

Contents

Preface to Second English Edition

ix

Preface to First English Edition

xiii

1. Molecular Rings Studded With Jewels	1
1.1 From Homocycle to Heterocycle	1
1.2 Building Heterocycles From Benzene	2
1.3 Some More Kinds of Heterocycles	6
1.4 Problems	8
1.5 Suggested Reading	8
2. Why Nature Prefers Heterocycles	11
2.1 Reactions for all Tastes	11
2.2 Heterocycles as Acids and Bases	14
2.3 Heterocycles and Metals	15
2.4 'There are Subtle Ties of Power...'	17
2.4.1 The van der Waals-London Interactions	18
2.4.2 Hydrogen Bonding	19
2.4.3 Electrostatic Interactions	21
2.4.4 Molecular Complexes	21
2.4.5 Hydrophobic Forces	25
2.5 Tautomerism: Heterocycles and Their 'Masks'	27
2.6 Problems	31
2.7 Suggested Reading	33
3. Heterocycles and Hereditary Information	35
3.1 Nucleic Acids	35
3.2 The Double Helix	38
3.3 How One DNA Doubles Itself	42
3.4 Protein Synthesis, Genetic Code and the Genome	45
3.5 What are Mutations?	50
3.6 Mysterious Telomeres	54
3.7 Gene Expression	55
3.8 Problems	60
3.9 Suggested Reading	61
4. Enzymes, Coenzymes and Vitamins	63
4.1 Molecular Robots	63
4.2 Coenzymes and Enzymes as 'Joint Molecular Ventures'	66

4.2.1	Oxidative–Reductive Coenzymes	67
4.2.2	Coenzymes as Carriers of Molecular Species	78
4.3	Vitamins, the ‘Molecules of Health’	97
4.4	Ribozymes: Vestiges of an Ancient World	99
4.5	Problems	103
4.6	Suggested Reading	104
5.	Heterocycles and Bioenergetics	107
5.1	ATP as the Universal Currency of Energy	108
5.2	Breathing	111
5.2.1	Glycolysis	112
5.2.2	The Krebs Cycle, or the ‘Molecular Merry-Go-Round’	115
5.2.3	The Respiratory Chain	118
5.3	Problems	122
5.4	Suggested Reading	123
6.	Heterocycles and Photosynthesis	125
6.1	Chlorophyll: Sunlight-Receiving Antenna and Energy Carrier	126
6.2	What Daylight can Achieve	130
6.3	Photosynthesis Without Light	135
6.4	Problems	138
6.5	Suggested Reading	138
7.	Heterocycles and Health	139
7.1	Medicines From a Natural Storehouse	139
7.2	Heterocycles Versus Infectious Microbes	143
7.2.1	In Search of ‘Magic Bullets’	143
7.2.2	Sulfanilamides and Heterocycles	144
7.2.3	Antibiotics	146
7.2.4	Antibiotics From the Ocean’s Depths	152
7.2.5	Heterocyclic Antifungal Agents	155
7.2.6	Heterocycles Against Parasitic Diseases	155
7.3	Heterocycles and Viral Infections	158
7.4	Heterocycles and the Diseases of Our Century	162
7.4.1	Heterocycles to Cure Stress, Brain Disorders and Pain	163
7.4.2	Heterocycles and Cardiovascular Diseases	169
7.4.3	Heterocycles and Malignant Tumors	173
7.5	Heterocyclic Molecules in Combat with Ulcers and Sexual Dysfunctions	178
7.6	Problems	181
7.7	Suggested Reading	182
8.	Heterocycles in Agriculture	185
8.1	A Century of Chemical Warfare Against Weeds	186
8.2	Regulators of Plant Growth	190
8.3	The Struggle Against Voracious Insects	193
8.4	Resisting the Kingdoms of Mustiness and Rot	200
8.5	Heterocycles in Animal Husbandry	202
8.6	Combinatorial Chemistry and Functional Genomics in the Synthesis of Biologically Active Heterocyclic Compounds	202

8.7	Problems	205
8.8	Suggested Reading	207
9.	Heterocycles in Industry and Technology	209
9.1	Heterocycles and Natural Colors	209
9.2	Dyes	211
9.2.1	From Imperial Cloaks to Jeans	211
9.2.2	'Cyanine' Means Azure	214
9.2.3	Phthalocyanines: Sometimes Better than Porphyrins	215
9.2.4	The Anchoring of Dyes	217
9.3	Fluorescent Agents	218
9.3.1	Why They Shine	218
9.3.2	Safety and Aesthetics	219
9.3.3	How to Convert White into Snow White	220
9.3.4	Markers and Tracers	221
9.3.5	Imaging and Diagnostic Agents	222
9.3.6	Lasers Containing Heterocyclic Luminophores	226
9.4	Color Change Compounds	231
9.5	Fire Retardancy	233
9.6	Photographic Materials and Recorders of Information	235
9.7	Heterocycles as Food Additives	237
9.8	Heterocycles as Cosmetics and Perfumery Ingredients	241
9.9	Other Applications	243
9.10	Problems	245
9.11	Suggested Reading	246
10.	Heterocycles and Supramolecular Chemistry	247
10.1	Molecular Recognition and Host–Guest Interactions	248
10.1.1	Cation Receptors	248
10.1.2	Anion-, Betaine- and Ionic Associated Receptors	257
10.1.3	Receptors for Neutral Molecules	259
10.1.4	Molecular Carcerands	261
10.1.5	Molecular Containers for the Proton	262
10.2	Self-Assembling Molecular Systems	267
10.3	Problems	272
10.4	Suggested Reading	274
11.	Heterocycles and Twenty-First Century Challenges	275
11.1	Energy Problem	275
11.1.1	Biofuels	275
11.1.2	Hydrogen as a Fuel	276
11.1.3	Direct Use of Solar Energy	278
11.1.4	Conducting Materials	286
11.2	Ecology and Green Chemistry	293
11.3	Biotechnology and Related Problems	299
11.3.1	Enzyme Technologies	299
11.3.2	DNA Technologies	304
11.3.3	New Trends in Health Care	309
11.3.4	Heterocycles as Molecular Sensors	310

11.4	From Molecular Devices to Molecular Computer	315
11.5	Problems	321
11.6	Suggested Reading	322
12.	The Origin of Heterocycles	325
12.1	The Origin of the Universe and the Appearance of Chemical Elements	326
12.2	Interstellar Molecules	328
12.3	Organic Compounds in Comets and Meteorites	333
12.4	Do Heterocycles Exist on the Moon and Mars?	335
12.5	The Atmosphere of Earth and Other Planets	335
12.6	Heterocycles and the Origin of the Biosphere	336
12.6.1	Simple Precursors of Heterocycles	336
12.6.2	Heterocyclic Amino Acids	338
12.6.3	Pyrroles and Porphyrins	340
12.6.4	Furanose Sugars	341
12.6.5	Nicotinamide	344
12.6.6	Purines and Pyrimidines	344
12.6.7	Nucleosides and Nucleotides	345
12.6.8	Polynucleotides and the Birth of 'Animated' Organic Molecules	350
12.7	Problems	358
12.8	Suggested Reading	358
	<i>Conclusion</i>	361
	<i>Answers and References to Selected Problems</i>	363
	<i>Index</i>	371