

Contents

| | |
|---|-----------|
| CHAPTER 1 INTRODUCTION | 1 |
| Characteristics of Useful Experimental Organisms | 4 |
| Methods of Genetic Study | 6 |
| Fields of Study Useful in Genetics | 8 |
| Practical Applications of Genetics | 10 |
| References | 12 |
| Problems | 12 |
| | |
| CHAPTER 2 MONOHYBRID INHERITANCE | 14 |
| The Standard Monohybrid Cross | 15 |
| Complete Dominance | 15 |
| Mechanism of the Monohybrid Cross | 17 |
| The Testcross | 20 |
| Modifications of the 3:1 Phenotypic Ratio | 21 |
| Incomplete Dominance | 21 |
| Codominance | 23 |
| Lethal Genes | 24 |
| References | 29 |
| Problems | 30 |
| | |
| CHAPTER 3 DIHYBRID INHERITANCE | 34 |
| Classic Two-Pair Ratios | 35 |
| Complete Dominance in Two Pairs | 35 |
| Gamete and Zygote Combinations | 38 |
| Testcross | 39 |
| Modifications of the 9:3:3:1 Ratio | 40 |
| Incomplete Dominance | 40 |
| Epistasis | 40 |
| References | 45 |
| Problems | 45 |
| | |
| CHAPTER 4 CYTOLOGICAL BASES OF INHERITANCE | 49 |
| The Interphase Nucleus | 49 |
| The Interphase Cycle | 52 |
| Cell Division | 56 |

| | |
|-------------------------|----|
| Mitosis | 57 |
| Cytokinesis | 62 |
| Significance of Mitosis | 63 |
| Chromosome Morphology | 65 |
| Meiosis | 73 |
| Significance of Meiosis | 87 |
| References | 88 |
| Problems | 89 |

CHAPTER 5 PROBABILITY AND GOODNESS OF FIT 91

| | |
|--|-----|
| Two Independent, Nongenetic Events | 91 |
| Single-Coin Tosses | 91 |
| Two-Coin Tosses | 92 |
| Four-Coin Tosses | 93 |
| The Binomial Expression | 94 |
| Genetic Applications of the Binomial | 97 |
| Probability of Separate Occurrence of Independent Events | 98 |
| Determining "Goodness of Fit" | 99 |
| Nongenetic Events | 99 |
| Genetic Applications of Chi-Square | 101 |
| References | 102 |
| Problems | 102 |

CHAPTER 6 LINKAGE, CROSSING-OVER, AND GENETIC MAPPING OF CHROMOSOMES 105

| | |
|--|-----|
| Linkage and Crossing-over | 106 |
| Bateson and Punnett on Sweet Pea | 106 |
| Arrangement of Linked Genes | 107 |
| Linkage, Linkage Groups, and Mapping | 108 |
| Cytological Evidence for Crossing-over | 110 |
| Mapping Nonhuman Chromosomes | 112 |
| The Three-Point Cross | 113 |
| Interference and Coincidence | 117 |
| Mapping Human Chromosomes | 119 |
| Linkage Studies in Bacteria | 120 |
| Evidence from Conjugation | 121 |
| Linkage Studies in Viruses | 124 |
| Mechanism of Recombination | 125 |
| Summary | 128 |
| References | 128 |
| Problems | 129 |

CHAPTER 7 MULTIPLE ALLELES AND BLOOD GROUP INHERITANCE 132

| | |
|--|-----|
| The Concept of Multiple Alleles | 132 |
| Coat Color in Rabbits | 132 |
| The Blood Groups in Humans | 136 |
| The Antigen-Antibody Reaction | 136 |
| Inheritance of A, B, AB, and O Blood Groups | 138 |
| The H Antigen | 140 |
| Medicolegal Aspects of the A-B-O Series | 141 |
| Other Blood Phenotypes | 143 |
| The Major Histocompatibility Complex in Humans | 145 |
| References | 147 |
| Problems | 148 |

CHAPTER 8 PSEUDOALLELES AND THE Rh BLOOD FACTOR 150

ix
CONTENTS

| | |
|------------------------------------|-----|
| <i>Drosophila</i> | 150 |
| <i>Human Beings: The Rh Factor</i> | 152 |
| <i>Origin of Pseudoalleles</i> | 157 |
| <i>References</i> | 157 |
| <i>Problems</i> | 157 |

CHAPTER 9 POLYGENIC INHERITANCE 159

| | |
|--|-----|
| <i>Kernel Color in Wheat</i> | 160 |
| <i>Calculating the Number of Polygenes</i> | 161 |
| <i>Human Eye Color</i> | 162 |
| <i>Other Human Traits</i> | 163 |
| <i>Transgressive Variation</i> | 164 |
| <i>Other Organisms</i> | 164 |
| <i>Concluding Statement</i> | 164 |
| <i>References</i> | 165 |
| <i>Problems</i> | 166 |

CHAPTER 10 STATISTICAL CONCEPTS AND TOOLS 168

| | |
|---|-----|
| <i>Basic Statistics</i> | 169 |
| <i>The Mean</i> | 169 |
| <i>Variance</i> | 170 |
| <i>Standard Deviation</i> | 171 |
| <i>The Standard Error of the Sample Mean</i> | 173 |
| <i>Standard Error of the Difference in Means</i> | 174 |
| <i>Applications of Statistics to Genetic Problems</i> | 176 |
| <i>Problems</i> | 178 |

CHAPTER 11 SEX DETERMINATION 180

| | |
|--|-----|
| <i>Sex Chromosomes</i> | 180 |
| <i>Diploid Organisms</i> | 180 |
| <i>Monoploid Organisms</i> | 182 |
| <i>Determination of Sex Under the Chromosomal System</i> | 183 |
| <i>Drosophila</i> | 183 |
| <i>Human Beings</i> | 188 |
| <i>The Sex Chromosomes</i> | 188 |
| <i>Sex Differentiation</i> | 190 |
| <i>Human Sex Anomalies</i> | 192 |
| <i>Plants</i> | 205 |
| <i>Genic Determination of Sex</i> | 207 |
| <i>Conclusion</i> | 210 |
| <i>References</i> | 210 |
| <i>Problems</i> | 211 |

CHAPTER 12 INHERITANCE RELATED TO SEX 213

| | |
|--------------------------------|-----|
| <i>Sex Linkage (X-Linkage)</i> | 213 |
| <i>Holandric Genes</i> | 219 |
| <i>Sex-Limited Genes</i> | 220 |
| <i>Sex-Influenced Genes</i> | 223 |
| <i>References</i> | 223 |
| <i>Problems</i> | 224 |

**CHAPTER 13 CHROMOSOMAL ABERRATIONS:
CHANGES IN NUMBER** 226

| | |
|------------------------------|-----|
| Changes in Chromosome Number | 226 |
| Euploidy | 226 |
| Aneuploidy | 235 |
| Trisomy in Humans | 239 |
| Nonhuman Trisomics | 247 |
| References | 247 |
| Problems | 250 |

**CHAPTER 14 CHROMOSOMAL ABERRATIONS:
STRUCTURAL CHANGES** 252

| | |
|---|-----|
| Types of Structural Changes | 254 |
| Deletions | 254 |
| Inversions | 261 |
| Translocations | 261 |
| Duplications and the Position Effect | 266 |
| Possible Causative Chemical Agents of Chromosomal Aberrations in Humans | 268 |
| Chromosomal Aberrations and Evolution | 270 |
| References | 271 |
| Problems | 272 |

CHAPTER 15 POPULATION GENETICS 274

| | |
|----------------------------------|-----|
| Calculating Gene Frequency | 275 |
| Factors Affecting Gene Frequency | 281 |
| The Mechanism of Evolution | 291 |
| References | 292 |
| Problems | 292 |

**CHAPTER 16 THE IDENTIFICATION OF THE
GENETIC MATERIAL** 295

| | |
|--------------------------|-----|
| Bacterial Transformation | 296 |
| Transduction | 297 |
| Deoxyribonucleic Acid | 302 |
| Location of DNA in Cells | 308 |
| Replication of DNA | 312 |
| References | 322 |
| Problems | 324 |

CHAPTER 17 PROTEIN SYNTHESIS 326

| | |
|--|-----|
| Genes and Enzymes | 326 |
| Protein Structure | 329 |
| Polypeptide Chain Synthesis—The Components | 330 |
| Minimum Necessary Materials | 344 |
| Polypeptide Chain Synthesis—The Process | 345 |
| In Vitro Protein Synthesis | 348 |
| References | 348 |
| Problems | 349 |

CHAPTER 18 THE GENETIC CODE 352

| | |
|------------------------------------|-----|
| Problems of the Nature of the Code | 353 |
| The Coding Dictionary | 357 |

| | |
|---|-----|
| <i>Degeneracy</i> | 358 |
| <i>Ambiguity</i> | 359 |
| <i>Colinearity</i> | 359 |
| <i>Chain Initiation and Termination</i> | 360 |
| <i>Universality</i> | 361 |
| <i>Summary of Code Characteristics</i> | 363 |
| <i>References</i> | 364 |
| <i>Problems</i> | 365 |

CHAPTER 19 MOLECULAR STRUCTURE OF THE GENE 367

| | |
|--|-----|
| <i>Mutagenic Agents</i> | 368 |
| <i>Radiation</i> | 369 |
| <i>Chemicals and Subnucleotide Changes</i> | 372 |
| <i>Mutation Rate in Human Beings</i> | 376 |
| <i>Genetic Polymorphism</i> | 376 |
| <i>Genetics of Glucose-6-Phosphate Dehydrogenase</i> | 377 |
| <i>Genetics of Hemoglobin</i> | 378 |
| <i>The Tryptophan Synthetase System</i> | 381 |
| <i>Fine Structure of the Gene</i> | 382 |
| <i>The Cistron</i> | 382 |
| <i>The Muton</i> | 385 |
| <i>The Recon</i> | 386 |
| <i>Dominance and Recessiveness</i> | 387 |
| <i>Conclusions</i> | 388 |
| <i>References</i> | 389 |
| <i>Problems</i> | 390 |

CHAPTER 20 REGULATION OF GENE ACTION 392

| | |
|--|-----|
| <i>Evidence of Regulation of Gene Action</i> | 393 |
| <i>Chromosome Puffs</i> | 393 |
| <i>Enzyme Regulatory Mechanisms</i> | 397 |
| <i>End-product Inhibition</i> | 397 |
| <i>The Operon</i> | 398 |
| <i>Other Operons</i> | 402 |
| <i>Summary of Gene Regulation</i> | 403 |
| <i>References</i> | 404 |
| <i>Problems</i> | 404 |

CHAPTER 21 CYTOPLASMIC GENETIC SYSTEMS 406

| | |
|--|-----|
| <i>Suggested Criteria for Cytoplasmic Genes</i> | 406 |
| <i>Chloroplasts</i> | 407 |
| <i>Mitochondria</i> | 411 |
| <i>Extranuclear Inheritance Without Known Cytoplasmic Structures</i> | 413 |
| <i>Plasmids</i> | 413 |
| <i>Maternal Effects</i> | 415 |
| <i>Infective Particles</i> | 416 |
| <i>Concluding View</i> | 418 |
| <i>References</i> | 418 |
| <i>Problems</i> | 419 |

CHAPTER 22 THE NEW GENETICS, RECOMBINANT DNA, AND THE FUTURE 421

| | |
|---|-----|
| <i>Rationale of Human Evolution Control</i> | 423 |
| <i>The Ethics of the "New Genetics"</i> | 434 |

Recombinant DNA and the Future 437
References 440
Questions for Reflection 441

APPENDIX A ANSWERS TO PROBLEMS 444

APPENDIX B SELECTED LIFE CYCLES 468

Bacteria 468
Neurospora 469
Saccharomyces (Yeast) 469
Chlamydomonas (Green Alga) 471
Sphaerocarpos (Liverwort) 471
Flowering Plants (Class Angiospermae) 472
Paramecium 474
Mammals 476

APPENDIX C THE BIOLOGICALLY IMPORTANT AMINO ACIDS 478

APPENDIX D USEFUL FORMULAS, RATIOS, AND STATISTICS 483

APPENDIX E USEFUL METRIC VALUES 487

APPENDIX F JOURNALS AND REVIEWS 488

GLOSSARY 489

INDEX 507