

Contents

Part I Gross Anatomy

1 The Head and Neck	3
Introduction	3
The Skull and Face	3
Skull Foramina	3
Jugular Foramen Syndrome	5
Scalp	6
Meninges	7
Meningeal Irritation	8
Epidural Hematomas	8
Subdural Hematomas	8
Common, External, and Internal Carotid Arteries	8
Venous Drainage Superficial Face and Neck	10
Subclavian Vein Line	10
Internal Jugular Vein Line	10
Venous Drainage of the Skull	11
Cavernous Sinus	12
Infratemporal Fossa	12
Sphenoid Bone	13
Maxillary Artery	14
Mandibular Nerve (V3)	15
Temporomandibular Joint	16
Masticator Space	17
The Pterygopalatine Fossa	17
Pterygopalatine Fossa Doorways	17
Autonomics of Lacrimal Gland	20
Facial Nerve	20
Facial Nerve, Muscles of Facial Expression and Parotid Gland	20
Ramsay Hunt Syndrome	24
Buccal Nerve from CN V Versus Buccal Branch of CN VII	24
Temporal Bone	25
Nasal Cavity	26
Oral Cavity	28
Palatine Bone	28

The Tongue	28
Eagle Syndrome	30
The Tonsils	30
Palate	31
Buccal Fat Pad	31
Glossopharyngeal Nerve: Cranial Nerve IX	31
Orbit	32
Overview of Eye Muscles and Nerves	33
Actions	33
Cranial Nerve Six Lesions	33
Parkinson's Sign	35
Cranial Nerve Three Lesions	35
Cranial Nerve Four Lesions	36
Testing	36
Oculomotor Nerve	36
Ophthalmic Artery	39
Blood Supply to the Retina	39
V1: The Ophthalmic Nerve	39
Superior Orbital Fissure	40
Inferior Orbital Fissure	41
Orbit Bones	41
Petroclival Region: AKA, the Back of the Orbit	42
The Maxilla	42
Ear	43
Neck	46
Triangles of the Neck	46
Ansa Cervicalis	47
Fascia of the Neck	47
Nerve Point of Neck	48
Accessory Nerve	49
Scalene Triangle and Thoracic Outlet Syndrome	49
Subclavian Artery	50
Pharynx and Larynx	51
Larynx	52
A Note on Terminology	54
Cricothyrotomy	54
Tracheotomy	55
Cranial Nerve X and the Larynx and Pharynx	55
Arteries to Larynx and Pharynx	56
Parasympathetic Hitchhikers	57
Parotid Gland	58
Frey Syndrome, Crocodile Tears, and Confused Parasympathetic Fibers	59
Aortic Arch, Carotid and Vertebrobasilar Systems	61
Thyroid Gland	61
Parathyroid Glands	62
Hyperparathyroidism	63
Hypoparathyroidism	64

Subclavian Steal Syndrome	64
Le Fort Fractures	65
Lymphatics of the Head and Neck	65
Self-test	66
Historical Snippet: Lucja Frey and Frey Syndrome	66
Further Reading	68
2 The Thorax	69
Anterior Thoracic Wall	69
Breasts	69
Neurovascular Supply to the Breast	70
Anterior Thoracic Wall Muscles	70
Neurovascular Organization of the Anterior Thoracic Wall	70
Mediastinum	71
The Pericardium and Sinuses	72
The Heart	72
Blood Supply to the Heart	73
Venous Drainage of the Heart	75
Nerves to the Heart	76
The Interior of the Heart	76
Borders of the Heart	77
Heart Valve Projections and Auscultation Sites	79
Esophagus	84
Zenker's Diverticulum	84
Thoracic Duct	85
Virchow's Node	86
Ribs and Sternum	86
The Pleura	87
The Trachea	87
The Lungs	89
Pneumothorax	90
Azygos Vein	90
Stellate Ganglion	91
Pericardiocentesis	92
Beck's Triad	92
Cross Sections Through Neck and Thorax	93
Cross Section of Heart and Its Borders	95
Chest Tube Placement	96
Historical Snippet: Gray's Anatomy	96
Further Reading	97
3 The Abdominal Cavity	99
Anterior Abdominal Wall	99
Arcuate Line	100
Anterior Abdominal Wall Hernias	101
Blood Supply to Anterior Abdominal Wall	101
Paraumbilical Veins with Superficial Epigastric Veins	102
Inguinal Canal	102
Inguinal Ligament	105

Processes Vaginalis	105
Indirect Inguinal Hernia	105
Direct Inguinal Hernias	106
Trapezoid of Disaster	106
Gubernaculum and Cryptorchidism	107
Layers of Spermatic Cord	108
Abdominal Cavity	109
The Diaphragm	109
Abdominal Aorta and Inferior Vena Cava	110
Inferior Vena Cava	111
Abdominal Contents	111
Peritoneum	112
Retroperitoneal Versus Intraperitoneal	115
Peritoneal Dialysis	115
Foregut	116
Midgut	119
Hind Gut	123
Pancreatitis and Portal Hypertension	131
Liver Subdivisions	131
Pancreas	132
Spleen	132
Internal Architecture of the Spleen	132
The White Pulp	133
Referred Pain	134
Greater, Lesser, and Least Splanchnic Nerves	134
The Rectum and Anal Canal	135
Venous Drainage of Anal Canal	135
Superior Mesenteric Artery and Nutcracker Syndrome	136
Duodenal Fossae and Folds	138
Transpyloric Line	138
Internal Pancreas	139
Kidneys	139
Renal Fascia	141
Renal Blood Supply	141
Adrenal Glands	142
Adrenal Medulla	143
Ureters	144
Nerves of Posterior Abdominal Wall	144
Branches of the Abdominal Aorta	145
Historical Snippet: The Pernkopf Atlas	146
Further Reading	147
4 Kidney Function	149
A Sodium Ion's Journey Through the Nephron and Collecting Duct: An Autobiography	149
Proximal Tubule	149
Loop of Henle Descending Limb	150
Loop of Henle Ascending Limb	150

Distal Convolutd Tubule	150
Macula Densa	150
Collecting Duct	150
The Kidney	152
Bowmans Capsule	152
Water and Na ⁺ Reabsorption	153
Proximal Tubule	153
Loop of Henle	153
Descending Thin Limb	154
The Thick Ascending Limb	154
Distal Convolutd Tubule	154
Collecting Duct—Fine Tuning Sodium Chloride Reabsorption	155
Antidiuretic Hormone (ADH) and Water Retention	157
Urea, ADH, and Urea Recycling	157
Diabetes Insipidus	158
Potassium	158
Juxtaglomerular Apparatus	158
Segmental Differences in Sodium Transport Mechanisms	159
Counter Current Multiplier	160
Heat Exchange and the Benefits of a Counter Current Multiplier	161
The Single Pass	161
Multiple Passes	163
The Vasa Recta: Countercurrent Exchange	163
Old “Recycled” Bicarbonate	164
New Bicarbonate	165
Calcium Reabsorption	165
Four Commonly Used Medications	166
Three Genetic Disorders	167
Altered Ion Levels	168
Acid Base Maintenance	169
Respiratory Acidosis and Alkalosis	169
Metabolic Acidosis and Alkalosis	170
Compensation	170
The Anion Gap	172
Acidosis or Alkalosis? Metabolic or Respiratory?	173
Arterial Blood Gas Questions	173
References	174
5 The Pelvis and Perineum	175
Introduction	175
Pelvic Diaphragm	176
Internal Iliac Artery	177
Internal Pudendal Artery	178
Pudendal Nerve	179
Erectile Tissue	180
Semen Production	180

The Bladder.....	180
Prostate	181
Uterus	181
Ovary, Uterine Tube, and Broad Ligament.....	182
Broad Ligament	183
Cardinal and Uterosacral Ligaments.....	183
Superficial Space and Deep Perineal Spaces	183
Dartos and Cremaster Muscles.....	185
The Testes	186
Penis	186
The Clitoris	187
Episiotomies and Caesarean Sections.....	188
Pudendal Versus Pelvic Splanchnic Nerves	188
Anal Canal	190
Bladder and Bowel Control.....	191
Superior Hypogastric Plexus.....	192
Pelvis.....	192
Some Differences Between Apes and Humans.....	193
Sacrum	194
Lymph Nodes	195
High Endothelial Venules	196
Lymphatic Bulbs.....	196
Historical Snippet: Ignaz Semmelweis, The Savior of Mothers...	197
Further Reading	198
6 The Lower Limb	199
Gluteal Region	199
Trendelenburg Sign and Trendelenburg Gait	200
Greater Trochanter	200
Nerves and Vessels of Gluteal Region	201
Piriformis	203
Trochanteric Bursitis.....	203
Cutaneous Sensation in Gluteal Region	203
Superficial Venous Drainage of the Lower Limb	203
The Thigh	205
Fascia Lata and Iliotibial Band.....	205
Anterior Thigh.....	205
Pes Anserinus	206
Medial Thigh.....	206
Posterior Thigh	207
Femoral Triangle.....	209
Superficial Inguinal Lymph Nodes	209
Femoral Nerve	210
Subsartorial Canal.....	211
Adductor Hiatus	212
Femoral Artery	212
Hip Joint	213
Anastomosis Around Hip	215

Fractures of the Femoral Neck	215
The Knee	217
Meniscus	218
Patella	218
Articularis Genu	219
The Popliteal Fossa	219
The Knee and the Screw-Home Mechanism	219
Popliteus	221
Q Angle	221
Genu Valgus or Genu Varum	221
The Leg and Foot	222
Posterior Leg	222
Anterior Leg	223
Lateral Leg	224
Sciatic Nerve and Branches in the Leg	224
Ankle Joints	225
Ankle Fractures	227
The Foot	228
Nerves and Arteries in the Sole of the Foot	230
Plantar Fasciitis	231
Lumbar Disc Herniations	231
Dermatomes and Peripheral Nerve Map of Lower Limb	231
Valga Versus Vara	231
An Anatomy Study Break—The Chicken Bone Case	231
Further Reading	233
7 The Upper Limb	235
Introduction	235
The Shoulder	236
The Shoulder Joint	237
The Clavicle	237
The Manubrium	238
Rotator Cuff	238
Abduction of the Upper Limb	239
Glenohumeral Joint	241
SLAP Tear and the Long Head of the Biceps	241
Bankart Tears	241
Scapula	241
Collateral Circulation Around Shoulder	242
Axilla	243
Clavipectoral Fascia	243
Axillary Artery	243
Brachial Plexus	244
The Compartments of the Upper Limb	246
Anterior Arm Compartment	246
Posterior Arm Compartment	247
Arteries of the Upper Limb	247
Nerves of the Posterior Compartment	248

The Elbow Joint	248
Cubital Fossa.	250
Forearm.....	250
Anterior Forearm	250
Deep Forearm Compartment.	253
Flexor Digitorum Superficialis and Flexor Digitorum Profundus Insertions	253
Dupuytren's Contracture.....	254
Neurovascular Compartment in Forearm	254
Posterior Forearm	256
Posterior Forearm Muscles to Thumb.....	256
Distal Radioulnar Joint	257
The Hand.....	257
Carpal Bones.....	258
Metacarpals.....	258
Thenar Compartment	259
The Hypothenar Compartment.....	259
Intermediate Compartment	259
Palmar and Dorsal Interossei	260
Lumbricals	260
Ulnar Nerve at the Wrist.....	260
Froment's Sign	261
Claw Hand	261
The Median Nerve at the Hand and Wrist	262
Nerves and Arteries on Palmar Wrist	262
Median Nerve Palsy	263
Ulnar Collateral Ligament and Gamekeeper's Thumb.....	264
Nerves to Fingers	264
Everything Is Not Always So Straightforward	265
Upper and Lower Tunk Injuries	265
Distal Fractures of the Radius.....	266
Fractures of the Humerus	266
Peripheral Nerve Map of the Upper Limb	267
Dermatomes of Upper Limb.....	268
Myotomes of the Upper Limb.....	268
Upper Limb Root Injuries.....	268
Hand and Finger Grips	268
Summary of Major Nerves to the Upper Limb and Their Lesions	269
Historical Snippet: The First African American Anatomy Professor in the US	269
Further Reading	276
8 The Back	277
Occipital Bone	277
Atlas (C1)	277
Axis (C2).....	277
Cruciate and Alar Ligaments	278

Cervical Fractures	279
Suboccipital Triangle	279
Back Ligaments	280
Anterior and Posterior Longitudinal Ligaments	280
Spinal Meninges	281
Cervical Vertebrae	283
Thoracic Vertebrae	283
Lumbar Vertebrae	284
Ribs	284
Costovertebral Joints	284
Palpating the Spinous Processes and the Rule of Three's	285
Geelhoed's Rule	286
Disk Herniations	286
Spondylolisthesis Versus Spondylolysis	288
Disk Herniations Versus Peripheral Nerve Trauma	289
Abormal Curves of Spine	290
Further Reading	292

Part II Neuroanatomy

9 The Three Long Tracts in the Spinal Cord	297
Introduction	297
Corticospinal Pathway	298
Cross Section of Spinal Cord	299
Deep Tendon Reflexes	301
Cerebral Peduncle, Basis Pontis, and Pyramid	301
C5 Hemisection	301
Spinothalamic	302
Dorsal Columns	303
Romberg Sign	304
Summary of the Three Long Tracts	305
The Long Tracts in the Brain Sem	305
A Test on the Long Tracts	307
Jendrassik Maneuver	309
Brown Séquard Syndrome	309
Syringomyelia	310
Tabes Dorsalis	311
Anterior Spinal Artery	311
Subacute Combined Degeneration	312
Central Cord Syndrome	312
Conus Medullaris Syndrome	312
Cervical Myelopathy	312
Axonal Polyneuropathy	313
Guillain-Barré Syndrome	313
Amyotrophic Lateral Sclerosis	313
Friedreich Ataxia	313
Spinal Shock	313
Dissociated Sensory Loss	314

Dermatome, Peripheral Nerve, and Myotome Maps	314
Radiculopathies	315
Tarlov Cysts	316
Some Terminology	316
Where Is the Lesion?	317
Same Case But More Information	317
Further Reading	318
10 Corticobulbar Tract and Cranial Nerve Nuclei	321
Corticobulbar	321
Nucleus Ambiguus	323
Facial Colliculus	324
Cranial Nerve V	325
Spinothalamic Tract vs. Ventral Trigeminothalamic Tract	326
Corticobulbar Projections to Cranial Nerve VII	327
Cranial Nerve XI	328
Cranial Nerve XII	329
Further Reading	329
11 Abducens Nerve Lesions	331
Cranial Nerve VI	331
Actions	332
Cranial Nerve VI Lesion	332
Cranial Nerve III Lesion	333
Cranial Nerve IV Lesion	333
Amblyopia	333
Testing	333
Cortex Control from Frontal Eye Field	334
Fast Phase of Nystagmus	334
One and a Half Syndrome	338
Who Are the Neighbors?	339
Historical Snippet: Coal Miner's Nystagmus	341
Further Reading	341
12 Vestibulocochlear Nerve Lesions	343
Introduction	343
Semicircular Canals and Hair Cells	343
Vestibular Nerve and the Slow Phase of Nystagmus	346
COWS Are Fast	348
Lateral Vestibular Nucleus and Lateral Vestibulospinal Tract	349
Decorticate and Decerebrate Rigidity	350
Chemically Induced Vestibulotoxicity	351
Auditory	351
Weber's and Rinne Tests	354
Audiometry and Audiograms	355
Auditory: Central Portion	356
Lateral Lemniscus and the Inferior Colliculus	358
The HiNTS Exam	358

Historical Snippet: The Caloric Reflex, the Nobel Prize, and a POW	359
Further Reading	359
13 Visual Pathway Lesions	361
Introduction.....	361
Some Advanced Visual Field Defects.....	363
Pie in the Sky and Pie on the Floor.....	363
Optic Chiasm Details	363
Anterior Communicating Artery Aneurysm	364
Prechiasmal versus Retrochiasmal Lesions	364
Cortical Blindness.....	364
Swinging Flashlight Test.....	364
Relative Afferent Pupillary Defect (RAPD) or a Marcus Gunn Pupil	365
The Accommodation Reflex	366
Argyll Robertson Pupil	367
Parinaud's Syndrome	368
Parinauds for the Non-Ophthalmologist.....	369
Adie's Tonic Pupil.....	369
The Retina.....	370
Photoreceptors: Rods and Cones	371
The Signaling Pathway	372
Oddity #1	372
Oddity #2 Rods and Cones in the Light and in the Dark	373
Oddity #3 the Bipolar Cells	374
Ganglion Cells	374
One More Way to Think about it	374
Color Vision	375
The Optic Disc and Glaucoma	376
Optic Nerve Sheath.....	377
Rod Shedding	377
Retinal Detachment.....	378
Macular Degeneration.....	378
The Lens, Cornea, and Refraction	378
More Complex Neuroophthalmolgy.....	382
Blood Supply to Retina.....	382
Occlusions to the Central Artery of the Retina.....	383
Ischemic Optic Neuropathy	384
Retinal Fiber Organization	385
Bow-Tie Atrophy	385
Optic Tract Pathology	386
Central Scotoma	386
Red Glass Test.....	387
Esotropia or Exotropia of <i>Right</i> Eye.....	387
Esotropia or Exotropia of the <i>Left</i> Eye	388
Historical Snippet: Lesion Analysis of the Visual System	389
Further Reading	389

14	Autonomics, Lesions, and Cell Bodies of Origin	391
	Introduction	391
	Sensory Ganglia in the Head	392
	The Parasympathetics to the Head	393
	Cranial Nerve III	394
	Cranial Nerve VII and Cell Bodies	394
	Cranial Nerve VII Branches	395
	Cranial Nerve Nine	396
	Sympathetic Fibers and White and Grey Rami	396
	Sympathetic Nerves to the Face	396
	Coma, the Autonomics, and the Eyes	398
	Reynaud's Disease	399
	Overview of Autonomics to GI Tract	399
	Bladder Control	400
	Upper Motor Neuron—Spastic bladder	401
	Lower Motor Neuron—Flaccid Bladder	402
	Parasympathetic Ganglia in the Head	403
	How the Sympathetic Fibers from L2 get into the L5 Nerve	404
	Cushing's Triad	405
	Further Reading	406
15	Cerebellar Lesions	409
	Introduction	409
	Lobes, Zones, and Divisions	409
	The Big Picture Corticospinal and Corticopontocerebellar	409
	Dorsal Spinocerebellar and Cuneocerebellar	410
	Dentatothalamic	411
	Red Nucleus	412
	Inputs	412
	Internal Cerebellar Circuitry	412
	Cerebellar Inputs	414
	Deep Cerebellar Nuclei	415
	Basket Cells, Stellate Cells, and Lateral Inhibition	415
	Clinical Symptoms of Cerebellar Lesions	416
	Slurred or Scanning Speech	416
	Chiari Malformations	418
	Ataxic Hemiparesis	418
	Summary of Cerebellar Lesions and Two Homunculi	418
	Further Reading	419
16	Basal Ganglia Lesions	421
	Introduction	421
	Function	422
	Hemiballismus	424
	Huntington's Chorea	425
	Parkinson's Disease	426
	Acetylcholine and Parkinson's	427
	Basal Ganglia and Cerebellum Together	428
	Glabellar Reflex	429

Wilson's Disease	429
Various Basal Ganglia Pathology	429
Further Reading	430
17 Thalamus and Hypothalamus	431
Organization	431
Circuits	431
Thalamic Pain Syndrome	433
Reticular Nucleus	433
Internal Capsule and Lacunar Infarcts	434
Lateral Striate Arteries	435
Thalamogeniculate Arteries	436
Artery of Percheron and Coma	436
Anterior Choroidal Arteries	436
Hypothalamus and Pituitary	437
The Anterior Pituitary and Hypophyseal Portal System	438
Posterior Pituitary	438
Thermal Regulation	439
Appetite Control	439
Hypothalamus and Sympathetic Control	439
Diabetes Insipidus	440
Syndrome of Inappropriate Secretion of ADH	440
Case Studies	440
Further Reading	440
18 The Limbic Circuit, Learning, Memory, and How the Brain Works	443
Introduction	443
Limbic Circuit	443
Hippocampus	444
Fornix	444
Wernicke Korsakoff's	445
Kluver-Bucy Syndrome	445
Amygdala	445
Hippocampus, Amygdala, and Orbitofrontal Cortex and Memories	446
Long Term Potentiation and Learning, AKA How the Brain Works	446
NMDA and AMPA Receptors	448
Nitric Oxide: The Good, The Bad, and the Ugly	449
Historical Snippet: Endothelial Derived Relaxing Factor = NO	449
Further Reading	450
19 Chemical Neuroanatomy	451
Introduction	451
Second Messenger Systems	452
Monoamine Systems	453
Dopamine	453
Mesolimbic Pathway	454
Dopaminergic Medications and Schizophrenia	454
Parkinson's Medications	457

Chemical Imbalance Theory of Depression	457
Reuptake Transporters	459
Psychedelics and the Serotonin 5-HT _{2A} Receptor.	460
Cholinergics	461
GABA, Barbiturates, and Benzodiazepines	463
The Opioids.	463
Historical Snippet: Opioid Epidemic in a Nutshell.	464
Further Reading	465
20 Brain Stem Lesions	467
Introduction.	467
Alternating Hemiplegia.	467
Inferior Alternating Hemiplegia	468
Middle Alternating Hemiplegia	469
Superior Alternating Hemiplegia	470
Rule of Fours.	471
Lateral Medullary Syndrome	472
Medial Medullary Syndrome	472
Lateral Pontine Syndrome.	473
Medial Pontine Syndrome.	473
Medial Midbrain Syndrome	474
Benedikt's Syndrome	475
Locked-In Syndrome	476
Superior Cerebellar Peduncle Lesion	476
Cranial Nerve III Lesions	476
Trochlear Nucleus.	479
Arteries to Brainstem	479
Two Abducens Cases	481
Abducens Nerve Case.	481
Abducens Nucleus Case	481
Localization of the Two Lesions.	482
Historical Snippet: Proustian Moment	482
Ondine's Curse	482
Further Reading	482
21 Cerebral Cortex Lesions.	483
Introduction.	483
Broca's Aphasia	484
Wernicke's Aphasia.	485
Conduction Aphasia	485
Cortical Blood Supply.	486
Top of Basilar Artery Stroke	488
Alexia Without Agraphia	488
Parietal Lobe	490
Man-in-a-Barrel	490
Gerstmann's Syndrome.	490
Temporal Lobe	491
Cingulate Gyrus	491
Hydrocephalus	491

Apraxia	491
Coup Contrecoup Lesions	492
Cerebral Cortex Gray Matter Layers	492
Historical Snippet: London Cabbies and the Hippocampus	493
Further Reading	493
22 Neurophysiology	495
Excitable Cells	495
Leak Channels	495
Sodium-Potassium Pump	497
Graded (Local) Potentials	498
Action Potentials	498
Differences Between Graded and Action Potentials	499
Action Potential Propagation	500
Fiber Classification	500
Deep Tendon Reflexes	501
Golgi Tendon Organs	502
Superficial Reflexes	503
Gate Control Theory of Pain	503
Blood-Brain and Blood-CSF Barriers	504
Choroid Plexus and CSF Production	505
CSF Reabsorption	506
Blood Brain Barrier	506
Virchow Robbin Spaces	507
Supporting Cells	507
Historical Snippet: The Discovery of Acetylcholine	508
Further Reading	509
23 Neuroanatomy Atlas	511
Atlas Overview	511
Dorsal Columns	512
Corticospinal Tract	512
Orientation to MRIs Versus Cross Sections	512
Cranial Nerves	513
Further Reading	526
24 Lesion and Blood Vessel Test	527
Lesion and Blood Supply Test	527
Answers to Lesion Test	529
Review of Blood Supply to Nervous System	532
Part III Embryology	
25 Testes, Ovaries, and Gametogenesis	541
Germ Cell Formation	541
Meiosis	541
Formation of Spermatozoa in the Testes	542
Leydig and Sertoli Cells	543
Spermatogenesis	543

Spermiogenesis	544
Female Gonads and Oogenesis	545
Folliculogenesis	545
The First 3 Weeks	546
Ovulation and Fertilization	547
Week One	548
Clinical Scenarios	549
Hydatidiform Mole	549
Twins	549
Stem Cells: Totipotent, Pluripotent, and Oligopotent	551
Week Two and Differentiation of Trophoblast and Embryoblast	552
Epiblast and Hypoblast	552
Week Three and Gastrulation	553
Body Folding	553
Historical Snippet: Heteropaternal Superfecundation	554
Further Reading	554
26 Development of Major Organs	555
Neurulation: Plate, to Groove, to Tube	555
Neural Tube Defects	556
Pituitary Development	557
Early Heart Development	557
Heart Development	557
Fetal Circulation	558
Development of the Atrial Septum	559
Development of the Ventricular Septum	560
Left-to-Right Shunts	560
Right-to-Left Shunts	561
Coarctation of the Aorta	561
Development of the GI Tract and Associated Organs	562
Development of the Pancreas and Liver	562
Clinical Scenarios	563
The Kidney	563
Urogenital Sinus	564
Development of Vagina and Uterus	565
Canal of Nuck	565
Development of Sexual Characteristics	566
Head and Neck Region	567
Development of the Facial Bones	568
Polyhydramnios Versus Oligohydramnios	569
Development of the Trachea	569
Ectoderm	570
Endoderm	571
Mesoderm	571

Mesoderm Divisions	571
Early Venous Drainage	572
Syndactyly	573
Further Reading	574
Appendix	575