Contents

CHAPTER 1

The Science of Genetics  1
The Personal Genome  1
An Invitation  2
Three Great Milestones in Genetics  2
MENDEL: GENES AND THE RULES OF INHERITANCE  2
WATSON AND CRICK: THE STRUCTURE OF DNA  3
THE HUMAN GENOME PROJECT: SEQUENCING DNA AND CATALOGING GENES  4
DNA as the Genetic Material  6
DNA REPLICAITION: PROPAGATING GENETIC INFORMATION  6
GENE EXPRESSION: USING GENETIC INFORMATION  7
MUTATION: CHANGING GENETIC INFORMATION  9
Genetics and Evolution  10
Levels of Genetic Analysis  11
CLASSICAL GENETICS  11
MOLECULAR GENETICS  11
POPULATION GENETICS  12
Genetics in the World: Applications of Genetics to Human Endeavors  12
GENETICS IN AGRICULTURE  12
GENETICS IN MEDICINE  14
GENETICS IN SOCIETY  15

CHAPTER 2

Cellular Reproduction  18
Dolly  18
Cells and Chromosomes  19
THE CELLULAR ENVIRONMENT  19
PROKARYOTIC AND EUKARYOTIC CELLS  20
CHROMOSOMES: WHERE GENES ARE LOCATED  20
CELL DIVISION  23
Mitosis  24
Meiosis  27
MEIOSIS: AN OVERVIEW  27
MEIOSIS I  27

CHAPTER 3

Mendelism: The Basic Principles of Inheritance  40
The Birth of Genetics: A Scientific Revolution  40
Mendel’s Study of Heredity  41
MENDEL’S EXPERIMENTAL ORGANISM, THE GARDEN PEA  41
MONOHYBRID CROSSES: THE PRINCIPLES OF DOMINANCE AND SEGREGATION  42
DIHYBRID CROSSES: THE PRINCIPLE OF INDEPENDENT ASSORTMENT  44
Applications of Mendel’s Principles  46
THE PUNNETT SQUARE METHOD  46
THE FORKED-LINE METHOD  46
THE PROBABILITY METHOD  47
SOLVE IT Using Probabilities in a Genetic Problem  48
Testing Genetic Hypotheses  48
TWO EXAMPLES: DATA FROM MENDEL AND DEVRIES  49
THE CHI-SQUARE TEST  49
SOLVE IT Using the Chi-Square Test  52
Mendelian Principles in Human Genetics  52
PEDIGREES  53
MENDELIAN SEGREGATION IN HUMAN FAMILIES  54
GENETIC COUNSELING  54
PROBLEM-SOLVING SKILLS Making Predictions from Pedigrees  56

SOLVE IT How Much DNA in Human Meiotic Cells  27
MEIOSIS II AND THE OUTCOMES OF MEIOSIS  31
SOLVE IT How Many Chromosome Combinations in Sperm  31
Life Cycles of Some Model Genetic Organisms  32
SACCHAROMYCES CEREVISIAE, BAKER’S YEAST  32
ARABIDOPSIS THALIANA, A FLOWERING PLANT  33
MUS MUSCULUS, THE MOUSE  34
PROBLEM-SOLVING SKILLS Counting Chromosomes and Chromatids  36
CHAPTER 4

Extensions of Mendelism 62
Genetics Grows beyond Mendel’s Monastery Garden 62

Allelic Variation and Gene Function 63
INCOMPLETE DOMINANCE AND CODOMINANCE 63
MULTIPLE ALLELES 64
ALLELIC SERIES 65
TESTING GENE MUTATIONS FOR ALLELISM 65
SOLVE IT The Test for Allelism 66
VARIATION AMONG THE EFFECTS OF MUTATIONS 66
GENES FUNCTION TO PRODUCE POLYPEPTIDES 67
WHY ARE SOME MUTATIONS DOMINANT AND OTHERS RECESSIVE? 68

Gene Action: From Genotype to Phenotype 69
INFLUENCE OF THE ENVIRONMENT 69
ENVIRONMENTAL EFFECTS ON THE EXPRESSION OF HUMAN GENES 70
PENETRANCE AND EXPRESSIVITY 70
GENE INTERACTIONS 71
EPISTASIS 71
EPISTASIS AND GENETIC PATHWAYS 72
PLEIOTROPY 74

PROBLEM-SOLVING SKILLS Going from Pathways to Phenotypic Ratios 75

Inbreeding: Another Look at Pedigrees 76
THE EFFECTS OF INBREEDING 76
GENETIC ANALYSIS OF INBREEDING 77
USES OF THE INBREEDING COEFFICIENT 80
SOLVE IT Compound Inbreeding 80
MEASURING GENETIC RELATIONSHIPS 81

CHAPTER 5

The Chromosomal Basis of Mendelism 88
Sex, Chromosomes, and Genes 88

Chromosomes 89
CHROMOSOME NUMBER 89
SEX CHROMOSOMES 89

The Chromosome Theory of Heredity 91
EXPERIMENTAL EVIDENCE LINKING THE INHERITANCE OF GENES TO CHROMOSOMES 91
NONDISJUNCTION AS PROOF OF THE CHROMOSOME THEORY 92

THE CHROMOSOMAL BASIS OF MENDEL’S PRINCIPLES OF SEGREGATION AND INDEPENDENT ASSORTMENT 94

SOLVE IT Sex Chromosome Nondisjunction 94

PROBLEM-SOLVING SKILLS Tracking X-Linked and Autosomal Inheritance 96

Sex-Linked Genes in Humans 97
HEMOPHILIA, AN X-LINKED BLOOD-CLOTTING DISORDER 97
COLOR BLINDNESS, AN X-LINKED VISION DISORDER 97
GENES ON THE HUMAN Y CHROMOSOME 99
GENES ON BOTH THE X AND Y CHROMOSOMES 99
SOLVE IT Calculating the Risk for Hemophilia 99

Sex Chromosomes and Sex Determination 99
SEX DETERMINATION IN HUMANS 100
SEX DETERMINATION IN DROSOPHILA 101
SEX DETERMINATION IN OTHER ANIMALS 101

Dosage Compensation of X-Linked Genes 103
HYPERACTIVATION OF X-LINKED GENES IN MALE DROSOPHILA 103
INACTIVATION OF X-LINKED GENES IN FEMALE MAMMALS 103

CHAPTER 6

Variation in Chromosome Number and Structure 109
Chromosomes, Agriculture, and Civilization 109

Cytological Techniques 110
ANALYSIS OF MITOTIC CHROMOSOMES 110
THE HUMAN KARYOTYPE 112
CYTOGENETIC VARIATION: AN OVERVIEW 113

Polyploidy 114
STERILE POLYPLOIDS 114
FERTILE POLYPLOIDS 115
TISSUE-SPECIFIC POLYPLOIDY AND POLYTENY 116
SOLVE IT Chromosome Pairing in Polyploids 116

Aneuploidy 118
TRISOMY IN HUMANS 119
MONOSOMY 120

PROBLEM-SOLVING SKILLS Tracing Sex Chromosome Nondisjunction 122
DELETIONS AND DUPLICATIONS OF CHROMOSOME SEGMENTS 122

Rearrangements of Chromosome Structure 124
INVERSIONS 124
Chapter 7

Linkage, Crossing Over, and Chromosome Mapping in Eukaryotes 133

The World’s First Chromosome Map 133

Linkage, Recombination, and Crossing Over 134

Early Evidence for Linkage and Recombination 134
Crossing Over as the Physical Basis of Recombination 136
Evidence That Crossing Over Causes Recombination 137
Chiasmata and the Time of Crossing Over 138

Chromosome Mapping 139

Crossing Over as a Measure of Genetic Distance 139
Recombination Mapping with a Two-Point Testcross 140
Recombination Mapping with a Three-Point Testcross 140

Solve It Mapping Two Genes with Testcross Data 141

Problem-Solving Skills Using a Genetic Map to Predict the Outcome of a Cross 144
Recombination Frequency and Genetic Map Distance 144

Cytogenetic Mapping 146

Localizing Genes Using Deletions and Duplications 146
Genetic Distance and Physical Distance 147

Solve It Cytological Mapping of a Drosophila Gene 148

Linkage Analysis in Humans 148

An Example: Linkage Between Blood Groups and the Nail-Patella Syndrome 149
Detecting Linkage with Molecular Markers 150

Recombination and Evolution 151

Evolutionary Significance of Recombination 151
Suppression of Recombination by Inversions 152

Chapter 8

The Genetics of Bacteria and Their Viruses 161

Multi-Drug-Resistant Bacteria: A Ticking Timebomb? 161

Viruses and Bacteria in Genetics 162

The Genetics of Viruses 163

Bacteriophage T4 163
Bacteriophage Lambda 164

The Genetics of Bacteria 167

Mutant Genes in Bacteria 168
Unidirectional Gene Transfer in Bacteria 169

Mechanisms of Genetic Exchange in Bacteria 170

Transformation 171
Mechanism of Transformation 172
Conjugation 173
Using Conjugation to Map E. coli Genes 175
Plasmids and Episomes 177

Problem-Solving Skills Mapping Genes Using Conjugation Data 178
F Factors and Sexduction 179
Transduction 180

Solve It How Can You Map Closely Linked Genes Using Partial Diploids? 181
Evolutionary Significance of Genetic Exchange in Bacteria 183

Solve It How Do Bacterial Genomes Evolve? 183

Chapter 9

DNA and the Molecular Structure of Chromosomes 189

Discovery of Nuclein 189

Proof That Genetic Information Is Stored in DNA and RNA 190

Proof That DNA Mediates Transformation 190
Proof That DNA Carries the Genetic Information in Bacteriophage T2 191
Proof That RNA Stores the Genetic Information in Some Viruses 193

The Structures of DNA and RNA 194

Nature of the Chemical Subunits in DNA and RNA 194
DNA Structure: The Double Helix 195
CHAPTER 12

Translation and the Genetic Code 280

Sickle-Cell Anemia: Devastating Effects of a Single Amino Acid Change 280

Protein Structure 281

POLYPEPTIDES: TWENTY DIFFERENT AMINO ACID SUBUNITS 281
PROTEINS: COMPLEX THREE-DIMENSIONAL STRUCTURES 281

Genes Encode Polypeptides 284

BEADLE AND TATUM: ONE GENE–ONE ENZYME 284
CRICK AND COLLEAGUES: EACH AMINO ACID IN A POLYPEPTIDE IS SPECIFIED BY THREE NUCLEOTIDES 286

The Components of Polypeptide Synthesis 289

OVERVIEW OF GENE EXPRESSION 289
RIBOSOMES 290
TRANSFER RNAs 292

The Process of Polypeptide Synthesis 294

POLYPEPTIDE CHAIN INITIATION 294
POLYPEPTIDE CHAIN ELONGATION 298
POLYPEPTIDE CHAIN TERMINATION 300

SOLVE IT Control of Translation in Eukaryotes 300

The Genetic Code 302

PROPERTIES OF THE GENETIC CODE 302
DECIPHERING THE CODE 302
INITIATION AND TERMINATION CODONS 303
A DEGENERATE AND ORDERED CODE 303
A NEARLY UNIVERSAL CODE 305

PROBLEM-SOLVING SKILLS Predicting Amino Acid Substitutions Induced by Mutagens 305

CHAPTER 13

Mutation, DNA Repair, and Recombination 313

Xeroderma Pigmentosum: Defective Repair of Damaged DNA in Humans 313

Mutation 314

SOMATIC AND GERMINAL MUTATIONS 314
SPONTANEOUS AND INDUCED MUTATIONS 314
FORWARD AND REVERSE MUTATIONS 315
USUALLY DELETERIOUS AND RECESSIVE 315

The Molecular Basis of Mutation 317

SINGLE BASE-PAIR CHANGES AND FRAMESHIFT MUTATIONS 317

SOLVE IT Nucleotide-Pair Substitutions in the Human HBB Gene 318

TRANSPORTON INSERTION MUTATIONS 318

MUTATIONS CAUSED BY EXPANDING TRINUCLEOTIDE REPEATS 319

Mutagenesis 320

MULLER’S DEMONSTRATION THAT MUTATIONS CAN BE INDUCED WITH X-RAYS 320
INDUCING MUTATIONS WITH RADIATION 321
INDUCING MUTATIONS WITH CHEMICALS 323
SCREENING CHEMICALS FOR MUTAGENICITY: THE Ames TEST 326

PROBLEM-SOLVING SKILLS Predicting Amino Acid Changes Induced by Chemical Mutagens 327

Assigning Mutations to Genes by the Complementation Test 329
DNA L (PCR) ng Sk T DNA M: DNA R OLVI OT S Sm-SB: COECOMBINANT-PCR LBV 9/10/2015   7:38:07 PM IOLVI A ILLS MR IR ng Sk FM.indd   16 xvi and t Librari es Construction and Screening of DN A and Clone Genes Basic Genetics The Techniques of Molecular Genomics DNA Repair Mechanisms 333 LIGHT-DEPENDENT REPAIR 333 EXCISION REPAIR 333 OTHER DNA REPAIR MECHANISMS 334 INHERITED HUMAN DISEASES WITH DEFECTS IN DNA REPAIR 336 DNA Recombination Mechanisms 338 RECOMBINATION: CLEAVAGE AND REJOINING OF DNA MOLECULES 338 GENE CONVERSION: DNA REPAIR SYNTHESIS ASSOCIATED WITH RECOMBINATION 341

CHAPTER 14
The Techniques of Molecular Genetics 350 Treatment of Pituitary Dwarfism with Human Growth Hormone 350 Basic Techniques Used to Identify, Amplify, and Clone Genes 351 DNA CLONING: AN OVERVIEW 351 RESTRICTION ENDONUCLEASES 351 SOLVE IT How Many Nol Restriction Fragments in Chimpanzee DNA? 354 PRODUCING RECOMBINANT DNA MOLECULES IN VITRO 354 AMPLIFICATION OF RECOMBINANT DNA MOLECULES IN CLONING VECTORS 354 CLONING LARGE GENES AND SEGMENTS OF GENOMES IN BACs, PACs, AND YACs 357 AMPLIFICATION OF DNA SEQUENCES BY THE POLYMERASE CHAIN REACTION (PCR) 358 Construction and Screening of DNA Libraries 360 CONSTRUCTION OF GENOMIC LIBRARIES 360 CONSTRUCTION OF cDNA LIBRARIES 361 SCREENING DNA LIBRARIES FOR GENES OF INTEREST 361 SOLVE IT How Can You Clone a Specific Nol Restriction Fragment from the Orangutan Genome? 363 The Molecular Analysis of DNA, RNA, and Protein 364 ANALYSIS OF DNAs BY SOUTHERN BLOT HYBRIDIZATIONS 364 ANALYSIS OF RNAs BY NORTHERN BLOT HYBRIDIZATIONS 365 ANALYSIS OF RNAs BY REVERSE TRANSCRIPTASE-PCR (RT-PCR) 366 ANALYSIS OF PROTEINS BY WESTERN BLOT TECHNIQUES 368

CHAPTER 15
Applications of Molecular Genetics 417

Gene Therapy Improves Sight in Child with Congenital Blindness 417

Use of Recombinant DNA Technology to Identify Human Genes and Diagnose Genetic Diseases 418

HUNTINGTON’S DISEASE 418

PROBLEM-SOLVING SKILLS Testing for Mutant Alleles that Cause Fragile X Mental Retardation 421

CYSTIC FIBROSIS 421

MOLECULAR DIAGNOSIS OF HUMAN DISEASES 424

Human Gene Therapy 426

DIFFERENT TYPES OF GENE THERAPY 426

GENE THERAPY VECTORS 427

CRITERIA FOR APPROVING GENE THERAPY 427

GENE THERAPY FOR AUTOSOMAL IMMUNODEFICIENCY DISEASE 428

GENE THERAPY FOR X-LINKED IMMUNODEFICIENCY DISEASE 428

SUCCESSFUL GENE THERAPY AND FUTURE PROSPECTS 430

DNA Profiling 431

DNA PROFILING 431

Paternity Tests 435

Forensic Applications 435

SOLVE IT How Can DNA Profiles Be Used to Establish Identity? 435

Production of Eukaryotic Proteins in Bacteria 437

Human Growth Hormone 437

Proteins with Industrial Applications 438

Transgenic Animals and Plants 439

Transgenic Animals: Microinjection of DNA into Fertilized Eggs and Transfection of Embryonic Stem Cells 439

Transgenic Plants: The Ti Plasmid of Agrobacterium Tumefaciens 440

Reverse Genetics: Dissecting Biological Processes by Inhibiting Gene Expression 442

Knockout Mutations in the Mouse 443

T-DNA and Transposon Insertions 445

RNA Interference 446

SOLVE IT How Might RNA Interference Be Used to Treat Burkitt’s Lymphoma? 448

Genome Engineering 448

The CRISPR/Cas9 System for Cleaving DNA Molecules 448

Targeted Mutagenesis with the CRISPR/Cas9 System 450

Deleting, Replacing, and Editing Genes with the CRISPR/Cas9 System 452

Regulation of Gene Expression in Prokaryotes 459

D’Hérelle’s Dream 459

Strategies for Regulating Genes in Prokaryotes 460

Constitutive, Inducible, and Repressible Gene Expression 461

Positive and Negative Control of Gene Expression 462

Operons: Coordinately Regulated Units of Gene Expression 464

The Lactose Operon in E. coli: Induction and Catabolite Repression 466

SOLVE IT Constitutive Mutations in the E. coli lac Operon 468

Induction 468

Catabolite Repression 469

PROBLEM-SOLVING SKILLS Testing Your Understanding of the lac Operon 471

Protein–DNA Interactions That Control Transcription of the lac Operon 472

The Tryptophan Operon in E. coli: Repression and Attenuation 474

Repression 474

Attenuation 475

SOLVE IT Regulation of the Histidine Operon of Salmonella typhimurium 477
Posttranscriptional Regulation of Gene Expression in Prokaryotes 479
TRANSLATIONAL CONTROL OF GENE EXPRESSION 479
POSTTRANSLATIONAL REGULATORY MECHANISMS 479

CHAPTER 18

Regulation of Gene Expression in Eukaryotes 484
African Trypanosomes: A Wardrobe of Molecular Disguises 484
Ways of Regulating Eukaryotic Gene Expression: An Overview 485
DIMENSIONS OF EUKARYOTIC GENE REGULATION 485
CONTROLLED TRANSCRIPTION OF DNA 485
ALTERNATE SPlicing OF RNA 486
CYTOPLASMIC CONTROL OF MESSENGER RNA STABILITY 486
SOLVE IT Counting mRNAs 487
Induction of Transcriptional Activity by Environmental and Biological Factors 487
TEMPERATURE: THE HEAT-SHOCK GENES 488
SIGNAL MOLECULES: GENES THAT RESPOND TO HORMONES 488
Molecular Control of Transcription in Eukaryotes 490
DNA SEQUENCES INVOLVED IN THE CONTROL OF TRANSCRIPTION 490
PROTEINS INVOLVED IN THE CONTROL OF TRANSCRIPTION: TRANSCRIPTION FACTORS 491
PROBLEM-SOLVING SKILLS Defining the Sequences Required for a Gene’s Expression 492
Posttranscriptional Regulation of Gene Expression by RNA Interference 494
RNAi PATHWAYS 494
SOURCES OF SHORT INTERFERING RNAs AND MicroRNAs 496
SOLVE IT Using RNAi in Cell Research 497
Gene Expression and Chromatin Organization 497
EUCHROMATIN AND HETEROCHROMATIN 498
MOLECULAR ORGANIZATION OF TRANSCRIPTIONALLY ACTIVE DNA 498
CHROMATIN REMODELING 499
DNA METHYLATION 500
IMPRINTING 502

Activation and Inactivation of Whole Chromosomes 503
INACTIVATION OF X CHROMOSOMES IN MAMMALS 504
HYPERACTIVATION OF X CHROMOSOMES IN DROSOPHILA 505
HYPOACTIVATION OF X CHROMOSOMES IN CAENORHABDITIS 506

CHAPTER 19

Inheritance of Complex Traits 511
Cardiovascular Disease: A Combination of Genetic and Environmental Factors 511
Complex Traits 512
QUANTIFYING COMPLEX TRAITS 512
GENETIC AND ENVIRONMENTAL FACTORS INFLUENCE QUANTITATIVE TRAITS 512
MULTIPLE GENES INFLUENCE QUANTITATIVE TRAITS 512
THRESHOLD TRAITS 514
Statistics of Quantitative Genetics 515
FREQUENCY DISTRIBUTIONS 515
THE MEAN AND THE MODAL CLASS 516
THE VARIANCE AND THE STANDARD DEVIATION 516
Statistical Analysis of Quantitative Traits 517
THE MULTIPLE FACTOR HYPOTHESIS 518
PARTITIONING THE PHENOTYPIC VARIANCE 518
BROAD-SENSE HERITABILITY 519
SOLVE IT Estimating Genetic and Environmental Variance Components 519
NARROW-SENSE HERITABILITY 520
PREDICTING PHENOTYPES 521
SOLVE IT Using the Narrow-Sense Heritability 522
ARTIFICIAL SELECTION 522
Molecular Analysis of Complex Traits 523
QUANTITATIVE TRAIT LOCI 523
GENOME-WIDE ASSOCIATION STUDIES OF HUMAN DISEASES 526
PROBLEM-SOLVING SKILLS Detecting Dominance at a QTL 527
Correlations between Relatives 531
CORRELATING QUANTITATIVE PHENOTYPES BETWEEN RELATIVES 531
INTERPRETING CORRELATIONS BETWEEN RELATIVES 533
Quantitative Genetics of Human Behavioral Traits 535
INTELLIGENCE 535
PERSONALITY 536
CHAPTER 20

Population Genetics 541
A Remote Colony 541

The Theory of Allele Frequencies 542
ESTIMATING ALLELE FREQUENCIES 542
RELATING GENOTYPE FREQUENCIES TO ALLELE
FREQUENCIES: THE HARDY–WEINBERG PRINCIPLE 543
APPLICATIONS OF THE HARDY–WEINBERG PRINCIPLE 543
EXCEPTIONS TO THE HARDY–WEINBERG PRINCIPLE 545

SOLVE IT The Effects of Inbreeding on Hardy–
Weinberg Frequencies 546
USING ALLELE FREQUENCIES IN GENETIC
COUNSELING 547

Natural Selection 548
THE CONCEPT OF FITNESS 548
NATURAL SELECTION AT THE LEVEL OF THE GENE 549

SOLVE IT Selection against a Harmful Recessive
Allele 550

Random Genetic Drift 552
RANDOM CHANGES IN ALLELE FREQUENCIES 552
THE EFFECTS OF POPULATION SIZE 553

PROBLEM-SOLVING SKILLS Applying Genetic
Drift to Pitcairn Island 554

Populations in Genetic Equilibrium 554
BALANCING SELECTION 555
MUTATION–SELECTION BALANCE 556
MUTATION–DRIFT BALANCE 557

Answers to Odd-Numbered Questions
and Problems 563

Glossary 584

Index 607

CHAPTER 21 (Online)

Transposable Genetic
Elements WC-1
Maize: A Staple Crop with a Cultural Heritage WC-1

Transposable Elements: An Overview WC-2

Transposable Elements in Bacteria WC-3
IS ELEMENTS WC-3
COMPOSITE TRANSPOSONS WC-5
THE Tn3 ELEMENT WC-5

SOLVE IT Accumulating Drug-Resistance Genes WC-5
Cut-and-Paste Transposons in Eukaryotes WC-7
Ac AND Ds ELEMENTS IN MAIZE WC-7
P ELEMENTS AND HYBRID DYSGENESIS IN DROSOPHILA WC-9

PROBLEM-SOLVING SKILLS Analyzing
Transposon Activity in Maize WC-10

Retroviruses and Retrotransposons WC-11
RETOVIRUSES WC-12
RETOVIRUSLIKE ELEMENTS WC-14
RETROPOSONS WC-16

Transposable Elements in Humans WC-17

The Genetic and Evolutionary Significance
of Transposable Elements WC-20
TRANSPOSONS AS MUTAGENS WC-20
GENETIC TRANSFORMATION WITH TRANSPOSONS WC-20

SOLVE IT Transposon-Mediated Chromosome
Rearrangements WC-22
TRANSPOSONS AND GENOME ORGANIZATION WC-22

CHAPTER 22 (Online)

The Genetic Control
of Animal Development WC-28
Stem-Cell Therapy WC-28

A Genetic Perspective on Development WC-29

Maternal Gene Activity in Development WC-31
MATERNAL-EFFECT GENES WC-31
DETERMINATION OF THE DORSAL-VENTRAL AND
ANTERIOR-POSTERIOR AXES WC-32

SOLVE IT A Maternal-Effect Mutation in the
cinnamon Gene WC-32

Zygotic Gene Activity in Development WC-35

BODY SEGMENTATION WC-35
ORGAN FORMATION WC-37
SPECIFICATION OF CELL TYPES WC-39

SOLVE IT Cave Blindness WC-39

PROBLEM-SOLVING SKILLS The Effects of
Mutations during Eye Development WC-41

Genetic Analysis of Development
in Vertebrates WC-41
VERTEBRATE HOMOLOGUES OF INVERTEBRATE
GENES WC-41
THE MOUSE: RANDOM INSERTION MUTATIONS
AND GENE-SPECIFIC KNOCKOUT MUTATIONS WC-42
CHAPTER 23 (Online)

The Genetic Basis of Cancer WC-51

A Molecular Family Connection WC-51

Cancer: A Genetic Disease WC-52

The Many Forms of Cancer WC-52
Cancer and the Cell Cycle WC-53
Cancer and Programmed Cell Death WC-54
A Genetic Basis for Cancer WC-54

Oncogenes WC-55

Tumor-Inducing Retroviruses and Viral Oncogenes WC-55
Cellular Homologues of Viral Oncogenes: The Proto-Oncogenes WC-56

SOLVE IT The v-erbB and v-fms Viral Oncogenes WC-56

Mutant Cellular Oncogenes and Cancer WC-57
Chromosome Rearrangements and Cancer WC-59

Tumor Suppressor Genes WC-60

Inherited Cancers and KNUDSON’S TWO-HIT HYPOTHESIS WC-60
Cellular Roles of Tumor Suppressor Proteins WC-63
pRB WC-63

SOLVE IT Estimating Mutation Rates in Retinoblastoma WC-63

p53 WC-65

SOLVE IT Downstream of p53 WC-65

pAPC WC-67
phMSH2 WC-68
pBRCA1 and pBRCA2 WC-69

Genetic Pathways to Cancer WC-70

CHAPTER 24 (Online)

Evolutionary Genetics WC-76

D’ou venons nous? Que sommes nous? Ou allons nous? WC-76

The Emergence of Evolutionary Theory WC-77

Darwin’s Theory of Evolution WC-77
Evolutionary Genetics WC-78

Genetic Variation in Natural Populations WC-79

Variation in Phenotypes WC-79
Variation in Chromosome Structure WC-80
Variation in Protein Structure WC-81
Variation in Nucleotide Sequences WC-81

Molecular Evolution WC-82

Molecules as “Documents of Evolutionary History” WC-83
Molecular Phylogenies WC-84
Rates of Molecular Evolution WC-84

SOLVE IT Using Mitochondrial DNA to Establish a Phylogeny WC-85

The Molecular Clock WC-87
Variation in the Evolution of Protein Sequences WC-87

SOLVE IT Calculating Divergence Times WC-87

Variation in the Evolution of DNA Sequences WC-88
The Neutral Theory of Molecular Evolution WC-89
Molecular Evolution and Phenotypic Evolution WC-90

SOLVE IT Evolution by Mutation and Genetic Drift WC-90

Speciation WC-92

What is a Species? WC-92
Modes of Speciation WC-94

Human Evolution WC-96

Humans and the Great Apes WC-96
Human Evolution in the Fossil Record WC-96
DNA Sequence Variation and Human Origins WC-97

Appendices (Online)

Appendix A: The Rules of Probability WA-1
Appendix B: Binomial Probabilities WA-3
Appendix C: Evolutionary Rates WA-5