## Contents

s

g

| CHAPTER 1 THE CONNECTION BETWEEN BIOLOGY AND PHYSICS  | 1                          |
|---|----------------------------|
| 1. The Difference between Living Organisms and Inanimate Matter   | 1                          |
| <ol> <li>The Possibility of giving a Molecular Description to Biological<br/>Phenomena</li> </ol>   | 3                          |
| CHAPTER 2 INTERACTIONS BETWEEN ATOMS IN MOLECULES AND BETWEEN<br>MOLECULES THEMSELVES   | 9                          |
| 3. The Chemical Units of Life   | 9                          |
| 4. The Electronic Structure of the Main Atoms of Biomolecules   | 10                         |
| <ol> <li>Interaction between Atoms</li> <li>5.1. Localised Chemical Bonds</li> <li>5.2. Incomplete Localisation of Chemical Bonds</li> </ol>  | 14<br>14<br>21             |
| <ul> <li>6. Interaction between Molecules</li> <li>6.1. Dispersion or van der Waal's Forces</li> <li>6.2. Hydrogen Bonds between Molecules</li> </ul>   | 23<br>23<br>25             |
| 7. The Interaction of Ions and Molecules with Water<br>7.1. The Hydration of Ions in Water<br>7.2. Hydrophobic and Hydrophilic Interactions   | 30<br>30<br>33             |
| CHAPTER 3 PROTEINS AND THEIR BIOLOGICAL FUNCTIONS   | 37                         |
| <ul> <li>8. Protein Structure</li> <li>8.1. Amino Acids</li> <li>8.2. The Primary Structure of Proteins</li> <li>8.3. The Secondary and Higher Order Structures of Protein<br/>Molecules</li> </ul>   | 38<br>38<br>42<br>44       |
| <ol> <li>Some Biological Functions of Proteins</li> <li>9.1. Proteins which Store and Transport Oxygen</li> <li>9.2. Biocatalysts - Enzymes</li> <li>9.3. Allosteric Enzymes. Cooperative Behaviour</li> <li>9.4. The Control of Biochemical Reactions</li> </ol> | 48<br>48<br>53<br>58<br>61 |
| 10. Enzymes with a Known Spatial Structure<br>10.1. Lysozyme<br>10.2. The Family of Enzymes which Break Down Proteins   | 64<br>64<br>66             |

vii

| Contents  |            | Contents   |
|---|------------|--|
| Contents  | 7.2        | 20. Modern Ideas on the Mechanism of Muscle Contra   |
| CELL MEMBRANES  |            | 20.1. The Sliding Filament Model                     |
| Surface of the Cell   | 73         | 20.2. Phenomenological Theories for the Mechanism    |
| Recognition of Cells by One Another                           | 75         | of Striated Muscles                                  |
|   | 76         | 20.3. The Molecular Theory of Muscular Contractio    |
| mposition and Structure of Cell Memorales                     | 80         | 31 The Contractile Systems in Nonskeletal Muscles    |
| Inner Membrane Proteins                                       | 81         | 21. The contractile systems in Nonskeletar Masters   |
| Dynamic Models for Cell Membranes                             | 82         | 21.1. The synchronous Flight Muscles in Insects      |
| Cooperative Phenomena in Memoranes                            |            | 21.2. Asynchronous Fright Muscles in Insects         |
| ssive Transport of Ions and Molecules Across Membranes        | 83         | 21.5. Movement with the help of cirra and radyou     |
| Transport of Molecules and Ions Across Membranes Separating   |            | 21.4. Spectatised Muscre ceris                       |
| Electrolytes  | 84         | CURPTER 7 THE MICRATION OF ENERGY AND ELECTRONS IN P |
| Passive Transport with the Participation of Carriers          | 86         | CHAPTER / THE MIGRATION OF ENERGY MUD EDUCTIONS IN 2 |
| The Molecular Mechanism for the Membrane Activity of          |            | 22. The Migration of Energy in One-Dimensional Mol   |
| Valinomycin   | 90         | 22.1. Excitons in Periodic One-Dimensional Molecu    |
| The Transmembrane Potential Difference                        | 92         | 22.2. Solitons in ordered One-Dimensional Molecul    |
| read Transport of Molecules and Ions Across Biological        |            | 22.3. Comparison of the Properties of Solitons an    |
| mbranes   | 94         | 22.4. Solitons in «-Spiral Protein Molecules         |
|   | 94         | 23 The Transport of Electrons in Biological Syste    |
| The Provided State of the Membrane                            | 98         | 23.1 Tunnelling Transfer of Electrons                |
| The Energised State of the Membrane                           | 100        | 23.2 The Bole of Proteins in the Process of Fler     |
| Oxidative PhosphoryLation                                     | 102        | 23.2. The Role of Floteins in the Flotess of Miec    |
| Active fransport in the memorane of Successa                  |            | 23.3 The Basic Equations Defining the Motion of      |
|   | 105        | a Quasi-One-Dimensional Molecular Chain              |
| ) DIOEMEROBIICO   | 105        | 23.4. Continuum Approximation                        |
| tabolic Reactions in the Cell                                 | 105        | 23.4. Concindum Approximación                        |
| The ATP Molecule as a Universal Accumulator of Energy in the  | 110        | Bibliography   |
| Cell  |            |  |
| itochondria - The Energy Factories of the Cell                | 113        | Index  |
| , The Electron Transport Chain in Mitochondria                | 115        |  |
| , Hypotheses on the Mechanism of Phosphorylation in the Inner |            | Other Titles in the Series                           |
| Membranes of Mitochondria                                     | 121 ,      | ч.   |
| . The Chemiosmotic Hypothesis on the Coupling between the     | 100        |  |
| Processes of Respiration and Phosphorylation                  | 123 -      |  |
| e Photosynthesis Mechanism                                    | 127        |  |
| Chlorophyll and other Light-Sensitive Pigments                | 130        |  |
| Photosynthesising Centres in Chloroplasts                     | 134        |  |
| Photosynthesising Systems of Bacteria and Blue-Green Algae    | 135        |  |
| Two Photosynthesising Systems in Plants                       | 138        |  |
| Counling Mechanism between Light-Elicited Charge Separation   |            |  |
| Reactions and Photophosphorylation                            | 142        |  |
| The Dark Phase of Photosynthesis                              | 145        |  |
| The Photosynthesising Mechanism without Chlorophyll Molecules | 145        |  |
| The Increasteriestoric requirem atomote entring the second    | 1.40       |  |
| pnduction of the Nerve Impulse                                | 149        |  |
| Non-Myelinated Nerve Fibres                                   | 120        |  |
| The Action Potential  | 152        |  |
| The Hodgkin-Huxley Equation                                   | 154        |  |
| The Propagation of Nerve Impulses along Nerve Fibres          | 150        |  |
| Synaptic Transmission   | 150<br>150 |  |
| Neuromuscular Synapses  | 128        |  |
| THE MOLECULAR MECHANISM OF MUSCLE CONTRACTION                 | 161        |  |
| Structural Organization of Striated Muscles                   | 161        |  |
| The Secondamic Reticulum in Striated Muscles                  | 163        |  |
| The Microstructure of Myofibrils                              | 165        |  |
| The Biochemistry of the Process of Muscle Contraction         | 167        |  |
| The Brochemistry of the Frocess of Musere construction        |            |  |

| Contents  | ix  |
|---|-----|
| 20 Modern Ideas on the Mechanism of Muscle Contraction                | 170 |
| 20.1. The Sliding Filament Model                                      | 171 |
| 20.2. Phenomenological Theories for the Mechanism of Contraction      |     |
| of Striated Muscles   | 171 |
| 20.3. The Molecular Theory of Muscular Contraction                    | 173 |
| 21. The Contractile Systems in Nonskeletal Muscles                    | 178 |
| 21.1. The Synchronous Flight Muscles in Insects                       | 178 |
| 21.2. Asynchronous Flight Muscles in Insects                          | 180 |
| 21.3. Movement with the Help of Cilia and Flagella                    | 181 |
| 21.4. Specialised Muscle Cells  | 183 |
| CHAPTER 7 THE MIGRATION OF ENERGY AND ELECTRONS IN BIOLOGICAL SYSTEMS | 185 |
| 22 The Migration of Energy in One-Dimensional Molecular Systems       | 185 |
| 22.1. Excitons in Periodic One-Dimensional Molecular Structures       | 186 |
| 22. Solitons in ordered One-Dimensional Molecular Structures          | 190 |
| 22.3. Comparison of the Properties of Solitons and Excitons           | 195 |
| 22.4. Solitons in $\propto$ -Spiral Protein Molecules                 | 197 |
| 23. The Transport of Electrons in Biological Systems                  | 203 |
| 23.1. Tunnelling Transfer of Electrons                                | 204 |
| 23.2. The Role of Proteins in the Process of Electron Transport       |     |
| over Large Distances  | 205 |
| 23.3. The Basic Equations Defining the Motion of Extra Electron in    |     |
| a Quasi-One-Dimensional Molecular Chain                               | 207 |
| 23.4. Continuum Approximation   |     |
| Bibliography  | 213 |
|   | 222 |
| Index   | 223 |
| Other Titles in the Series  | 227 |

.

.

•

A second se

١