

CHAPTER 49: ORGANIZATION OF THE ANIMAL BODY

CHAPTER SYNOPSIS

The human organism is a vertebrate, therefore it is also a deuterostome and a coelomic animal. The diaphragm divides the body into the thoracic cavity containing the lungs and the heart and the peritoneal cavity containing the stomach, liver, intestines, and various other organs. It is supported by an internal skeleton of jointed bones. A skull surrounds the brain and the hollow vertebral column surrounds the dorsal nerve cord. All vertebrates are organized in successively more inclusive levels: cells to tissues to organs to organ systems. Humans contain eleven principal organ systems, each a collection of functional units composed of several different tissues. The tissues themselves are derived from embryonic endoderm, mesoderm, and ectoderm and are of four main types: epithelial, connective, muscle, and nervous tissue.

Epithelium protects other tissues from dehydration and damage and provides a selective barrier. Simple epithelium is only a single cell layer thick; the cells may exhibit squamous (flattened, irregular), cuboidal, or columnar shapes. Stratified epithelium is a few cell layers thick and is made up of a combination of cell shapes. The outer epithelium of terrestrial vertebrates is highly keratinized for protection against abrasion. Glands are epithelial tissues that serve a secretory function. Exocrine glands are connected to epithelium by ducts while endocrine glands are ductless and secrete their hormonal products directly into the blood system.

Connective tissues are derived from mesoderm and divided into connective tissue proper and special connective tissue. Connective tissues are composed of widely-spaced cells imbedded in an extracellular matrix. Loose connective tissues contain cells scattered in an amorphous protein substance, strengthened by collagen, elastin, or reticulin. Dense connective tissues contain tightly packed collagen fibers. Regular dense connective tissue, like tendons and ligaments, have collagen fibers aligned in parallel. Irregular tissue fibers are not regularly oriented and compose the tissues that cover organs, muscles, nerves, and bones. Cartilage is composed of collagen fibers

interspersed with living chondrocyte cells. Bone is cartilage that has been hardened by calcification. Even though embedded in a calcium matrix, the osteocytes remain alive. Numerous types of cells are found within the liquid matrix of the blood. They include erythrocytes (red cells), leukocytes (white cells), and thrombocytes (platelets). There are several types of white cells: neutrophils, eosinophils, and basophils are named by their special affinity to biological stains. Monocytes and macrophages are phagocytes, while lymphocytes comprise an important part of the immune system.

Muscle tissue is also derived from mesoderm and exhibits the unique function of contractibility. These cells possess a great concentration of actin and myosin containing myofibrils. There are three general types of muscles, categorized by their location and cellular structure. Smooth muscle cells surround various internal organs and are composed of uninucleate spindle-shaped cells. Two types of contractions occur in smooth muscle. Muscles lining blood vessels and those in the iris of the eye contract with nerve stimulation. Other smooth muscles, like those in the walls of the digestive tract contract spontaneously. Nerves simply regulate their activity. Skeletal muscle connects bones to one another and underlies the skin. It is composed of multinucleate fibers produced by the fusion of many individual cells. These contract only when stimulated by nerves. Cardiac muscle is found in the heart and is composed of specially arranged striated muscle fibers. Certain cells in the myocardium generate a spontaneous electrical impulse which causes all cells in the myocardium to contract in unison.

Nerve tissue is composed of neurons and supporting cells. An individual neuron is composed of a processing cell body, receiving dendrites, and a transmitting axon. They are capable of conducting an electrical current and thereby transmit information. The brain and spinal cord comprise the central nervous system (CNS) while nerves and ganglia make up the peripheral nervous system (PNS).

CHAPTER OBJECTIVES

- ä Understand how vertebrate cells are organized into tissues, organs, and organ systems and give examples of each.
- ä Describe the general characteristics and functions of epithelial tissue.
- ä Indicate the two classes and three subdivisions into which epithelial tissue is divided and give examples of each.
- ä Differentiate between exocrine and endocrine glands.
- ä Understand the composition and function of loose versus dense connective tissue.
- ä Explain how cartilage and bone are related and the structural advantages of each.
- ä Describe and characterize the cellular and noncellular components of blood.
- ä Differentiate among smooth, striated, and cardiac muscle in terms of derivation, location, and initiation of contraction.
- ä Understand the functional specialization of nervous tissue and how it relates to the anatomy of an individual neuron.

KEY TERMS

adipose cell
 chondrocyte
 connective tissue proper
 dense irregular connective tissue
 dense regular connective tissue
 ectoderm
 endocrine gland
 endoderm

epithelium
 exocrine gland
 ground substance
 loose connective tissue
 matrix
 mesoderm
 organ
 organ system

peritoneal cavity
 simple epithelial membrane
 skeleton
 special connective tissue
 stratified epithelial membrane
 striated muscle
 thoracic cavity
 tissue

CHAPTER OUTLINE

49.0 Introduction

I. VERTEBRATES ARE REPRESENTATIVE ANIMALS

A. All Vertebrates Share the Same Body Plan and Operation

B. All Vertebrate Organs Operate in Much the Same Way fig 49.1

49.1 The bodies of vertebrates are organized into functional systems

I. ORGANIZATION OF THE BODY

A. General Body Architecture fig 49.2

1. Digestive tube suspended within internal body cavity, the coelom
 - a. Divided into two cavities in fish, amphibians, most reptiles
 - b. Heart in one cavity and the liver, stomach, intestines in other
2. Muscular diaphragm divides coelom in mammals and some reptiles
 - a. Peritoneal cavity: Stomach, intestines, and liver
 - b. Thoracic cavity: Heart and lungs
 - 1) Pericardial cavity contains heart
 - 2) Pleural cavities contain lungs

3. All vertebrates supported by internal skeleton of jointed bones or cartilage
 - a. Bony skull surrounds brain
 - b. Column of hollow vertebrae surrounds dorsal spinal nerve cord
 4. Four levels of organization in the body
 - a. Cells tissues organs organ systems
 - b. Bodies composed of many different types of cells
- B. Tissues
1. Groups of cells with similar structure and functions are called tissues
 2. Three fundamental embryonic tissues: Endoderm, mesoderm, and ectoderm
 3. Four principal adult primary tissues: Epithelial, connective, muscle, nerve fig 49.3
- C. Organs and Organ Systems
1. Organs are a structural and functional unit composed of different tissues fig 49.4
 - a. Example: The heart
 - b. Contains cardiac muscle, connective tissue, epithelial tissue
 - c. Laced with nerves to regulate heart beat
 2. Organ system is a group of organs that function together to carry out body activities
 - a. Digestive system composed of digestive tract, liver, gall bladder, pancreas
 - b. Humans contain eleven principal organ systems tbl 49.1, fig 49.5

49.2 Epithelial tissue forms membranes and glands

I. CHARACTERISTICS OF EPITHELIAL TISSUE

- A. Epithelium Covers Every Surface of the Body
1. Examples
 - a. Epidermis derived from ectoderm, comprises outer layer of skin
 - b. Inner surface of digestive tract lined with endoderm-derived epithelium
 - c. Inner surface of body cavities lined with mesoderm-derived epithelium
 2. Functions of epithelial tissues
 - a. Provide selective barrier
 - 1) Any entering or exiting substance must cross an epithelial layer
 - 2) Facilitate or impede passage of materials into underlying tissues
 - 3) Protect underlying tissue from dehydration and airborne pathogens
 - 4) Digestive epithelium allows passage of digestive products, not toxic substances
 - 5) Lung epithelium allows for rapid diffusion of gases
 - b. Secrete materials via glands
 3. Characteristics of epithelial layers
 - a. Cells bound tightly together
 - b. Are only a few cell layers thick
 - c. Possess few blood vessels, transport materials via diffusion
 - d. Readily regenerated
 4. Two general classes tbl 49.2
 - a. Simple epithelium
 - b. Stratified epithelium
 - c. Further subdivided by cell shape
 - 1) Simple squamous: Flat cells
 - 2) Simple cuboidal: Equal height and width
 - 3) Columnar: Height greater than width

B. Types of Epithelial Tissues

1. Simple epithelial membrane
 - a. A single cell layer thick
 - b. Simple squamous cells
 - 1) Have irregular, flattened shape with tapered edges
 - 2) Line lungs and blood capillaries
 - 3) Permit rapid passage of molecules across membrane
 - c. Simple cuboidal cells line small ducts inside glands
 - d. Simple columnar cells line respiratory and gastrointestinal tract
 - 1) Interspersed with goblet cells, respiratory tract cells have cilia
 - 2) Surface of intestine has microvilli projections to increase surface area
2. Stratified epithelial membrane
 - a. Several cell layers thick, named according to features of uppermost layers
 - b. Epidermis is a stratified squamous epithelium
 - 1) Has an upper layer of squamous cells
 - 2) Terrestrial vertebrates have keratinized epithelium
 - a) Superficial cells are dead and filled with keratin
 - b) Keratin increased in response to abrasion-forming calluses
 - c) Lips covered by nonkeratinized, stratified squamous epithelium
3. Glands
 - a. Derived from invaginated epithelia, produce various substances
 - b. Two categories of glands
 - 1) Exocrine glands: Connected to epithelium by a duct
 - a) Product channeled to outside or to body cavity
 - b) Sweat and oil glands channel products externally
 - c) Accessory digestive glands are internal
 - 2) Endocrine glands: Connection with epithelium lost, ductless
 - a) Secretions called hormones
 - b) Hormones enter blood capillaries, don't leave body

49.3 **Connective tissues contain abundant extracellular material**

I. CONNECTIVE TISSUE PROPER

A. Structural Building Blocks

tbl 49.3

1. Derived from mesoderm
2. Divided into two categories
 - a. Connective tissue proper: Loose and dense tissue
 - b. Special connective tissue: Cartilage, bone, blood
3. Composed of widely-spaced cells imbedded in an extracellular matrix
 - a. Bone extracellular matrix contains crystals
 - b. Blood extracellular matrix is plasma fluid

B. Loose Connective Tissue

1. Cells scattered within protein mass called ground substance
2. Strengthened by collagen, elastin, and/or reticulin
3. Fibroblasts secrete collagen and fibrous proteins
4. Contains other living cells
 - a. Mast cells produce histamine and heparin
 - b. Phagocytic macrophages defend against invading organisms
5. May contain adipose cells
 - a. Each cell stores a droplet of fat (triglycerides)
 - b. Cell hydrolyses triglyceride and secretes fatty acids into blood stream
 - c. Number of fat cells in an adult is usually fixed, can change in size

fig 49.6

fig 49.7

C. Dense Connective Tissue

1. Contains tightly packed collagen fibers
2. May be regular or irregular
 - a. In dense regular tissue, collagen fibers are lined up in parallel
 - 1) Tendons bind muscle to bone
 - 2) Ligaments bind bone to bone
 - b. In dense irregular tissue, fibers have different orientations
 - 1) Tough coverings of organs like capsules of kidneys and adrenal glands
 - 2) Perimysium covers muscles, perineurium covers nerves, periosteum covers bones

II. SPECIAL CONNECTIVE TISSUE

A. Cartilage

fig 49.8

1. Has special ground substance made from characteristic glycoprotein
2. Parallel collagen fibers laid down along lines of stress
3. Produces firm, flexible tissue that is tough and doesn't stretch
4. Makes up skeleton of agnathans, cartilaginous fishes, cushions bone joints
5. Chondrocytes remain alive even with no blood vessels
 - a. Found in spaces called lacunae
 - b. Receive oxygen and nutrients by diffusion from surrounding blood vessels
 - c. Diffusion occurs because cartilage matrix is not calcified like bone

B. Bone

fig 49.9

1. Many bones in fetus first modeled in cartilage
2. Cartilage hardened by calcification, cells die, replaced by living bone
3. Osteocytes are living bone cells, matrix is hardened with calcium phosphate
4. Blood vessels travel through canals in bone
 - a. Osteocytes communicate with blood vessels through canals
 - b. Canals called canaliculi
5. Few bones like those of cranium not formed first in cartilage

C. Blood

fig 49.10

1. Contains abundant matrix material: Fluid plasma
2. Cells include erythrocytes (red cells) and leukocytes (white cells)
3. Thrombocytes or platelets are fragments of a type of bone marrow cell
4. Erythrocytes are the most common blood cells
 - a. Lose nucleus, mitochondria, and ER during maturation
 - b. Metabolically are relatively inactive
 - c. Has iron-containing hemoglobin protein, carries oxygen
5. Several types of leukocytes
 - a. Have nuclei and mitochondria, no hemoglobin
 - b. Neutrophils, eosinophils, basophils have special affinity to biological stains
 - c. Lymphocytes and monocytes are other components of immune system
6. Blood plasma contains nutrients, metabolic wastes, heat, regulatory molecules
 - a. Includes sugars, lipids
 - b. Wastes carried to kidneys, liver, lungs/gills for disposal
 - c. Hormones travel to organs to regulate their activities
7. Plasma contains other materials as well
 - a. Also contains sodium, calcium, other inorganic salts
 - b. Includes proteins like fibrinogen and albumin
 - c. Contains lymphocyte-produced antibodies

49.4 Muscle tissue provides for movement, and nerve tissue provides for control

I. MUSCLE TISSUE

A. Muscle Cells Are Motors of the Vertebrate Body

1. Possess large numbers of actin and myosin filaments, specialized for contraction
2. Three types of vertebrate muscle: Smooth, skeletal, and cardiac fig 49.4
3. Skeletal and cardiac are also striated muscles
4. Control of muscle tissue
 - a. Skeletal muscle is under voluntary control
 - b. Cardiac and smooth muscle under involuntary control

B. Smooth Muscle

1. Earliest form to evolve, found throughout animal kingdom
2. Found in viscera of vertebrate animals
3. Cells organized into sheets to form smooth muscle tissue
4. Cells are long and spindle-shaped, each with one nucleus
5. Two types of contraction occur
 - a. All muscles contract as a unit when stimulated by nerve
 - 1) Muscles lining blood vessels
 - 2) Muscles of iris
 - b. Individual cells contract spontaneously
 - 1) Causes slow, steady contraction of the tissue
 - 2) Muscles in the walls of the gut
 - 3) Nerves regulate activity, do not cause it

C. Skeletal Muscle

1. Attached to bones by tendons, contract and cause bones to move at joint
2. Numerous parallel muscle cells called muscle fibers, act in concert
3. Stronger contractions result when more fibers stimulated to contract by nerve
 - a. Nerves vary strength of muscle contraction
 - b. Contraction due to substructures called myofibrils fig 49.11
 - c. Contain highly ordered arrays of actin and myosin filaments
 - d. Gives muscle striated appearance
4. Fibers produced during development by the fusion of several cells
 - a. A single fiber runs the length of an individual vertebrate muscle
 - b. Each fiber contains all of the original nuclei of the fused cells

D. Cardiac Muscle

1. Vertebrate hearts made of specially arranged striated muscle fibers
 - a. Composed of interconnected cells, each with its own nucleus
 - b. Interconnections appear as lines called intercalated disks fig 49.10
 - c. Lines are really regions where cells are linked by gap junctions
2. Interconnections allow heart to contract as single unit
 - a. Functioning unit called myocardium
 - b. Certain muscle cells generate spontaneous electrical impulse
 - c. Impulses spread across gap junction from cell to cell
 - d. All cells in myocardium ultimately contract

II. NERVE TISSUE

A. Composition of Nerve Tissue

1. Composed of neurons and supporting neuroglia cells
2. Neurons: Specialized for transmission of nerve impulses
 - a. Composed of three parts: Cell body, dendrites, axon fig 49.12
 - b. Cell body contains the nucleus
 - c. Dendrites
 - 1) Thin, highly branched protrusions from the cell body
 - 2) Receive stimulation
 - 3) Conduct electrical events to cell body
 - d. Axon
 - 1) Transmit nerve impulse away from the cell body
 - 2) Long tubular extension of the cell body
 - 3) Axon can be long, resulting in long nerve cell
3. Neuroglia support and insulate neurons, eliminate foreign materials
 - a. May form insulating layer called myelin sheath
 - b. Membrane of cell forms successive wraps around axon
 - c. Periodic interruptions in sheath called nodes of Ranvier, accelerate impulse

B. Nervous System Has Two Components

1. Central nervous system (CNS): Includes brain and spinal cord
2. Peripheral nervous system (PNS): Includes nerves and ganglia
 - a. Nerves are bundles of axon fibers
 - b. Ganglia are collections of neuron cell bodies

INSTRUCTIONAL STRATEGY

PRESENTATION ASSISTANCE:

Compare the organization of the human body to the construction of a house. The screws, nails, wood, glass, and pipes (tissues) combine to make interior walls, ceilings, floors, and windows

(organs). These are then combined to form entire rooms (organ systems) that finally comprise the whole house (the body).

VISUAL RESOURCES:

Obtain a number of animal organs to illustrate how they are made up of various tissues. Samples from the grocery are best, but in very

large classes may be substituted with photographs.