CONTENTS

Preface viii
Introduction / Embryology: Clinical Relevance and
Historical Perspective xii

Part 1 General Embryology 01

Chapter I / Introduction to Molecular Regulation and Signaling 3

Gene Transcription 3
Other Regulators of Gene Expression 5
Induction and Organ Formation 5
Cell Signaling 6

Chapter 2 / Gametogenesis: Conversion of Germ Cells into Male and Female Gametes 10

Primordial Germ Cells 10
The Chromosome Theory of Inheritance 11
Morphological Changes During Maturation
of the Gametes 21

Chapter 3 / First Week of Development: Ovulation to Implantation 29

Ovarian Cycle 29
Fertilization 32
Cleavage 37
Blastocyst Formation 37
Uterus at Time of Implantation 39

Chapter 4 / Second Week of Development: Bilaminar Germ Disc 43

Day 8 43 Day 9 43 Days II and I2 44 Day I3 46

Chapter 5 / Third Week of Development: Trilaminar Germ Disc 5 l

Gastrulation: Formation of Embryonic Mesoderm and Endoderm 51
Formation of the Notochord 51
Establishment of the Body Axes 52
Fate Map Established During Gastrulation 57
Growth of the Embryonic Disc 57
Further Development of the Trophoblast 59

Chapter 6 / Third to Eighth Weeks: The Embryonic Period 63

Derivatives of the Ectodermal Germ Layer 63
Derivatives of the Mesodermal Germ Layer 70
Derivatives of the Endodermal Germ Layer 78
Patterning of the Anteroposterior Axis: Regulation by Homeobox Genes 81
External Appearance During the Second Month 81

Chapter 7 / The Gut Tube and the Body Cavities 86

A Tube on Top of a Tube 86
Formation of the Body Cavity 87
Serous Membranes 88
Diaphragm and Thoracic Cavity 90
Formation of the Diaphragm 92

Chapter 8 / Third Month to Birth: The Fetus and Placenta 96

Development of the Fetus 96
Fetal Membranes and Placenta 100
Chorion Frondosum and Decidua Basalis 102
Structure of the Placenta 103
Amnion and Umbilical Cord 107
Placental Changes at the End of Pregnancy 108
Amniotic Fluid 109
Fetal Membranes in Twins 110
Parturition (Birth) 115

Chapter 9 / Birth Defects and Prenatal Diagnosis 117

Birth Defects 117 Prenatal Diagnosis 125 Fetal Therapy 128

Part 2 Systems-Based Embryology 131

Chapter 10 / The Axial Skeleton 133

Skull 133 Vertebrae and the Vertebral Column 142 Ribs and Sternum 144

Chapter 11 / Muscular System 145

Striated Skeletal Musculature 145
Innervation of Axial Skeletal Muscles 146
Skeletal Muscle and Tendons 148
Molecular Regulation of Muscle Development 148
Patterning of Muscles 148
Head Musculature 148
Limb Musculature 148
Cardiac Muscle 149
Smooth Muscle 149

Chapter 12 / Limbs 151

Limb Growth And Development 151 Limb Musculature 152

Chapter 13 / Cardiovascular System 162

Field 162
Formation and Position of the Heart Tube 164
Formation of the Cardiac Loop 166
Molecular Regulation of Cardiac Development 169
Development of the Sinus Venosus 170
Formation of the Cardiac Septa 171
Formation of the Conducting System of the
Heart 185

Establishment and Patterning of the Primary Heart

Vascular Development 185 Circulation Before and After Birth 195

Chapter 14 / Respiratory System 201

Formation of the Lung Buds 201 Larynx 203 Trachea, Bronchi, And Lungs 203 Maturation of the Lungs 205

Chapter 15 / Digestive System 208

Divisions of the Gut Tube 208

Molecular Regulation of Gut Tube
Development 209

Mesenteries 210

Foregut 211

Molecular Regulation of Liver Induction 219

Pancreas 221

Midgut 222

Hindgut 229

Chapter 16 / Urogenital System 232

Urinary System 232 Genital System 243

Chapter 17 / Head and Neck 260

Pharyngeal Arches 262 Pharyngeal Pouches 266 Pharyngeal Clefts 268
Molecular Regulation of Facial Development 268
Tongue 273
Thyroid Gland 274
Face 275
Intermaxillary Segment 278
Secondary Palate 278
Nasal Cavities 282
Teeth 283
Molecular Regulation of Tooth Development 285

Chapter 18 / Central Nervous System 287

Spinal Cord 288
Brain 297
Molecular Regulation of Brain Development 308
Cranial Nerves 313
Autonomic Nervous System 315

Chapter 19 / Ear 321

Internal Ear 321 Middle Ear 324 External Ear 325

Chapter 20 / Eye 329

Optic Cup and Lens Vesicle 329
Retina, Iris, and Ciliary Body 331
Lens 333
Choroid, Sclera, and Cornea 333
Vitreous Body 333
Optic Nerve 334
Molecular Regulation of Eye Development 334

Chapter 21 / Integumentary System 339

Skin 339 Hair 341 Sweat Glands 342 Mammary Glands 342

Part 3 Appendix 345

Answers to Problems 347 Figure Credits 357 Glossary of Key Terms 361

Index 371