

Contents

- 1 Introduction to Human Development** 1
 - Importance of and Advances in Embryology 1
 - Descriptive Terms 5
 - Clinically Oriented Questions 5
- 2 Human Reproduction** 7
 - Reproductive Organs 7
 - Female Reproductive Organs 7
 - Male Reproductive Organs 10
 - Gametogenesis 10
 - Meiosis 10
 - Spermatogenesis 11
 - Oogenesis 14
 - Comparison of Male and Female Gametes 14
 - Female Reproductive Cycles 14
 - Ovarian Cycle 14
 - Menstrual Cycle 17
 - Transportation of Gametes 19
 - Oocyte Transport 19
 - Sperm Transport 19
 - Maturation of Sperms 20
 - Viability of Oocytes and Sperms 20
 - Clinically Oriented Questions 20
- 3 First Week of Development** 21
 - Fertilization 21
 - Phases of Fertilization 21
 - Results of Fertilization 23
 - Cleavage of Zygote 24
 - Formation of Blastocyst 24
 - Clinically Oriented Questions 27
- 4 Second Week of Development** 29
 - Formation of Amniotic Cavity and Embryonic Disc 30
 - Development of Chorionic Sac 32
 - Clinically Oriented Questions 33
- 5 Third Week of Development** 35
 - Gastrulation: Formation of Germ Layers 35
 - Primitive Streak 36
 - Notochordal Process and Notochord 36
 - Neurulation: Formation of the Neural Tube 38
 - Neural Plate and Neural Tube 38
 - Neural Crest Formation 39
 - Development of Somites 39
 - Development of Intraembryonic Coelom 40
 - Early Development of Cardiovascular System 40
 - Vasculogenesis and Angiogenesis 43
 - Development of Chorionic Villi 45
 - Clinically Oriented Questions 47
- 6 Development During Weeks Four to Eight** 49
 - Folding of Embryo 49
 - Head and Tail Folds 51
 - Lateral Folds 51
 - Germ Layer Derivatives 51
 - Control of Embryonic Development 51
 - Estimation of Embryonic Age 54
 - Highlights of Development during Weeks Four to Eight 54
 - Fourth Week 54
 - Fifth Week 56
 - Sixth Week 58
 - Seventh Week 58
 - Eighth Week 58
 - Clinically Oriented Questions 61
- 7 Fetal Period: The Ninth Week to Birth** 63
 - Highlights of Fetal Period 63
 - Nine to Twelve Weeks 64
 - Thirteen to Sixteen Weeks 65

- Seventeen to Twenty Weeks 65
- Twenty-One to Twenty-Five Weeks 65
- Twenty-Six to Twenty-Nine Weeks 67
- Thirty to Thirty-Eight Weeks 67
- Expected Date of Delivery 67
- Factors Influencing Fetal Growth 67**
- Procedures for Assessing Fetal Status 68**
 - Ultrasonography 68
 - Diagnostic Amniocentesis 69
 - Chorionic Villus Sampling 69
 - Cell Cultures 69
 - Percutaneous Umbilical Cord Blood Sampling 69
 - Magnetic Resonance Imaging 69
 - Fetal Monitoring 69
 - Alpha Fetoprotein Assay 70
- Clinically Oriented Questions 70**
- 8 Placenta and Fetal Membranes 71**
 - Placenta 71**
 - Decidua 72
 - Development of Placenta 72
 - Fetomaternal Junction 72
 - Intervillous Space 72
 - Amniochorionic Membrane 74
 - Placental Circulation 74
 - Parturition 79**
 - Stages of Labor 79
 - Placenta and Fetal Membranes after Birth 80
 - Umbilical Cord 82
 - Amnion and Amniotic Fluid 82**
 - Significance of Amniotic Fluid 84
 - Umbilical Vesicle 84**
 - Significance of Umbilical Vesicle 84
 - Allantois 85**
 - Fetal Membranes in Multiple Pregnancies 85**
 - Twins and Fetal Membranes 85
 - Other Types of Multiple Births 87
 - Clinically Oriented Questions 88**
- 9 Body Cavities, Mesenteries, and Diaphragm 89**
 - Embryonic Body Cavity 89**
 - Mesenteries 90
 - Division of Embryonic Body Cavity 90
 - Development of Diaphragm 91**
 - Septum Transversum 93
 - Pleuroperitoneal Membranes 93
 - Dorsal Mesentery of Esophagus 93
 - Muscular Ingrowth from Lateral Body Walls 93
 - Positional Changes and Innervation of Diaphragm 94
 - Clinically Oriented Questions 97**
- 10 Pharyngeal Apparatus 99**
 - Pharyngeal Arches 99**
 - Pharyngeal Arch Components 100
 - Pharyngeal Pouches 105**
 - Derivatives of Pharyngeal Pouches 105
 - Pharyngeal Grooves 107**
 - Pharyngeal Membranes 110**
 - Development of Thyroid Gland 110**
 - Development of Tongue 112**
 - Papillae and Taste Buds of Tongue 113
 - Nerve Supply of Tongue 113
 - Development of Salivary Glands 114**
 - Development of Face 114**
 - Development of Nasal Cavities 118**
 - Paranasal Sinuses 119
 - Development of Palate 120**
 - Primary Palate 120
 - Secondary Palate 120
 - Clinically Oriented Questions 125**
- 11 Respiratory System 127**
 - Development of Larynx 129**
 - Development of Trachea 130**
 - Development of Bronchi and Lungs 130**
 - Maturation of Lungs 131
 - Clinically Oriented Questions 135**
- 12 Alimentary System 137**
 - Foregut 137**
 - Development of Esophagus 138
 - Development of Stomach 138
 - Development of Duodenum 141
 - Development of Liver and Biliary Apparatus 142
 - Development of Pancreas 144
 - Development of Spleen 146**
 - Midgut 146**
 - Rotation of Midgut Loop 146
 - Cecum and Appendix 149
 - Hindgut 149**
 - Cloaca 154
 - Anal Canal 155
 - Clinically Oriented Questions 159**
- 13 Urogenital System 161**
 - Development of Urinary System 161**
 - Development of Kidneys and Ureters 161
 - Positional Changes of Kidneys 163

- Changes in Blood Supply of Kidneys 163
 - Development of Urinary Bladder 167
 - Development of Urethra 169
 - Development of Suprarenal Glands 169**
 - Development of Genital System 171**
 - Development of Gonads 171
 - Development of Genital Ducts 176
 - Development of External Genitalia 177
 - Development of Inguinal Canals 184**
 - Descent of Testes 187
 - Descent of Ovaries 187
 - Clinically Oriented Questions 188**
- 14 Cardiovascular System 189**
- Early Development of the Heart and Blood Vessels 190**
 - Development of Embryonic Veins Associated with the Heart 190
 - Pharyngeal Arch Arteries and Other Branches of Dorsal Aorta 191
 - Fate of Vitelline and Umbilical Arteries 191
 - Later Development of the Heart 191**
 - Circulation through Primordial Heart 194
 - Partitioning of Primordial Heart 196
 - Changes in Sinus Venosus 200
 - Primordial Pulmonary Vein and Formation of Left Atrium 202
 - Partitioning of Primordial Ventricle 202
 - Partitioning of Bulbus Cordis and Truncus Arteriosus 203
 - Development of Cardiac Valves 203
 - Conducting System of Heart 205
 - Birth Defects of the Heart and Great Vessels 205**
 - Derivatives of Pharyngeal Arch Arteries 211**
 - Derivatives of First Pair of Pharyngeal Arch Arteries 211
 - Derivatives of Second Pair of Pharyngeal Arch Arteries 211
 - Derivatives of Third Pair of Pharyngeal Arch Arteries 211
 - Derivatives of Fourth Pair of Pharyngeal Arch Arteries 212
 - Fate of Fifth Pair of Pharyngeal Arch Arteries 212
 - Derivatives of Sixth Pair of Pharyngeal Arch Arteries 212
 - Pharyngeal Arch Artery Anomalies 213**
 - Fetal and Neonatal Circulation 215**
 - Fetal Circulation 215
 - Transitional Neonatal Circulation 216
 - Derivatives of Fetal Vascular Structures 217
 - Development of the Lymphatic System 220**
 - Development of Lymph Nodes 222
 - Development of Spleen and Tonsils 222
 - Clinically Oriented Questions 222**
- 15 Musculoskeletal System 223**
- Skeletal System 223**
 - Development of Cartilage and Bone 225**
 - Histogenesis of Cartilage 225
 - Histogenesis of Bone 225
 - Development of Joints 227**
 - Fibrous Joints 227
 - Cartilaginous Joints 227
 - Synovial Joints 227
 - Development of Axial Skeleton 227**
 - Development of Vertebral Column 227
 - Cartilaginous Stage of Vertebral Development 229
 - Bony Stage of Vertebral Development 229
 - Development of Ribs 230
 - Development of Sternum 230
 - Development of Cranium 230
 - Development of Appendicular Skeleton 233**
 - Muscular System 236**
 - Development of Skeletal Muscle 236
 - Development of Smooth Muscle 238
 - Development of Cardiac Muscle 238
 - Development of Limbs 239**
 - Early Stages of Limb Development 239
 - Final Stages of Limb Development 240
 - Cutaneous Innervation of Limbs 241
 - Blood Supply to Limbs 242
 - Clinically Oriented Questions 242**
- 16 Nervous System 247**
- Origin of Nervous System 247**
 - Development of Spinal Cord 250**
 - Development of Spinal Ganglia 252
 - Development of Spinal Meninges 252
 - Positional Changes of Spinal Cord 253
 - Myelination of Nerve Fibers 253
 - Birth Defects of Spinal Cord 253**
 - Development of Brain 254**
 - Brain Flexures 254
 - Hindbrain 255
 - Myelencephalon 255
 - Metencephalon 256
 - Choroid Plexuses and Cerebrospinal Fluid 256

Midbrain	257	Numerical Chromosomal Abnormalities	296
Forebrain	257	Structural Chromosomal Abnormalities	300
Congenital Anomalies of Brain	261	Birth Defects Caused by Mutant Genes	302
Development of Peripheral Nervous System	265	Birth Defects Caused by Environmental Factors	303
Spinal Nerves	266	Principles of Teratogenesis	303
Cranial Nerves	266	Human Teratogens	306
Development of Autonomic Nervous System	269	Environmental Chemicals as Teratogens	309
Sympathetic Nervous System	269	Infectious Agents as Teratogens	309
Parasympathetic Nervous System	269	Radiation as a Teratogen	310
Clinically Oriented Questions	270	Maternal Factors as Teratogens	311
		Mechanical Factors as Teratogens	311
17 Eyes and Ears	271	Birth Defects Caused by Multifactorial Inheritance	311
Development of Eyes and Related Structures	271	Clinically Oriented Questions	311
Development of Retina	273		
Development of Choroid and Sclera	276	20 The Cellular and Molecular Basis of Development	313
Development of Ciliary Body	276	Intercellular Communication	314
Development of Iris	276	Morphogens	314
Development of Lens	276	Retinoic Acid	314
Development of Aqueous Chambers	277	Transforming Growth Factor β /Bone Morphogenetic Protein	315
Development of Cornea	277	Hedgehog	315
Development of Eyelids	278	Wnt/ β -Catenin Pathway	316
Development of Lacrimal Glands	278	Receptor Tyrosine Kinases	316
Development of Ears	278	Common Features	316
Development of Internal Ears	278	Regulation of Angiogenesis by Receptor Tyrosine Kinases	317
Development of Middle Ears	280	Notch-Delta Pathway	318
Development of External Ears	280	Transcription Factors	318
Clinically Oriented Questions	282	Hox/Homeobox Proteins	318
		Pax Genes	319
18 Integumentary System	283	Basic Helix-Loop-Helix (bHLH) Transcription Factors	319
Development of Skin	283	Epigenetics	319
Epidermis	283	DNA Methylation	319
Dermis	284	Acetylation	320
Glands of Skin	285	Summary of Common Signaling Pathways Used during Development	320
Development of Hairs	286		
Development of Nails	286	References and Suggested Reading	321
Development of Mammary Glands	287		
Development of Teeth	288	Answers to Clinically Oriented Questions	325
Bud Stage of Tooth Development	288		
Cap Stage of Tooth Development	289	Index	335
Bell Stage of Tooth Development	289		
Tooth Eruption	289		
Clinically Oriented Questions	293		
19 Human Birth Defects	295		
Teratology: Study of Abnormal Development	295		
Birth Defects Caused by Genetic Factors	296		