

CONTENTS

, INTRODUCTION, I

The Phylum Chordata, 2 The Vertebrate Body: General Plan. 2 Regional Differentiation, 3 Bilateral Symmetry and Anatomic Planes, 4 Metamerism, 5 vertebrate Characteristics: The Big Four. 6 Notochord and Vertebral Column, 6 Pharynx: Pouches, Slits, and Arches, 8 Dorsal Hollow Central Nervous System, 12 venebrate Characteristics: Some Satellite Features, 13 Integument, 13 Respiratory Mechanisms, 13 Coelom, 13 Digestive Organs, 14 Urogenital Organs, 15 Circulatory System, 15 Skeleton, 16 Muscles, 16 Sense Organs, 16

2 CONCEPTS, PREMISES, AND PIONEERS, 19

Concepts and Premises. 19
Phylogeny and Ontogeny. 19
Taxonomy and Systematics. 20
Homology and Analogy, 21
Adaptation and Natural Selection. 23
Convergent and Parallel Evolution. 24
Homoplasy, 25
Speciation, 25
Organic Evolution, 26
Paedogenesis, Neoteny, Paedomorphosis, and Heterochrony, 28

Anatomy from Galen to Darwin, 29 Words to Ponder, 32

3 PROTOCHORDATES AND THE ORIGIN OF VERTEBRATES, 37

Prochordates. 37
Urochordates. 39
Cephalochordates. 42
Hemichordates: Incertae sedis. 49
The Origin of Vertebrates. 51
The Ammocoete: A Vertebrate Larva. 53
An Alternate Theory of AmmocoeteProtochordate Relationships. 55

4 PARADE OF THE VERTEBRATES IN TIME AND TAXA, 58

Vertebrate Taxa, 58 Agnatha, 61 Ostracoderms, 61 Cyclostomes, 63 Acanthodii and Placodermi, 65 Chondrichthyes, 66 Elasmobranchs, 67 Holocephalans, 68 Osteichthyes, 68 Ray-finned Fishes, 68 Lobe-finned Fishes, 71 Amphibia, 73 Labyrinthodents, 73 Lepospondyls, 75 Lissamphibians, 75 Reptilia, 80 Anapsids, 83 Lepidosaurs, 83 Archosaurs, 84

A CONTRACTOR DIGESTIVE SYSTEM, 375 the Digestive Tract: An Overview, 376 Mouth and Oral Cavity, 379 Tongue, 381 Oral Glands, 384 Teeth, 386 Morphology of the Gut Wall, 397 Esophagus, 399 Stomach, 399 Intestine, 405 Fishes, 405 Tetrapods: The Small Intestine, 406 The Large Intestine, 408 Liver and Gallbladder, 408 Exocrine Pancreas, 411 Cloaca; 411

13 RESPIRATORY SYSTEM, 415

Gills. 416 Agnathans, 416 Cartilaginous Fishes, 418 Bony Fishes, 420 Larval Gills, 423 Excretory Role of Gills, 424 Air Breathing in Bony Fishes, 424 Nares and Nasal Canals, 425 Swim Bladders and the Origin of Lungs, 426 Lungs and Their Ducts, 429 The Larynx and Vocalization, 429 Trachea, Syrinx, and Bronchi, 432 Amphibian Lungs, 434 Reptilian Lungs, 435 Lungs and Their Ducts in Birds, 437 Mammalian Lungs, 440

14 CIRCULATORY SYSTEM, 446

Blood, 449
Hemopoiesis, 450
The Formed Elements, 450
The Heart and Its Evolution, 451
The Hearts of Gill-Breathing Fishes, 452
The Hearts of Lungfishes and Amphibians, 453

The Hearts of Amnioles, 455
Innervation of the Heart, 457
Arterial Channels and Their Modification
Aortic Arches of Fishes, 461
Aortic Arches of Tetrapods, 464
Aortic Arches and von Baer's Law, 473
Coronary Arteries, 474
Retia Mirabilia, 474
Venous Channels and Their Modification
The Basic Pattern: Sharks, 476
Other Fishes, 479
Tetrapods, 479
Circulation in the Mammalian Fetus, and Changes at Birth, 484
Lymphatic System, 487

15 UROGENITAL SYSTEM, 494

Kidneys and Their Ducts, 494 The Osmoregulatory Role of Kidneys, 4% Basic Pattern and the Archinephros, 495 Pronephros, 502 Mesonephros, 503 Mctanephros, 507 Extrarenal Salt Excretion, 510 Urinary Bladders, 511 Genital Organs, 513 Gonadal Primordia, 513 Testes and Male Genital Ducts, 516 Intromittent Organs, 520 Ovaries: 523 Translocation of Mammalian Gonads, Female Genital Tracts Below Placental Mammals, 526 Female Tracts of Placental Mammals, The Cloaca, 535 Fate of the Cloaca in Placental Mamin

16 NERVOUS SYSTEM, 543

The Neuron, 544
Growth and Differentiation of the Nervol
System, 547
Neural Tube, 548
Development of Motor Components of
Nervos, 549

pevelopment of Sensory Components of Nerves, 550 Neuroglia and Neurilemma, 551 Spinal Cord, 552 Spinal Nerves, 554 Roots and Ganglia, 554 Occipitospinal Nerves, 556 Spinal Nerve Metamerism, 556 Rami and Plexuses, 557 Functional Components of Spinal Nerves, 558 Brain, 558 Meténcephalon and Myelencephalon: The

Hindbrain, 560
Mesencephalon: The Midbrain, 563
Diencephalon, 564
Telencephalon, 568
Blood Supply to Brain, 572
Choroid Plexuses and Cerebrospinal Fluid,

573

Cranial Nerves, 574

Predominantly Sensory Cranial Nerves, 574
Eyeball Muscle Nerves, 576
Branchiomeric Nerves, 577
Accessory and Hypoglossal Nerves, 581
Innervation of the Mammalian Tongue: An Anatomic Legacy, 583
Functional Components of Cranial Nerves, 583
Autonomic Nervous System, 586

17 SENSE ORGANS, 595

Special Somatic Receptors, 597
Neuromast Organs of Fishes and Aquatic
Amphibians, 597
Membranous Labyrinth, 600
Saccus Vasculosus, 612
Visual Organs: Lateral Eyes, 612
Median Eyes, 619
Infrared Receptors of Snakes, 621
Special Visceral Receptors, 621

Olfactory Organs, 622
Organs of Taste, 625
General Somatic Receptors, 626
Cutaneous Receptors, 626
Proprioceptors, 629
General Visceral Receptors, 631

18 ENDOCRINE ORGANS, 636

Neurosecretory Role of the Nervous System, 637 Endocrine Organs Derived from Ectoderm, 641 Pituitary Gland, 641 Pineal Gland, 645 Aminogenic Tissue and the Adrenal Medulla, 646 Endocrine Organs Derived from Mesoderm, 648 Steroidogenic Tissue and the Adrénal Cortex, 648 Gonads as Endocrine Organs, 649 Corpuscles of Stannius, 651 Endocrine Organs Derived from Endoderm, 651 Thyroid Gland, 651. Parathyroid Glands, 655 Ultimobranchial Glands, 655 Thymus, 656 Endocrine Pancreas, 658 Gastrointestinal Hormones, 659 Hormonal Control of Biological Rhythms, 660

APPENDIX I

Synoptic Classification of Chordates, 666

APPENDIX II

Selected Prefixes, Suffixes, Roots, and Stems Employed in Text, 671

COMPREHENSIVE REFERENCES.