UNIT 22 - ANIMAL TISSUES

Objectives

After completing this unit you will be able to:

- understand the classification scheme for vertebrate tissues
- identify the distinguishing features of each tissue
- associate structure with function for each type of tissue
- identify each tissue type

Introduction

Vertebrates contain between fifty and several hundred different kinds of cells, depending on how finely one differentiates between cell types. These diverse cell types are grouped into four types of tissues based on structure and function: **epithelial**, **connective**, **muscular**, and **nervous tissues**. Cells with similar structure and function constitute a **tissue**. Tissues and their functions integrate to form **organs**. An organ is composed of more than one tissue type and has a definite structure and function. Organs work together as **systems** (for example, respiratory system, digestive system, and so on).

I. Epithelial Tissue

Epithelial cells are tightly linked together with little space or extracellular material between them. Epithelial tissue consists of single or multiple layers of cells. In all cases, one cell layer surface does not have another tissue over it. The other surface adheres to an underlying layer called a **basement membrane**. Epithelial tissues cover the exterior of an organism, line the gut, line internal cavities and tubes, and form the secretory portions of glands. Epithelial cells perform three functions: (1) protect the underlying tissues from dehydration and mechanical damage, (2) provide a permeable barrier that can facilitate or impede passage of materials, (3) provide sensory surfaces, and (4) secrete various fluids. The two classes of epithelial tissue are **simple epithelium** and **stratified epithelium**.

A. Simple Epithelium

A layer of simple epithelium is one cell thick and is classified according to the shapes of its cells (*Figure 22.1*).

Figure 22.1 Three shapes of epithelial cells

1. Simple Squamous Epithelial Cells

Simple squamous epithelial cells have an irregular flattened shape. The one cell layer of simple squamous epithelium is a minimal barrier to diffusion. Squamous cells line the alveoli of the lungs, the filtration system of the kidneys, and the major cavities of the body. These cells are relatively inactive metabolically and are associated with the diffusion of water, electrolytes, and other substances.

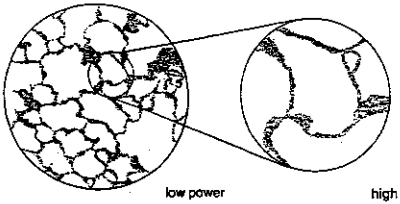


Figure 22.2 Alveolar tissue showing simple squamous epithelium

2. Simple Cuboidal Epithelium

Simple cuboidal epithelium is made up of a single layer of cube-shaped cells. This type of tissue is found lining the kidney tubules.

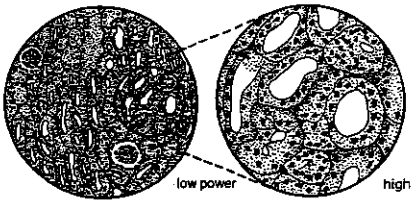


Figure 22.3 Kidney tissue showing simple cuboidal epithelium

Simple columnar epithelium is made up of a single layer of cells that are longer than they are wide. The small intestine is lined with this type of tissue. The small intestine is a tubular organ that connects the stomach to the large intestine. Food is digested and absorbed in the intestine. Unicellular glands called **goblet cells** are scattered through the simple columnar epithelial cells and secrete mucus. The free surface of each columnar cell has tiny hairlike projections called **microvilli**. They increase the surface area for absorption. You will not be able to see the microvilli on your slide.

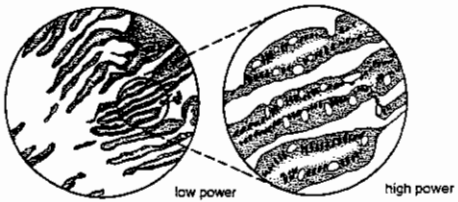


Figure 22.4 Ileum showing simple columnar epithelium

B. Stratified Squamous Epithelium

Stratified tissues are several cell layers thick. You will examine the lining of a cat esophagus. The skin is also an example of stratified squamous epithelium.

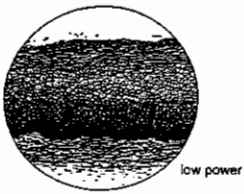


Figure 22.5 Cat esophagus showing stratified squamous epithelium

II. Connective Tissue

Connective tissues provide the body with support, defense, and storage, as well as bind structures together. Cells of connective tissue are not as tightly packed as epithelial cells. Typically they are suspended in an extracellular **matrix**. The matrix is the nonliving material between cells that is produced and secreted by the cells. It may be liquid, semi-solid, gel-like, or very hard. Fibers of various types and amounts are also deposited and form part of the matrix. Some connective tissues are dispersed in the circulatory system. Classification of connective tissue cells is based more on function and the nature of the extracellular matrix than structure.

A. Connective Tissue Proper

The matrix of connective tissue proper is more or less fluid with cells scattered through it. The three types of connective tissue are loose connective, dense connective, and adipose.

1. Loose Connective Tissue

Loose connective tissue (*Figure 22.6*) supports most epithelia and many organs. It also surrounds blood vessels and nerves. Cells called **fibroblasts** are widely dispersed in this tissue. They are irregular, branching cells that secrete strong fibrous proteins as an extracellular matrix. The most commonly secreted protein is **collagen**, which represents one-fourth of all vertebrate protein. If all components of the body except collagen were removed, a ghostly mesh of fibers would remain as the framework of the body and all its organ systems. Collagen is tough and flexible. It gives strength to the tissue.

Elastin fibers, which are thinner, are also secreted by fibroblasts. They are composed of protein fibers with longer cross-links than those of collagen. This structure gives elastin fibers great elasticity.

magnification _____
cell size (µm) _____

Figure 22.6 Loose connective tissue

2. Dense Connective Tissue

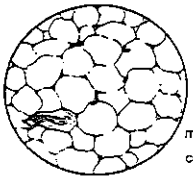
Dense connective tissue provides strong connections between different tissues. Its collagen fibers are bundled irregularly or in a parallel fashion. **Tendons**, which connect muscle to bone, derive their strength from the regular, longitudinal arrangement of bundles of collagen fibers. **Ligaments** bind bone to bone and are similar in structure to tendons.

magnification _____
cell size (µm) _____

Figure 22.7 Dense regular connective tissue (tendon)

3. Adipose Tissue

Adipose tissue is composed of fat cells, each containing a large vacuole of oil. This tissue stores energy, insulates, and pads some organs. In the cells of adipose tissue, the cytoplasm and nucleus have been pressed to the inner edge of the cell membrane. This gives the cell the appearance of a signet ring.



magnification _____
cell size (µm) _____

Figure 22.8 Adipose tissue

external ear. It derives its resilient and supportive properties from an extracellular gelatinous matrix of **chondrin**. The chondrin of cartilage may be impregnated with fibers of collagen. This matrix is secreted by cells called **chondrocytes**.

Hyaline cartilage serves as a cushion for bone surfaces at joints. **Elastic cartilage** is commonly found in the external ear and voice box (larynx). It is more flexible than hyaline cartilage and is rich in fibers.

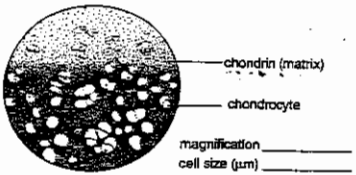


Figure 22.9 Hyaline cartilage

C. Bone

Bone (*Figure 22.9*) and its properties are also derived from a strong extracellular matrix with fibers. The collagen fibers of bone are surrounded by hard crystals of calcium salts rather than the flexible matrix of chondrin found in cartilage. This fibrous and crystalline matrix is produced by bone cells called osteocytes.

Compact bone is laid down in thin concentric layers called **lamellae**. Lamellae form a series of tubes around narrow channels called **Haversian canals**, which are arranged parallel to the long axis of the bone. The Haversian canals surround blood vessels and nerve cells throughout the bone and communicate with osteocytes in **lacunae** (spaces within the dense bone matrix that contain the living bone cells) through **canaliculi**. Canaliculi are small, microscopic canals between the various lacunae.

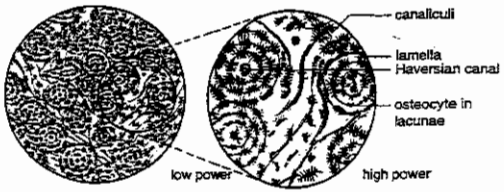


Figure 22.10 Bone structure

III. Muscle Tissue

The distinctive feature of muscle tissue is its ability to contract, resulting from the interaction of **actin** and **myosin filaments** within cells. Bundles of these contractile filaments are called myofibrils and are found within a single muscle cell. Their uniform contraction causes considerable force and movement. Vertebrates contain three kinds of muscle: **skeletal**, **smooth**, and **cardiac**.

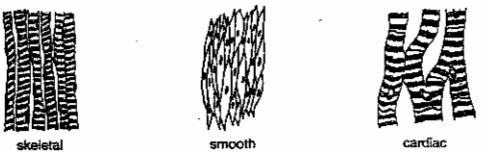


Figure 22.11 Three types of muscle

A. Skeletal Muscle

Skeletal muscles are attached to the skeleton and are under voluntary control. A skeletal muscle "cell" is a long fiber of regularly arranged contractile units with **many nuclei** scattered at the periphery of the fiber. The stacked array of actin and myosin filaments within the fibers gives skeletal muscle its banded or striated appearance.

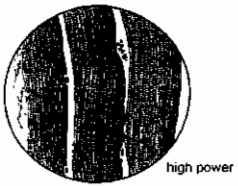
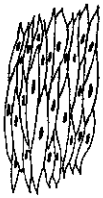


Figure 22.12 Skeletal muscle

B. Smooth Muscle

Smooth muscle cells are long and spindle-shaped and have a **single nucleus**. Smooth muscles line the walls of the gut and blood vessels, and their contraction is under involuntary control. Smooth muscle tissue is organized into sheets of cells that contract slowly and rhythmically.



sheet of smooth muscle cells

individual smooth muscle cells (teased apart)

Figure 22.14 Smooth muscle tissue

Cardiac (heart) muscle (*Figure 23.14*) is striated and composed of chains of single, uninucleate cells. These cells are branched and fit together at specialized junctions called **intercalated disks**. The cells are organized into rather continuous functional fibers similar to those of skeletal muscle cells. Thus, cardiac cells depolarize and contract more as a functional unit than the sheets of loosely associated cells of smooth muscle.

magnification _____

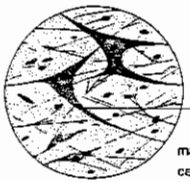
cell size (μm) _____

Figure 23.14 Cardiac muscle

Nervous Tissue

The fourth major class of vertebrate tissue is nervous tissue. It functions in communication between parts of the body. It is composed of **neurons** (*Figure 23.15*), which are specialized cells for the transmission of nerve impulses, and **neuroglia**, which assist propagation of the nerve impulse and provide nutrients to the neuron.

Neurons are composed of a **cell body** containing a nucleus and cytoplasmic extensions that conduct the nerve impulse. **Dendrites** are short extensions of the cell that carry impulses toward the cell body from other cells or sensory systems. **Axons** are long extensions that carry impulses away from the cell body. Some dendrites and axons carry impulses in both directions, depending on the circumstance. Since cell bodies are located only in the brain, spinal cord, and dorsal root ganglia, some axons and dendrites must be a meter long to reach distant parts of the body.



neuron

magnification _____

cell size (μm) _____

Figure 23-15 Nervous tissue with neurons

Table 5-5 Tissues

Epithelial		
Membranous		
Simple squamous	Alveoli of lungs	Absorption by diffusion of respiratory gases between alveolar air and blood
	Lining of blood and lymphatic vessels (called endothelium; classified as connective tissue by some histologists)	Absorption by diffusion, filtration, osmosis
	Surface layer of pleura, pericardium, peritoneum (called mesothelium; classified as connective tissue by some histologists)	Absorption by diffusion and osmosis; also, secretion
Stratified squamous	Surface of mucous membrane lining mouth, esophagus, and vagina	Protection
	Surface of skin (epidermis)	Protection
Transitional	Surface of mucous membrane lining urinary bladder and ureters	Permits stretching
Simple columnar	Surface layer of mucous lining of stomach, intestines, and part of respiratory tract	Protection; secretion; absorption; moving of mucus (by ciliated columnar epithelium)
Stratified columnar	Lining of portions of the male urethra; mucous membrane near anus (rare)	Protection
Pseudostratified columnar	Surface of mucous membrane lining trachea, large bronchi, nasal mucosa, and parts of male reproductive tract (epididymis and vas deferens); lines large ducts of some glands (e.g., parotid)	Protection
Simple cuboidal	Ducts and tubules of many organs, including exocrine glands and kidneys	Secretion; absorption
Stratified cuboidal	Ducts of sweat glands; lining of pharynx; covering portion of epiglottis	Protection
Glandular	Glands	Secretion
Connective		
Fibrous		
Loose, ordinary (areolar)	Between other tissues and organs	Connection
	Superficial fascia	Connection
Adipose (fat)	Under skin	Protection
	Padding at various points	Insulation Support Reserve food
Reticular	Inner framework of spleen, lymph nodes, bone marrow	Support
	Filtration	

Table 5-3 [illegible]

Dense fibrous		
Regular	Tendons Ligaments Aponeuroses	Flexible but strong connection
Irregular	Deep fascia Dermis Scars Capsule of kidney, etc.	Connection Support
Bone	Skeleton	Support Protection Calcium reservoir
Cartilage		
Hyaline	Part of nasal septum Covering articular surfaces of bones Larynx Rings in trachea and bronchi	Firm but flexible support
Fibrocartilage	Disks between vertebrae Symphysis pubis	
Elastic	External ear Eustachian tube	
Blood	In the blood vessels	Transportation Protection
Muscle		
Skeletal (striated voluntary)	Muscles that attach to bones Extrinsic eyeball muscles Upper third of esophagus	Movement of bones Eye movements First part of swallowing
Smooth (nonstriated, involuntary, or visceral)	In walls of tubular viscera of digestive, respiratory, and genitourinary tracts In walls of blood vessels and large lymphatic vessels In ducts of glands Intrinsic eye muscles (iris and ciliary body) Arrector muscles of hairs	Movement of substances along respective tracts Change diameter of blood vessels, thereby aiding in regulation of blood pressure Movement of substances along ducts Change diameter of pupils and shape of lens Erection of hairs (gooseflesh)
Cardiac (striated involuntary)	Wall of heart	Contraction of heart
Nervous		
	Brain Spinal cord Nerves	Excitability Conduction