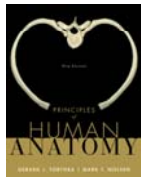


Chapter 3

Tissues



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Introduction

- **Tissue** - is a group of similar cells that usually have a common embryological origin and function together to carry out specialized activities
- **Histology** - is the science that deals with the study of tissues
- **Pathologist** - is a physician who specializes in laboratory studies of cells and tissues to help other physicians make accurate diagnoses.

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Four Major Families of Tissues

- **Epithelial tissue** covers body surfaces, lines hollow organs, body cavities, and ducts; it also forms glands
- **Connective tissue** protects and supports the body and its organs; binds organs together; stores energy reserves as fat; provides immunity
- **Muscular tissue** generates physical force for movement and thereby generates body heat.
- **Nervous tissue** detects changes in a variety of conditions and responds by initiating and transmitting nerve impulses (signals) that help control and coordinate body activities.

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Cell Junctions

- Cell junctions are points of contact between neighboring plasma membranes.
- There are five major types of cell junctions:
 1. Tight junctions
 2. Adherens junctions
 3. Desmosomes
 4. Hemidesmosomes
 5. Gap junctions (Fig. 3.1)

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Cell Junctions

- **Tight junctions** - form tight seals between cells such as the epithelial cells that comprise the inner lining of the stomach, intestines, and urinary bladder; they prevent the passage of substances between cells
- **Adherens junctions** - strongly fasten cells to each other; they help epithelial surfaces resist separation

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Cell Junctions

- **Desmosomes** - strongly fasten cells to each other; they prevent epidermal cells from separating under tension and cardiac muscle cells from pulling apart during contraction
- **Hemidesmosomes** - strongly anchor cells to an underlying basement membrane
- **Gap junctions** - formed by minute, fluid-filled tunnels that permit passage of electrical signals or chemicals (i.e., ions and small molecules) from one cell to a neighboring cell, located in some parts of the nervous system, in heart muscle, and in the gastrointestinal tract

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Cell Junctions (Fig. 3.1)

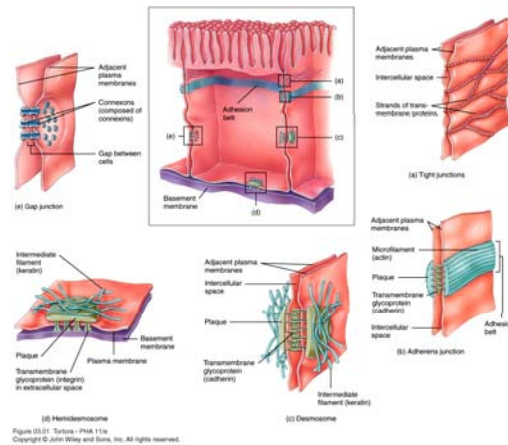


Figure 33.11 Tortora: Principles of Anatomy and Physiology, 11e
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Epithelial Tissue or Epithelium

- **General features:**
- cells arranged in continuous sheets in either single or multiple layers usually closely packed cells with little extracellular material between neighboring cells
- cells have **lateral surfaces**, **apical (free) surface** and **basal surface**; the latter is connected to underlying connective tissue via a thin extracellular **basement membrane**

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Epithelium

- numerous cell junctions that securely attach neighboring cells
- avascular tissue that exchanges materials with adjacent connective tissue via diffusion
- high capacity for cell division in order to replace cells lost due to wear and tear and injury
- numerous functions including: protection, filtration, secretion, absorption, excretion

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Surfaces of Epithelial Cells; Basement Membrane (Fig. 3.2)

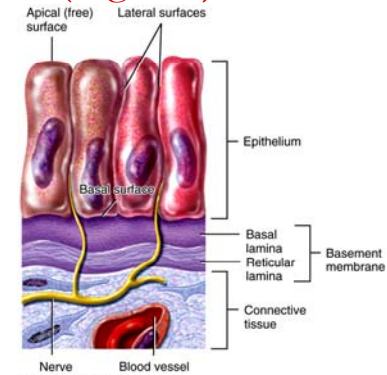


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Comparison of Epithelial and Connective Tissue

- Differences are obvious under a microscope
- Epithelial tissue
 - many cells, tightly packed
 - no blood vessels
- Connective tissue
 - large amount of extracellular material separating widely scattered cells
 - significant network of blood vessels

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Two Major Types of Epithelium

- Covering and lining epithelium
- Glandular epithelium

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Covering and lining epithelium

- Arrangement of cells into layers reflects its location and function, arrangements include:
 - **Simple (unilaminar) epithelium** (single layer of cells)
 - **Pseudostratified epithelium** (single layer that appears stratified)
 - **Stratified (multilaminar) epithelium** (two or more layers of cells) (Fig. 3.3)

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Covering and lining epithelium

Cells may be categorized by cell shape:

- **Squamous** cells are flattened
- **Cuboidal** cells are usually cube-shaped or hexagons
- **Columnar** cells are tall and cylindrical
- **Transitional** cells are able to undergo changes in shape caused by distension

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Cell Shapes and Arrangement of Layers (Fig. 3.3)

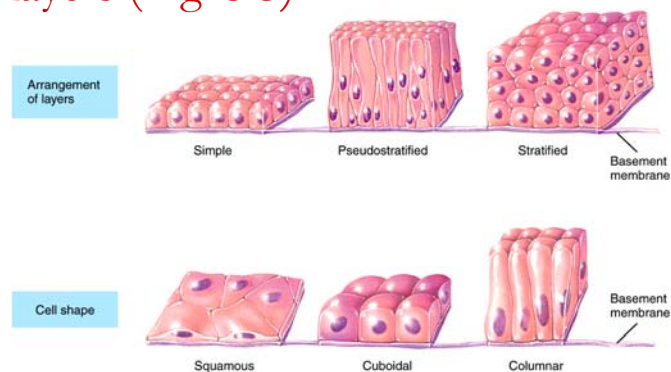


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Types of Epithelial Tissues

Simple Epithelium

- **Simple Squamous Epithelium** located in areas subject to little wear and tear, and adapted for diffusion (e.g., lung alveoli) and filtration (e.g., blood filtration in kidneys)
- **Simple cuboidal epithelium** adapted for secretion and absorption (e.g., lines kidney tubules and smaller ducts of many glands)

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Simple Epithelium (continued)

- **Simple columnar epithelium** which in some areas (e.g., upper respiratory passageways) has cilia (to move materials past the cells) while in other areas (e.g., small intestine) may have microvilli (to increase efficiency of absorption)
- **Pseudostratified columnar epithelium** which functions in secretion or movement of materials by ciliary action (e.g., upper respiratory passageways)

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Stratified Epithelium

- **Stratified squamous epithelium** provides protection in areas subject to wear and tear (e.g., outer layer of skin, lining of mouth), first line of defense against microbes, keratinized and nonkeratinized forms
- **Stratified cuboidal epithelium** (rare type) which provides protection (e.g., ducts of adult sweat glands)

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Stratified Epithelium (continued)

- **Stratified columnar epithelium** (rare type) which functions in protection and secretion (e.g., large ducts of some glands)
- **Transitional epithelium** contains cells that may undergo changes in shape and therefore is located in areas subject to stretching (e.g., urinary bladder)

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Glandular Epithelium (Table 3.2)

- Specialized epithelial cells organized to form **glands** that **secrete** substances into ducts, onto a surface, or into the blood
- **Endocrine glands** are ductless (e.g., thyroid gland, adrenal glands) and secrete **hormones** which diffuse through the interstitial fluid into the blood
- **Exocrine glands** (e.g., sweat glands, salivary glands) secrete substances (e.g., sweat, saliva) into **ducts**

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Exocrine Glands

- Are structurally classified into **unicellular** and **multicellular glands** (including **simple** or **compound** as well as **tubular**, **acinar** and **tubuloacinar** glands) (Fig. 3.4)
- Are functionally classified into **merocrine** (e.g., salivary glands), **apocrine** (e.g., mammary glands), and **holocrine** (e.g., sebaceous glands) [Fig. 3.5]

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Glands - Classification: Simple and Compound

- Simple tubular
- Simple branched tubular
- Simple coiled tubular
- Simple acinar
- Simple branched acinar
- Compound tubular
- Compound acinar
- Compound tubuloacinar (Fig. 3.4)

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Multicellular Exocrine Glands (Fig. 3.4)

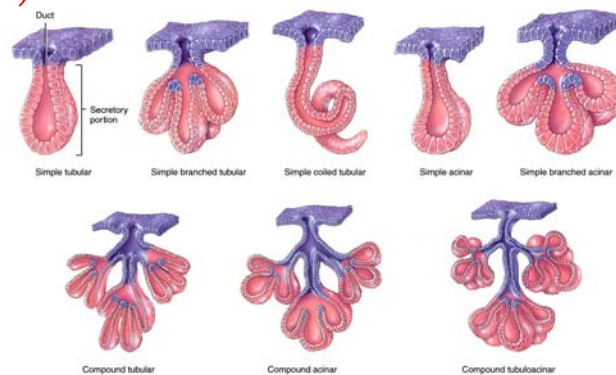


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Functional Classification of Multicellular Exocrine Glands (Fig. 3.5)

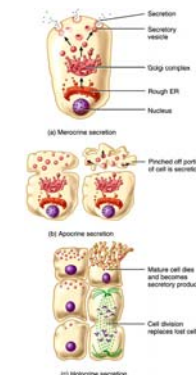


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Connective Tissue

- Connective tissue is one of the most abundant and widely distributed tissues in the body
- Its **functions** include:
 - binds together, supports and strengthens other tissues
 - protects and insulates internal organs
 - compartmentalizes certain structures (e.g., skeletal muscles)
 - **blood** is a connective tissue that transports substances
 - adipose (fat) tissue stores energy reserves
 - is the main source of immune responses.

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General Features of Connective Tissue

- composed of cells separated by an **extracellular matrix** that consists of ground substance and fibers; matrix has variable qualities (e.g., fluid, gelatinous, calcified); fibers are secreted by the connective tissue cells
- not usually located on free surfaces
- has a rich blood supply (except in cartilage and tendons)
- has a nerve supply (except in cartilage)

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Characteristics of Connective Tissue Cells

- derived from mesenchyme
- immature cells have names that end with -blast (e.g., osteoblast); they retain the capacity for cell division and secrete the matrix
- mature cells have names that end with -cyte (e.g., osteocyte); they usually have a reduced capacity for cell division and matrix secretion; their major role is maintenance of the matrix
- some notable examples of cells include fibroblasts, macrophages, plasma cells, mast cells, adipocytes, and leukocytes (Fig. 3.6)

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Cells and Fibers in Connective Tissue (Fig. 3.6)

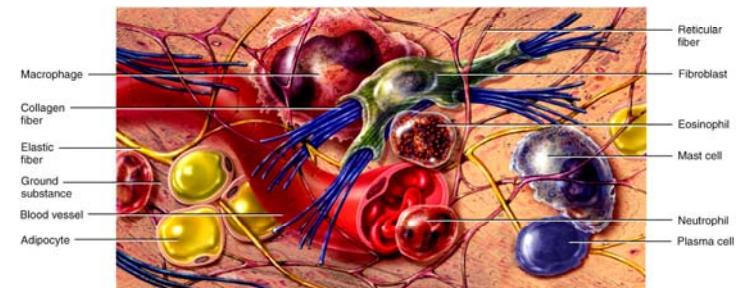


Figure 03.06 Tortora - PHA 11/e
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Connective Tissue Matrix

- Consists of **ground substance (interfibrillar extracellular matrix)** that may be fluid, semifluid, gelatinous, or calcified and is composed of numerous polysaccharides (i.e., glycosaminoglycans or GAGs) and proteins (e.g., proteoglycans)
- GAGs trap water
- Proteoglycans form the support structure

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Extracellular Matrix - Fibers

- Protein **fibers (fibrillar extracellular matrix)** including:
 - **collagen fibers** which provide strength and flexibility to the tissue (most abundant protein in the body)
 - **elastic fibers** which provide strength and elasticity
 - **reticular fibers** which provide support and strength

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Classification of Connective Tissue

- **Embryonic connective tissue** (see Table 3.3) includes:
 - **Mesenchyme** gives rise to all other connective tissues
 - **Mucous connective tissue (Wharton's jelly)** is found primarily in the umbilical cord of the fetus

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Mature Connective Tissue - Loose

1. **Areolar connective tissue** - has several types of cells: fibroblasts, macrophages, etc.- has all three types of fibers- ground substance is semifluid- located in subcutaneous layer of skin, blood vessels, etc.- provides strength, elasticity, and support
2. **Adipose tissue** - contains **adipocytes** that store triglycerides- located in subcutaneous layer, around organs, etc.- white adipose tissue insulates, stores energy reserves, supports and protects various organs; brown adipose tissue generates heat in the newborn

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Mature Connective Tissue - Loose (continued)

- 3. **Reticular connective tissue** - contains reticular fibers and reticular cells- binds together cells of smooth muscle tissue, forms stroma (framework) of organs, etc.

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Mature Connective Tissue - Dense

- **Dense regular connective tissue**- contains rows of fibroblasts located between numerous parallel (i.e., regularly arranged) bundles of collagen fibers- forms tendons and most ligaments- provides strong attachment between various structures
- **Dense irregular connective tissue**- contains fibroblasts scattered among randomly oriented (i.e., irregularly arranged) collagen fibers- located in dermis, periosteum, heart valves, etc.- provides strength
- **Elastic connective tissue**- contains fibroblasts scattered among elastic fibers- located in walls of elastic arteries, lung tissue, etc.- provides elasticity and strength (Table 3.4)

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Cartilage

- **Cartilage** contains **chondrocytes** (cells of mature cartilage) embedded in the **lacunae** (spaces) of a gelatinous matrix that includes collagen fibers and elastic fibers; it is avascular (therefore heals slowly) and lacks nerves; it is usually covered by a **perichondrium**

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Hyaline Cartilage

- Fine collagen fibers that are not visible with ordinary staining techniques used in light microscopy
- Most abundant (but weakest) type of cartilage.
- Located on ends of long bones, nose, trachea, etc.
- Provides flexibility and support.
- At joints, it reduces friction and absorbs shocks.

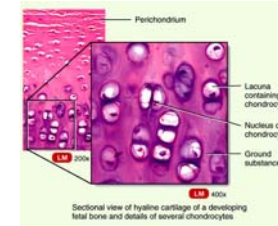


Table 33.04g Tortora - PMA 11/e
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Fibrocartilage

- Contains visible bundles of collagen fibers, making it the strongest type of cartilage- it lacks a perichondrium.
- Located in intervertebral discs, knee menisci, etc.
- Provides strength and rigidity as well as flexibility and support

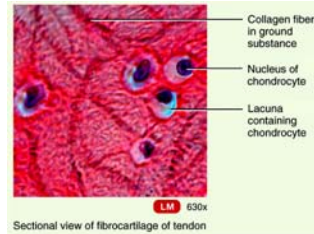


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Elastic cartilage

- contains network of elastic fibers.
- located in epiglottis, external ear, etc.
- maintains shape and provides strength and elasticity.

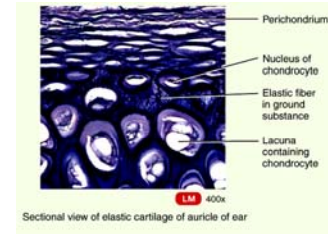


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Bone (Osseous) Tissue

Contains **osteocytes** (mature bone cells) embedded in **lacunae** (with **canaliculi**) of a rigid, calcified matrix that includes collagen fibers; it is classified as:

- **Compact (dense) bone** composed of **osteons (haversian systems)** in which there are concentric rings of matrix called **lamellae**; each osteon contains a **central (haversian) canal**
- **Spongy (cancellous) bone** consisting of **trabeculae**; spaces between the trabeculae contain **red bone marrow**. Bone supports, protects, helps generate movement, stores minerals, and houses red marrow and yellow marrow.

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Liquid Connective Tissue - Blood and Lymph

- **Blood tissue** consists of a liquid matrix called **plasma** in which the following **formed elements** are suspended:
- **Erythrocytes** (red blood cells) transport the gases oxygen and carbon dioxide
- **Leukocytes** (white blood cells) are involved in phagocytosis, immunity, and allergic reactions
- **Platelets** play a role in blood clotting
- **Lymph** is interstitial fluid that flows in the lymphatic vessels

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Membranes

- An **epithelial membrane** consists of an epithelial layer and an underlying connective tissue layer
- The principal epithelial membranes are:
 - **Mucous membranes (mucosa)**
 - **Serous membranes (serosa)**
 - **Cutaneous membrane (skin)**

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Membranes

- **Mucous membrane (mucosa)** lines a cavity that opens to the exterior (e.g., gastrointestinal tract, respiratory tract, etc.); it forms a barrier against entry of microbes, secretes mucus to prevent dehydration and trap pathogens, etc.; the connective tissue layer is called **lamina propria**
- **Serous membrane (serosa)** lines (**parietal layer**) a body cavity that does not open to the exterior (e.g., thoracic cavity, abdominal cavity), and it covers (**visceral layer**) organs inside these cavities (e.g., lungs, stomach); the epithelial layer secretes a lubricating **serous fluid** that reduces friction between the organs and the walls of the cavities; examples include the **pericardium, pleura and peritoneum**

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Synovial Membranes

- **Synovial membranes** (which lack an epithelial layer) line joint cavities, bursae, and tendon sheaths; **synoviocytes** secrete components of a lubricating **synovial fluid** that reduces friction during movements.

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Muscular Tissue

- Muscular tissue consists of cells, usually called **muscle fibers (myocytes)**, that are specialized to **contract** and therefore provide motion, maintain posture, and generate heat
- There are three major types (see [Table 3.5](#)):
 - **Skeletal muscle tissue** is usually attached to bones and consists of long, cylindrical cells that are **striated** and **multinucleate**; it is under **voluntary** control
 - **Cardiac muscle tissue** forms most of the wall of the heart and consists of **striated**, branching cells connected by **intercalated discs**; it is under **involuntary** control

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Muscular Tissue

- **Smooth muscle tissue** is located primarily in the walls of hollow internal organs (e.g., stomach, blood vessels, etc.) and consists of **non-striated** spindle-shaped cells; single, centrally located nucleus; it is usually under involuntary control.

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Nervous Tissue

- Nervous tissue consists of two major kinds of cells (see Table 3.6):
- **Neurons** detect stimuli, convert stimuli into **action potentials** (nerve impulses), and conduct these messages to other neurons, muscle fibers or glands; neurons consist of:
 - **Cell body** which contains the nucleus and most other organelles
 - branched processes called **dendrites**
 - process called **axon** which conducts nerve impulses away from the cell body
- **Neuroglia** provide protection and support to the neurons.

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Aging and Tissues

- Tissues heal faster and leave less obvious scars in the young than in the aged
- The extracellular components of tissues, such as collagen and elastic fibers, change with age

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