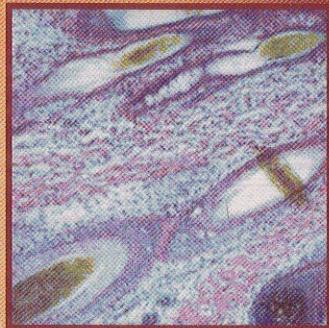
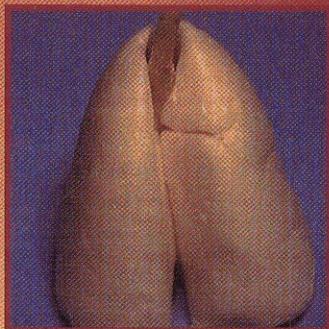


Second Edition

CLINICAL ANATOMY and PHYSIOLOGY

for Veterinary Technicians



Thomas Colville
Joanna M. Bassett

MOSBY
ELSEVIER

evolve

<http://evolve.elsevier.com>

Contents

1. INTRODUCTION TO ANATOMY AND PHYSIOLOGY, 1

Anatomy and Physiology, 1

Terminology, 2

Anatomical Planes of Reference, 2

Directional Terms, 4

General Plan of the Animal Body, 6

Bilateral Symmetry, 6

Body Cavities, 6

Dorsal Body Cavity, 6

Ventral Body Cavity, 6

Levels of Organization, 7

Cells, 7

Tissues, 7

Organs, 7

Systems, 7

Health, 7

Homeostasis, 8

2. CHEMICAL BASIS FOR LIFE, 9

Why Matter Matters, 10

Elements, 10

Atoms, 13

Molecules and Compounds, 15

Chemical Bonds, 17

Covalent Bonds, 17

Ionic Bonds, 18

Hydrogen Bonds, 19

Chemical Reactions, 20

Chemical Components of Living

Organisms: Organic and Inorganic Compounds, 21

Inorganic Compounds, 21

Water, 21

Salts, 23

Acids and Bases, 23

The pH Scale, 24

Buffers, 24

Organic Molecules, 25

Carbohydrates, 25

Lipids, 27

Neutral Fats, 27

Phospholipids, 29

Steroids, 29

Eicosanoids, 30

Proteins, 31

Amino Acids, 31

Structure of Proteins, 33

Structural Proteins, 33

Functional Proteins, 34

How Enzymes Work, 34

Nucleic Acids, 35

Nucleotides, 36

DNA, 36

RNA, 36

ATP, 38

3. THE AMAZING CELL, 39

Evolution of Cells, 41

The Cell Theory, 41

Size Limitations, 41

Mammalian Cell Anatomy, 46

Cell Membrane, 46

Membrane Structure, 48

Flagella and Cilia, 51

Cytoplasm, 51

Cytosol, 51

Cytoskeleton, 51

Organelles, 53

Inclusions, 57

Centrioles, 57

Nucleus, 57

Nuclear Envelope and Nucleoplasm, 58

DNA, RNA, and Chromatin, 58

Nucleoli, 61

Cell Physiology, 63

The Cellular Environment, 63

Body Fluids, 63

Ions, Electrolytes, and pH, 63

Membrane Processes: Excretion and Absorption, 64

Passive Membrane Processes, 64

Active Membrane Processes, 70

Resting Membrane Potential, 72

Life Cycle of the Cell, 73

Mitosis, 73

DNA Replication, 74

The Mitotic Phase, Cell Division, 76

Control of Cell Division, 76

Protein Synthesis, 76

Transcription, 78

Translation: Protein Synthesis, 79

Genetic Mutations, 81

Cell Differentiation and Development, 83

4. TISSUES: LIVING COMMUNITIES, 90

Gross and Microscopic Anatomy, 91

Epithelial Tissue, 91

General Characteristics of Epithelia, 91

Cellular Attachments, 92

Basement Membrane, 93

Surface Specialization, 93

Classifications of Epithelia, 94

Types of Epithelia, 94

- Simple Squamous Epithelium, 94
- Simple Cuboidal Epithelium, 95
- Simple Columnar Epithelium, 95
- Stratified Squamous Epithelium, 97
- Stratified Cuboidal Epithelium, 100
- Stratified Columnar Epithelium, 100
- Pseudostratified Columnar Epithelium, 100
- Transitional Epithelium, 102
- Glandular Epithelia, 103
- Endocrine Glands, 103
- Exocrine Glands, 103

Connective Tissue, 107

- General Characteristics, 107
- Components of Connective Tissue, 108
 - Ground Substance, 108
 - Fibers of Connective Tissue, 108
 - Major Cell Types, 109
- Types of Connective Tissue, 110
 - Connective Tissue Proper, 110
 - Loose Connective Tissue, 110
 - Specialized Connective Tissues, 114

Membranes, 117

- Mucous Membranes, 118
- Serous Membranes, 120
- Cutaneous Membranes, 120
- Synovial Membranes, 120

Muscle Tissue, 125

- Skeletal Muscle, 125
- Smooth Muscle, 125
- Cardiac Muscle, 125

Nervous Tissue, 125

Tissue Healing and Repair, 128

- Inflammation: The First Step, 128
 - Steps in the Process of Inflammation, 129
- Organization: The Formation of Granulation Tissue, 129
 - Regeneration or Fibrosis, 129
 - Epithelialization and Scar Tissue, 129
 - Classification, 130

5. THE INTEGUMENT AND RELATED STRUCTURES, 131

The Integument, 131

Epidermis, 133

- Cells of the Epidermis, 133
- Layers of the Epidermis, 134
- Epidermis of Hairy Skin, 135

Dermis, 138

Hypodermis or Subcutaneous Layer, 138

Special Features of the Integument, 139

- Pigmentation, 139
- Paw Pads, 139
- Planum Nasale, 139
- Ergots and Chestnuts, 139
- Cutaneous Pouches in Sheep, 140

Related Structures of the Integument, 140

Hair, 140

- Hair Strands and Their Follicles, 142
- Growth Cycles of Hair, 142
- Hair Color, 144
- Types of Hair, 144
- Arrector Pili Muscles, 144

Glands of the Skin, 146

- Sebaceous Glands, 146
- Sweat Glands, 146
- Tail Glands, 146
- Anal Sacs, 147

Claws and Dewclaws, 147

The Hoof, 148

- The Wall, 149
- The Sole, 150
- The Frog, 150
- Horns, 150

6. THE SKELETAL SYSTEM, 153

Bone, 154

Bone Terminology, 154

Bone Characteristics, 154

Functions of Bone, 154

- Support, 154
- Protection, 154
- Leverage, 154
- Storage, 154
- Blood Cell Formation, 154

Bone Structure, 154

- Cancellous Bone, 154
- Compact Bone, 154

Bone Cells, 155

Blood Supply to Bone, 157

Bone Formation, 157

Bone Shapes, 159

- Long Bones, 159
- Short Bones, 159
- Flat Bones, 160
- Irregular Bones, 160

Bone Marrow, 160

- Red Bone Marrow, 160
- Yellow Bone Marrow, 160

Common Bone Features, 160

- Articular Surfaces, 160
- Processes, 161
- Holes and Depressed Areas, 161

Axial Skeleton, 161

Skull, 161

- External Bones of the Cranium, 161
- Internal Bones of the Cranium, 168
- Bones of the Ear, 168
- External Bones of the Face, 168
- Internal Bones of the Face, 169

Hyoid Bone, 169

Spinal Column, 169

- Vertebrae Characteristics, 170

Cervical Vertebrae, 171	Characteristics of Muscle Contraction, 200
Thoracic Vertebrae, 171	Chemistry of Muscle Contraction, 201
Lumbar Vertebrae, 172	Heat Production, 202
Sacral Vertebrae, 172	Cardiac Muscle, 202
Coccygeal Vertebrae, 172	Gross Anatomy of Cardiac Muscle, 202
Ribs, 173	Microscopic Anatomy of Cardiac Muscle, 202
Sternum, 174	Physiology of Cardiac Muscle, 202
Appendicular Skeleton, 174	Muscle Contractions, 202
Thoracic Limb, 175	Nerve Supply, 203
Scapula, 175	Smooth Muscle, 203
Humerus, 175	Gross Anatomy of Smooth Muscle, 203
Ulna, 176	Microscopic Anatomy of Smooth Muscle, 203
Radius, 176	Physiology of Smooth Muscle, 203
Carpal Bones, 176	Visceral Smooth Muscle, 203
Metacarpal Bones, 177	Multiunit Smooth Muscle, 204
Phalanges, 178	
Pelvic Limb, 181	8. THE CARDIOVASCULAR SYSTEM, 205
Pelvis, 181	Composition of the Heart Wall, 205
Femur, 181	Blood Flow Through the Heart, 206
Patella, 181	External Structures of the Heart, 208
Fabellae, 181	Internal Structures of the Heart, 209
Tibia, 183	How the Heart Fills and Pumps: The Cardiac Cycle, 211
Fibula, 183	Blood Circulation in the Fetus, 213
Tarsal Bones, 183	Normal Heart Sounds, 213
Metatarsal Bones, 184	Heart Rate and Cardiac Output, 214
Phalanges, 184	The Electrocardiogram, 216
Visceral Skeleton, 184	Vascular Anatomy and Physiology, 216
Joints, 184	Venipuncture, 218
Joint Terminology, 185	9. BLOOD, LYMPH AND IMMUNITY, 220
Types of Joints, 185	Blood, 220
Fibrous Joints, 186	Introduction, 220
Cartilaginous Joints, 186	Function, 220
Synovial Joints, 186	Composition, 221
Synovial Joint Characteristics, 186	Plasma, 221
Synovial Joint Movements, 186	Cellular Components of Blood, 223
Types of Synovial Joints, 188	A Word About Stains, 223
Hinge Joints, 188	Hematopoiesis, 224
Gliding Joints, 189	Blood Storage, 225
Pivot Joints, 189	Red Blood Cells, 226
Ball-and-Socket Joints, 190	Formation, 226
7. THE MUSCULAR SYSTEM, 191	Characteristics, 226
Skeletal Muscle, 192	Function, 227
Gross Anatomy of Skeletal Muscle, 193	Hemoglobin, 227
Muscles, 193	Life Span and Destruction, 228
Muscle Attachments, 193	Anemia and Polycythemia, 228
Muscle Actions, 194	Platelets, 230
Muscle-Naming Conventions, 194	Formation, 230
Selected Muscles, 194	Characteristics, 230
Microscopic Anatomy of Skeletal Muscle, 198	Function, 230
Skeletal Muscle Cells, 198	Life Span and Destruction, 230
Neuromuscular Junction, 199	White Blood Cells, 231
Connective Tissue Layers, 199	Formation, 231
Physiology of Skeletal Muscle, 199	Function, 231
Initiation of Muscle Contraction and Relaxation, 199	Granulocytes, 232
Mechanics of Muscle Contraction, 200	Agranulocytes, 237

The Lymphatic System, 239

- Lymph Formation, 239**
- Characteristics, 239**
- Function, 240**
- Lymphatic Structures, 240**

- Lymph Nodes, 240**
- Spleen, 241**
- Thymus, 241**
- Tonsils, 241**
- Gut Associated Lymph Tissue, 242**

The Immune System, 242

- Function, 242**
- Immune Reactions, 242**
 - Nonspecific Immunity, 242**
 - Specific Immunity, 243**
- Immunization: Protection Against Disease, 245**
 - Passive Immunity, 245**
 - Active Immunity, 246**

10. THE RESPIRATORY SYSTEM, 247

Structure, 248

- Upper Respiratory Tract, 248**
 - Nose, 248**
 - Pharynx, 250**
 - Larynx, 251**
 - Trachea, 253**
- Lower Respiratory Tract, 254**
 - Bronchial Tree, 254**
 - Alveoli, 255**
 - Lungs, 255**
 - Thorax, 257**

Function, 258

- Negative Intrathoracic Pressure, 258**
- Inpiration, 259**
- Expiration, 260**
- Respiratory Volumes, 260**
- Exchange of Gases in Alveoli, 260**
- Partial Pressures of Gases, 261**
- Control of Breathing, 261**
 - Mechanical Control, 262**
 - Chemical Control, 262**

11. THE DIGESTIVE SYSTEM, 264

Basic Structure and Function of the Digestive Tract, 265

- Peristalsis and Segmental Contractions, 266**

Mouth or Oral Cavity, 266

- Teeth, 266**
- Function of the Oral Cavity, 269**

Esophagus, 269

Stomach, 271

- The Monogastric Stomach, 271**
 - Gastric Motility, 271**
 - Gastric Secretions, 272**
 - Role of Prostaglandins in Gastric Health, 273**
- The Ruminant, 274**
 - Reticulum, 274**

Rumen, 275

- Omasum, 276**
- Abomasum, 276**
- Young Ruminant Digestive Tract, 276**

Small Intestine, 277

- Small Intestine Motility, 277**
- Small Intestine Digestion, 278**
 - Carbohydrate Digestion, 278**
 - Protein Digestion, 278**
 - Fat Digestion, 279**
- Dietary Changes, 279**

Large Intestine, 280

- Rectum and Anus, 281**
- Other Organs Related to Digestion, 281**
 - Liver, 281**
 - Pancreas, 282**

12. NUTRIENTS AND METABOLISM, 283

Nutrients, 284

- Oxygen and Water, 285**
- Carbohydrates, 287**
- Fats and Lipids, 289**
 - Neutral Fats, 289**
 - Phospholipids, 291**
 - Steroids, 291**
 - Other Lipid Substances, 291**
- Proteins, 291**
- Vitamins, 295**
- Minerals, 295**

Metabolism, 297

- Catabolic Metabolism, 297**
 - Stage One: The Gastrointestinal Tract, 297**
 - Stage Two: The Cytosol, 297**
 - Stage Three: The Mitochondria, 297**
- Anabolic Metabolism, 298**
- Control of Metabolic Reactions, 300**
 - Enzymes, 300**
 - Coenzymes and Cofactors, 302**
 - Energy for Metabolic Reactions, 303**
- Metabolic Pathways, 304**
 - Carbohydrate Metabolism, 304**
 - Lipid Metabolism, 309**
 - Protein Metabolism, 311**

13. THE NERVOUS SYSTEM, 314

Neurons and Supporting Cells, 315

Organization of the Nervous System, 317

- Anatomical Location: CNS Versus PNS, 317**
- Direction of Impulses: Afferent Versus Efferent, 317**

- Function: Autonomic Versus Somatic, 317**

Neuron Function: Depolarization and Repolarization, 317

- Resting State, Polarization, and Resting Membrane Potential, 317**

- Depolarization, 318**

- Repolarization, 318**

Depolarization Threshold, Nerve Impulse Conduction, and All-or-Nothing Principle, 319

Refractory Period, 320

How Myelinated Axons Conduct Action Potentials Quicker: Saltatory Conduction, 320

How Neurons Communicate: The Synapse, 321

Types of Neurotransmitters and their Effect on Postsynaptic Membranes, 322

Stopping and Recycling the Neurotransmitter, 323

The Brain and Spinal Cord, 324

Cerebrum, 324

Cerebellum, 324

Diencephalon, 325

Brain Stem, 325

Other Clinically Important Structures of the Brain, 326

Meninges, 326

Cerebrospinal Fluid, 326

Blood-Brain Barrier, 327

Cranial Nerves, 327

Spinal Cord, 328

The Autonomic Nervous System, 328

Structure, 328

General Functions, 329

Neurotransmitters and Receptors, 331

Reflexes and the Reflex Arc, 332

Stretch Reflex, 332

Withdrawal Reflex, 333

Crossed Extensor Reflex, 334

The Role of the Upper CNS in Moderating Reflexes, 334

Other Clinically Significant Reflexes, 335

14. SENSE ORGANS, 337

General Senses, 338

Visceral Sensations, 338

Touch, 338

Temperature, 339

Pain, 340

Proprioception, 340

Special Senses, 342

Taste, 342

Smell, 342

Hearing, 343

External Ear, 345

Middle Ear, 345

Inner Ear, 346

Equilibrium, 349

Vestibule, 349

Semicircular Canals, 349

Vision, 350

Terminology, 350

Major Layers of the Eyeball, 350

Major Compartments of the Eyeball, 352

Lens, 353

Retina, 353

Formation of a Visual Image, 355

Extraocular Structures, 355

15. THE ENDOCRINE SYSTEM, 358

Hormones, 359

Characteristics, 359

Control of Hormone Secretion, 359

The Major Endocrine Glands, 361

The Hypothalamus, 361

Characteristics, 361

Relationship With Pituitary Gland, 361

The Pituitary Gland, 361

Characteristics, 361

The Anterior Pituitary, 362

The Posterior Pituitary, 364

The Thyroid Gland, 365

Characteristics, 365

Thyroid Hormone, 365

Calcitonin, 366

The Parathyroid Glands, 367

Characteristics, 367

Parathyroid Hormone, 367

The Adrenal Glands, 367

Characteristics, 367

Adrenal Cortex, 367

Adrenal Medulla, 369

The Pancreas, 369

The Pancreatic Islets, 369

Pancreatic Hormones, 369

The Gonads, 370

The Testes, 370

The Ovaries, 370

Other Endocrine Organs, 371

The Kidneys, 371

The Stomach, 372

The Small Intestine, 372

The Placenta, 372

The Thymus, 372

The Pineal Body, 372

Prostaglandins, 372

16. THE URINARY SYSTEM, 374

Waste Excretion, 374

Parts of the Urinary System, 375

Kidneys, 375

Function, 375

Location, 376

Gross Anatomy, 376

Microscopic Anatomy, 376

Nerve Supply, 377

Blood Supply, 377

Mechanisms of Renal Action, 377

Filtration of Blood, 379

Reabsorption, 379

Secretion, 380

Urine Volume Regulation, 381

- Ureters, 383**
- Anatomy, 383**
 - Function, 383**
- Urinary Bladder, 384**
- Anatomy, 384**
 - Function, 384**
 - Control of Urination, 384**
 - Urine Accumulation, 384**
 - Muscle Contraction, 384**
 - Sphincter Muscle Control, 384**
- Urethra, 384**
- Anatomy, 384**
 - Function, 385**
- 17. THE REPRODUCTIVE SYSTEM, 387**
- Meiosis, 388**
- Chromosomes, 388**
 - Diploid Chromosome Number, 388**
 - Sex Chromosomes, 388**
 - Haploid Chromosome Number, 388**
 - Meiosis Versus Mitosis, 389**
 - Spermatogenesis, 389**
 - Oogenesis, 390**
- Male Reproductive System, 391**
- Testes, 391**
 - Characteristics, 391**
 - Functions, 391**
 - Spermatozoa, 391**
 - Development and Location, 393**
 - Scrotum, 393**
 - Spermatic Cord, 393**
 - Structure, 393**
 - Vas Deferens, 396**
 - Urethra, 396**
 - Accessory Reproductive Glands, 396**
 - Seminal Vesicles, 397**
 - Prostate Gland, 397**
 - Bulbourethral Glands, 397**
 - Penis, 397**
 - Roots, 397**
 - Body, 397**
 - Glans, 398**
 - Prepuce, 398**
 - Penis of the Dog, 398**
 - Sigmoid Flexure, 398**
 - Reproductive Functions, 398**
- Female Reproductive System, 399**
- Ligaments, 399**
 - Ovaries, 400**
 - Characteristics, 400**
 - Functions, 401**
 - Ovarian Cycle, 401**
 - Oviducts, 402**
 - Uterus, 402**
 - Cervix, 403**
 - Vagina, 403**
 - Vulva, 403**
- The Estrous Cycle, 404**
- Estrous Cycle Intervals, 404**
 - Stages of the Estrous Cycle, 404**
- 18. PREGNANCY, DEVELOPMENT, AND LACTATION, 405**
- Fertilization and Pregnancy, 405**
- Copulation, 405**
 - Transport of Spermatozoa, 405**
 - Capacitation, 406**
 - Fertilization of the Ovum, 406**
 - The Zygote, 406**
 - Cleavage, 406**
 - Implantation, 406**
 - The Placenta, 407**
 - Structure, 407**
 - Attachment to the Uterus, 408**
 - Pregnancy, 409**
 - Parturition, 409**
 - Involution of the Uterus, 410**
- Mammary Glands and Lactation, 410**
- Characteristics, 410**
 - Species Differences, 411**
 - Udder of the Cow, 411**
 - Characteristics, 411**
 - Alveoli and Duct System, 411**
 - Mammary Gland Development, 411**
 - Lactation, 412**
 - Colostrum, 412**
 - Maintenance of Lactation, 413**
 - Milk Letdown, 413**
- 19. AVIAN ANATOMY AND PHYSIOLOGY, 414**
- Topography, 415**
- Integument, 415**
- Skin, 415**
 - Glands, 415**
 - Beaks, 416**
 - Claws, 416**
 - Feathers, 418**
 - Functions, 418**
 - Structure, 418**
 - Types of Feathers, 419**
 - Location, 420**
 - Feather Damage, 420**
 - Moltling, 421**
- Musculoskeletal System, 423**
- Skeleton, 423**
 - Axial Skeleton, 423**
 - Appendicular Skeleton, 425**
 - Muscles, 427**
 - Classification, 427**
 - Wing Muscles, 427**
 - Leg Muscles, 427**
 - Muscles of the Head and Neck, 427**

Sense Organs, 429

Vision, 429

Anatomy of the Eye, 429

Photoreception, 433

Color Vision, 433

Visual Spectrum, 433

Hearing and Equilibrium, 433

Anatomy of the Ear, 434

Hearing in Nocturnal Owls, 434

Taste, 434

Touch, 434

Smell, 435

Endocrine System, 436

Digestive System, 436

Anatomy, 436

Beaks and Bills, 436

Mouth, 436

Esophagus, 437

Stomach, 437

Liver, 437

Pancreas, 437

Duodenum, 438

Ceca, 438

Large Intestine, 438

Cloaca, 438

Feeding Habits, 439

Circulatory System, 440

Anatomy, 440

Heart, 440

Vessels, 441

Blood Flow, 441

Electrocardiogram, 441

Blood, 441

Erythrocytes, 441

Leukocytes, 441

Thrombocytes, 444

Plasma, 444

Respiratory System, 445

Anatomy, 445

Oral Cavity, 445

Trachea, 445

Syrinx, 446

Bronchi, 447

Parabronchi, 447

Air Sacs, 447

Lungs, 447

Airflow, 447

Respiratory Rate, 447

Thermoregulation, 447

Urogenital System, 449

Urinary System, 449

Anatomy, 449

Urine Composition, 450

Reproductive System, 450

Anatomy, 450

Male Reproductive System, 450

Female Reproductive System, 451

The New Arrival, 452

Appendix 19-1: Bird Classification, 453

Appendix 19-2: Life Spans of Common Pet Bird Species, 454

20. AMPHIBIAN AND REPTILIAN ANATOMY AND PHYSIOLOGY, 455

Taxonomy, 455

Metabolism, 456

Integument, 457

Vision, 459

Periocular Structures, 459

The Globe and Intraocular Structures, 460

Cardiovascular System, 460

Blood, 462

Respiratory System, 463

Ears and Hearing, 465

Gastrointestinal Tract, 465

Cloaca, 468

Kidneys, 469

Reproductive System, 471

Male Anatomy, 471

Female Anatomy, 472

Reproductive Cycle, 472

Oviposition, 472

Egg Incubation, 472

Sex Determination, 473

Secondary Sexual Characteristics, 473

Amphibian Reproduction, 473

Endocrine System, 474

Nervous System, 475

Musculoskeletal System, 475

The Skull, 475

Axial Skeleton, 476

Appendicular Skeleton, 476

Muscles, 477