetic Biology.....	185
13.9 Exercises for Chap. 13.....	192
Literature.....	193
14 We Can Think About Ourselves – The Computer Cannot	197
14.1 People Question, Computers Follow Programs	198
14.2 Artificial Intelligence.....	200
14.3 Current Applications of Artificial Intelligence in Bioinformatics	203
14.4 Biological Intelligence.....	207
14.5 Exercises for Chap. 14.....	208
Literature.....	209

15	How Is Our Own Extremely Powerful Brain Constructed?	213
15.1	Modular Construction Leads to Ever New Properties – Up to Consciousness	214
15.2	Bioinformatics Helps to Better Describe the Brain	217
15.3	Brain Blueprints	219
15.4	Possible Objectives	220
15.5	Exercises for Chap. 15	222
	Literature	223
16	Bioinformatics Connects Life with the Universe and All the Rest	225
16.1	Solving Problems Using Bioinformatics	226
16.2	Model and Mitigate Global Problems	229
16.3	Global Digitalisation and Personal Space	233
16.4	What Are the Tasks for Modern Bioinformatics in the Internet Age?	237
16.5	Exercises for Chap. 16	239
	Literature	240
17	Conclusion and Summary	243
	Part IV Glossary, Tutorial, Solutions and Web Links	247
18	Glossary	249
19	Tutorial: An Overview of Important Databases and Programs	267
19.1	Genomic Data: From Sequence to Structure and Function	267
19.2	RNA: Sequence, Structure Analysis and Control of Gene Expression . . .	278
19.3	Proteins: Information, Structure, Domains, Localization, Secretion and Transport	282
19.4	Cellular Communication, Signalling Cascades, Metabolism, Shannon Entropy	289
19.5	Life Always Invents New Levels of Language	295
19.6	Introduction to Programming (Meta Tutorial)	297
20	Solutions to the Exercises	307
20.1	Sequence Analysis: Deciphering the Language of Life	307
20.2	Magic RNA	309
20.3	Genomes – Molecular Maps of Living Organisms	314
20.4	Modeling Metabolism and Finding New Antibiotics	318
20.5	Systems Biology Helps to Discover the Causes of Disease	319
20.6	Extremely Fast Sequence Comparisons Identify all the Molecules that Are Present in the Cell	322
20.7	How to Better Understand Signal Cascades and Measure the Encoded Information	325
20.8	When Does the Computer Stop Calculating?	330

20.9	Complex Systems Behave Fundamentally in a Similar Way	331
20.10	Understand Evolution Better Applying the Computer.	333
20.11	Design Principles of a Cell	336
20.12	Life Continuously Acquires New Information in Dialogue with the Environment.	341
20.13	Life Always Invents New Levels of Language	342
20.14	We Can Think About Ourselves – The Computer Cannot.	347
20.15	How Is Our Own Extremely Powerful Brain Constructed?.	349
20.16	Bioinformatics Connects Life with the Universe and all the Rest.	350
	Literature.	351
 Overview of Important Databases and Programs and Their General Use		353