

# Contents

|   |   |    |
|---|---|----|
| 1 | Evolution by natural selection                | 2  |
|   | Darwin's theory                               | 3  |
|   | Evolution <i>in vitro</i>                     | 5  |
|   | Lamarck, Weismann, and the central dogma      | 8  |
|   | Further reading                               | 12 |
|   | Problems                                      | 13 |
|   | Computer projects                             | 13 |
| 2 | Models of populations                         | 14 |
|   | Models of population growth                   | 15 |
|   | Selection in an asexual population            | 17 |
|   | The accuracy of replication                   | 20 |
|   | Genetic drift in finite populations ✓         | 24 |
|   | Further reading                               | 27 |
|   | Problems                                      | 27 |
|   | Computer projects                             | 28 |
| 3 | Evolution in diploid populations              | 30 |
|   | Gene frequencies and the Hardy-Weinberg ratio | 31 |
|   | The concept of fitness                        | 36 |
|   | The spread of a favourable gene               | 40 |
|   | Further reading                               | 45 |
|   | Problems                                      | 46 |
|   | Computer projects                             | 47 |
| 4 | The variability of natural populations        | 48 |
|   | The evidence for genetic variability          | 49 |
|   | Mutation                                      | 53 |
|   | The maintenance of variation                  | 65 |
|   | Further reading                               | 77 |
|   | Problems                                      | 77 |
|   | Computer projects                             | 78 |
| 5 | Evolution at more than one locus              | 80 |
|   | Linkage disequilibrium                        | 81 |
|   | Heterostyly in plants                         | 84 |



|  |            |
|--|------------|
| Mimicry in butterflies                                       | 86         |
| Linkage disequilibrium in natural populations                | 87         |
| Normalizing selection and linkage disequilibrium             | 89         |
| Further reading  | 91         |
| Problems   | 91         |
| Computer projects  | 91         |
| <b>6 Quantitative genetics</b>                               | <b>92</b>  |
| Nature and nurture   | 93         |
| The additive genetic model                                   | 96         |
| A more realistic model                                       | 108        |
| Experiments in artificial selection                          | 113        |
| Quantitative variation and fitness                           | 117        |
| The maintenance of genetic variation for quantitative traits | 119        |
| Further reading  | 122        |
| Problems   | 122        |
| Computer projects  | 123        |
| <b>7 A model of phenotypic evolution</b>                     | <b>124</b> |
| Pairwise interactions  | 126        |
| Some extensions of the model                                 | 132        |
| Will a sexual population evolve to an ESS?                   | 135        |
| Further reading  | 136        |
| Problems   | 136        |
| Computer projects  | 137        |
| <b>8 Finite and structured populations</b>                   | <b>138</b> |
| Inbreeding   | 139        |
| Genetic drift  | 144        |
| The rate of neutral molecular evolution                      | 147        |
| Mitochondrial DNA  | 153        |
| Migration and differentiation between populations            | 156        |
| The establishment of a new favourable mutation               | 161        |
| Further reading  | 162        |
| Problems   | 162        |
| Computer projects  | 163        |
| <b>9 Evolution in structured populations</b>                 | <b>164</b> |
| Selection in trait groups                                    | 165        |
| The evolution of co-operation: synergistic selection         | 167        |
| The evolution of co-operation: relatedness                   | 169        |



|  |            |
|--|------------|
| The group as the unit of evolution               | 175        |
| The shifting balance theory                      | 181        |
| Further reading                                  | 183        |
| Problems   | 183        |
| Computer projects                                | 184        |
| <b>10 The evolution of prokaryotes</b>           | <b>186</b> |
| The evolution of gene function                   | 187        |
| Phages, plasmids, and transposable elements      | 189        |
| The evolution of phages and their hosts          | 191        |
| The evolution of plasmids                        | 192        |
| The evolution of transposons                     | 195        |
| The population genetics of <i>E. coli</i>        | 196        |
| The evolution of viruses                         | 198        |
| Further reading                                  | 201        |
| Computer projects                                | 201        |
| <b>11 The evolution of the eukaryotic genome</b> | <b>202</b> |
| The nature of the genome                         | 203        |
| The haemoglobin gene family                      | 205        |
| Duplication and the increase of DNA content      | 211        |
| The ribosomal genes                              | 214        |
| Unequal crossing over and gene conversion        | 215        |
| Repetitive DNA                                   | 217        |
| The evolution of chromosome form                 | 224        |
| Further reading                                  | 227        |
| Computer projects                                | 228        |
| <b>12 The evolution of genetic systems.</b>      |            |
| <b>I. Sex and recombination</b>                  | <b>230</b> |
| The natural history of eukaryotic sex            | 231        |
| The evolutionary significance of sex             | 237        |
| The evolution of recombination                   | 246        |
| Further reading                                  | 254        |
| <b>13 The evolution of genetic systems.</b>      |            |
| <b>II. Some consequences of sex</b>              | <b>256</b> |
| The sex ratio                                    | 257        |
| Selfing and outcrossing                          | 261        |
| Hermaphroditism                                  | 261        |



|                            |            |
|----------------------------|------------|
| Sexual selection           | 264        |
| Further reading            | 269        |
| Problems                   | 269        |
| Computer projects          | 270        |
| <b>14 MacroevoIution</b>   | <b>272</b> |
| Species and speciation     | 273        |
| Patterns of evolution      | 280        |
| Coevolution                | 292        |
| Further reading            | 303        |
| Problems                   | 303        |
| Computer projects          | 303        |
| <b>Answers to problems</b> | <b>305</b> |
| <b>References</b>          | <b>313</b> |
| <b>Index</b>               | <b>321</b> |