

BRIEF CONTENTS



McGraw-Hill
Irwin

PART I INTRODUCTION

- 1 Overview of Genetics 1

PART II PATTERNS OF INHERITANCE

- 2 Mendelian Inheritance 17
- 3 Reproduction and Chromosome Transmission 44
- 4 Extensions of Mendelian Inheritance 71
- 5 Linkage and Genetic Mapping in Eukaryotes 100
- 6 Genetic Transfer and Mapping in Bacteria and Bacteriophages 133
- 7 Non-Mendelian Inheritance 161
- 8 Variation in Chromosome Structure and Number 187

PART III MOLECULAR STRUCTURE AND REPLICATION OF THE GENETIC MATERIAL

- 9 Molecular Structure of DNA and RNA 221
- 10 Chromosome Organization and Molecular Structure 246
- 11 DNA Replication 270

PART IV MOLECULAR PROPERTIES OF GENES

- 12 Gene Transcription and RNA Modification 29
- 13 Translation of mRNA 324
- 14 Gene Regulation in Bacteria and Bacteriophages 360
- 15 Gene Regulation in Eukaryotes 389
- 16 Gene Mutation and DNA Repair 424
- 17 Recombination and Transposition at the Molecular Level 455

PART V GENETIC TECHNOLOGIES

- 18 Recombinant DNA Technology 482
- 19 Biotechnology 514
- 20 Genomics I: Analysis of DNA 542
- 21 Genomics II: Functional Genomics, Proteomics and Bioinformatics 571

PART VI GENETIC ANALYSIS OF INDIVIDUALS AND POPULATION

- 22 Medical Genetics and Cancer 599
- 23 Developmental Genetics 632
- 24 Population Genetics 665
- 25 Quantitative Genetics 697
- 26 Evolutionary Genetics 727

TABLE OF CONTENTS

••

Preface ix

A Visual Guide to *Genetics: Analysis and Principles* xvi

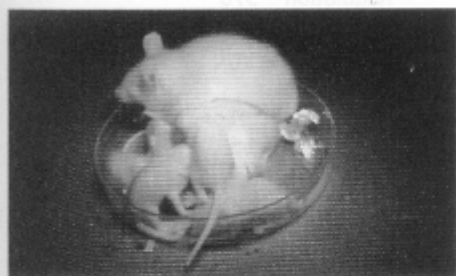
PART I

INTRODUCTION 1

1

OVERVIEW OF GENETICS 1

- 1.1 The Relationship Between Genes and Traits 4
- 1.2 Fields of Genetics 10



PART II

PATTERNS OF INHERITANCE 17

2

MENDELIAN INHERITANCE 17

- 2.1 Mendel's Laws of Inheritance 18
 - Experiment 2A Mendel Followed the Outcome of a Single Trait for Two Generations 21
 - Experiment 2B Mendel Also Analyzed Crosses Involving Two Different Traits 25
- 2.2 Probability and Statistics 30

3

REPRODUCTION AND CHROMOSOME TRANSMISSION 44

- 3.1 General Features of Chromosomes 44
- 3.2 Cell Division 48
- 3.3 Sexual Reproduction 54
- 3.4 The Chromosome Theory of Inheritance and Sex Chromosomes 60
 - Experiment 3A Morgan's Experiments Showed a Connection Between a Genetic Trait and the Inheritance of a Sex Chromosome in *Drosophila* 64

4

EXTENSIONS OF MENDELIAN INHERITANCE 71

- 4.1 Inheritance Patterns of Single Genes 71
- 4.2 Gene Interactions 86
 - Experiment 4A Bridges Observed an 8:4:3:1 Ratio Because the Cream-Eye Gene Can Modify the X-Linked Eosin Allele but Not the Red or White Alleles 89

5

LINKAGE AND GENETIC MAPPING IN EUKARYOTES 100

- 5.1 Linkage and Crossing Over 100
 - Experiment 5A Creighton and McClintock Showed That Crossing Over Produced New Combinations of Alleles and Resulted in the Exchange of Segments Between Homologous Chromosomes 106

5.2 Genetic Mapping in Plants and Animals 109

Experiment 5B Alfred Sturtevant Used the Frequency of Crossing Over in Dihybrid Crosses to Produce the First Genetic Map 113

5.3 Genetic Mapping in Haploid Eukaryotes 118

6

GENETIC TRANSFER AND MAPPING IN BACTERIA AND BACTERIOPHAGES 133

6.1 Genetic Transfer and Mapping in Bacteria 134

Experiment 6A Conjugation Experiments Can Map Genes Along the *E. coli* Chromosome 139

6.2 Intragenic Mapping in Bacteriophages 148

7

NON-MENDELIAN INHERITANCE 161

7.1 Maternal Effect 161

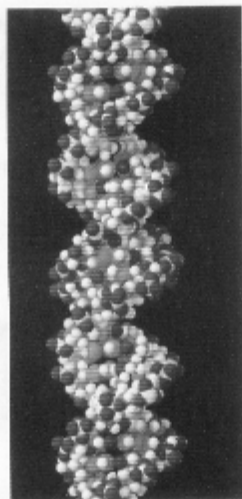
7.2 Epigenetic Inheritance 164

Experiment 7A In Adult Female Mammals, One X Chromosome Has Been Permanently Inactivated 166

7.3 Extranuclear Inheritance 174

8 VARIATION IN CHROMOSOME STRUCTURE AND NUMBER 187

- 8.1 Variation in Chromosome Structure 187
 - Experiment 8A Comparative Genomic Hybridization Is Used to Detect Chromosome Deletions and Duplications 193
- 8.2 Variation in Chromosome Number 200
- 8.3 Natural and Experimental Ways to Produce Variations in Chromosome Number 207



PART III

MOLECULAR STRUCTURE AND REPLICATION OF THE GENETIC MATERIAL 221

9 MOLECULAR STRUCTURE OF DNA AND RNA 221

- 9.1 Identification of DNA as the Genetic Material 221
 - Experiment 9A Hershey and Chase Provided Evidence That the Genetic Material Injected into the Bacterial Cytoplasm Is T2 Phage DNA 224
- 9.2 Nucleic Acid Structure 228
 - Experiment 9B Chargaff Found That DNA Has a Biochemical Composition in Which the Amount of A Equals T and the Amount of G Equals C 231

10 CHROMOSOME ORGANIZATION AND MOLECULAR STRUCTURE 246

- 10.1 Viral Genomes 246
- 10.2 Bacterial Chromosomes 248
- 10.3 Eukaryotic Chromosomes 251
 - Experiment 10A The Repeating Nucleosome Structure Is Revealed by Digestion of the Linker Region 256

11 DNA REPLICATION 270

- 11.1 Structural Overview of DNA Replication 270
 - Experiment 11A Three Different Models Were Proposed That Described the Net Result of DNA Replication 272
- 11.2 Bacterial DNA Replication 274
 - Experiment 11B DNA Replication Can Be Studied In Vitro 285
- 11.3 Eukaryotic DNA Replication 288



PART IV

MOLECULAR PROPERTIES OF GENES 297

12 GENE TRANSCRIPTION AND RNA MODIFICATION 297

- 12.1 Overview of Transcription 298
- 12.2 Transcription in Bacteria 300
- 12.3 Transcription in Eukaryotes 305

- 12.4 RNA Modification 309
 - Experiment 12A Introns Were Experimentally Identified Via Microscopy 311

13 TRANSLATION OF mRNA 324

- 13.1 The Genetic Basis for Protein Synthesis 324
 - Experiment 13A Synthetic RNA Helped to Decipher the Genetic Code 329
- 13.2 Structure and Function of tRNA 337
 - Experiment 13B tRNA Functions as the Adaptor Molecule Involved in Codon Recognition 339
- 13.3 Ribosome Structure and Assembly 344
- 13.4 Stages of Translation 347

14 GENE REGULATION IN BACTERIA AND BACTERIOPHAGES 360

- 14.1 Transcriptional Regulation 361
 - Experiment 14A The *lacI* Gene Encodes a Diffusible Repressor Protein 366
- 14.2 Translational and Posttranslational Regulation 376
- 14.3 Gene Regulation in the Bacteriophage Reproductive Cycle 377

15 GENE REGULATION IN EUKARYOTES 389

- 15.1 Regulatory Transcription Factors 390
- 15.2 Changes in Chromatin Structure 397
 - Experiment 15A DNase I Sensitivity Can Be Used to Study Changes in Chromatin Compaction 398
- 15.3 Regulation of RNA Processing, RNA Stability, and Translation 406
 - Experiment 15B Fire and Mello Show That Double-Stranded RNA Is More Potent Than Antisense RNA at Silencing mRNA 412

16 GENE MUTATION AND DNA REPAIR 424

- 16.1 Consequences of Mutation 425
 16.2 Occurrence and Causes of Mutation 432
 Experiment 16A X-Rays Were the First Environmental Agent Shown to Cause Induced Mutations 438
 16.3 DNA Repair 443

17 RECOMBINATION AND TRANSPOSITION AT THE MOLECULAR LEVEL 455

- 17.1 Homologous Recombination 455
 Experiment 17A The Staining of Harlequin Chromosomes Can Reveal Recombination Between Sister Chromatids 456
 17.2 Site-Specific Recombination 464
 17.3 Transposition 466
 Experiment 17B McClintock Found That Chromosomes of Corn Plants Contain Loci That Can Move 466



PART V GENETIC TECHNOLOGIES 482

18 RECOMBINANT DNA TECHNOLOGY 482

- 18.1 Gene Cloning 483
 Experiment 18A In the First Gene Cloning Experiment, Cohen, Chang, Boyer, and Helling Inserted a *kanamycin*[®] Gene into a Plasmid Vector 488

- 18.2 Detection of Genes, Gene Products, and Protein-DNA Interactions 497
 18.3 Analysis and Alteration of DNA Sequences 503

19 BIOTECHNOLOGY 514

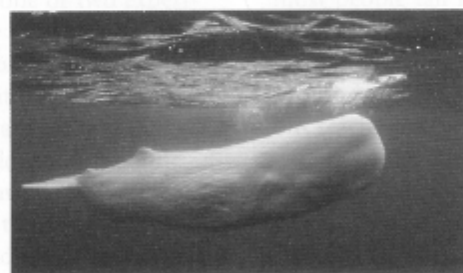
- 19.1 The Uses of Microorganisms in Biotechnology 514
 Experiment 19A Somatostatin Was the First Human Peptide Hormone Produced by Recombinant Bacteria 515
 19.2 Genetically Modified Animals 521
 19.3 Genetically Modified Plants 531
 19.4 Human Gene Therapy 535

20 GENOMICS I: ANALYSIS OF DNA 542

- 20.1 Cytogenetic and Linkage Mapping 543
 Experiment 20A RFLP Analysis Can Be Used to Follow the Inheritance of Disease-Causing Alleles 551
 20.2 Physical Mapping 554
 20.3 Genome Sequencing Projects 560

21 GENOMICS II: FUNCTIONAL GENOMICS, PROTEOMICS, AND BIOINFORMATICS 571

- 21.1 Functional Genomics 571
 Experiment 21A The Coordinate Regulation of Many Genes Is Revealed by a DNA Microarray Analysis 575
 21.2 Proteomics 580
 21.3 Bioinformatics 584



PART VI

GENETIC ANALYSIS OF INDIVIDUALS AND POPULATIONS 599

22 MEDICAL GENETICS AND CANCER 599

- 22.1 Genetic Analysis of Human Diseases 600
 22.2 Genetic Basis of Cancer 610
 Experiment 22A DNA Isolated from Malignant Mouse Cells Can Transform Normal Mouse Cells into Malignant Cells 612

23 DEVELOPMENTAL GENETICS 632

- 23.1 Invertebrate Development 632
 Experiment 23A Heterochronic Mutations Disrupt the Timing of Developmental Changes in *C. elegans* 644
 23.2 Vertebrate Development 647
 23.3 Plant Development 650
 23.4 Sex Determination in Animals and Plants 654

24 POPULATION GENETICS 665

- 24.1 Genes in Populations, and the Hardy-Weinberg Equation 665
 24.2 Factors That Change Allele and Genotype Frequencies in Populations 670
 Experiment 24A The Grants Have Observed Natural Selection in Galápagos Finches 681
 24.3 Sources of New Genetic Variation 684

25 QUANTITATIVE GENETICS 697

- 25.1 Quantitative Traits 697

25.2 Polygenic Inheritance 702

Experiment 25A Polygenic Inheritance
Explains DDT Resistance
in *Drosophila* 705

25.3 Heritability 708

Experiment 25B Heritability of Dermal
Ridge Count in Human Fingerprints
Is Very High 713

26**EVOLUTIONARY
GENETICS 727****26.1 Origin of Species 728****26.2 Phylogenetic Trees and Molecular
Evolution 734**

Experiment 26A Scientists Can
Analyze Ancient DNA to Examine the
Relationships Between Living and
Extinct Flightless Birds 744

**26.3 Evo-Devo: Evolutionary Developmental
Biology 749****Appendix A**

Experimental Techniques 758

Appendix B

Solutions to Even-Numbered
Problems 766

Glossary 809

Credits 823

Index 825