ERIN C. AMERMAN
FLORIDA STATE COLLEGE AT JACKSONVILLE

Lecture Presentation by Suzanne Pundt
University of Texas at Tyler

MODULE 4.1 INTRODUCTION TO TISSUES

HISTOLOGY

Histology – study of normal structures of **tissues** (a group of *structurally* and *functionally related* cells and their external environment that together perform common functions); all tissues share two *basic components*:

- Consist of discrete population of cells that are *related* in *structure* and *function*
- Have a surrounding material called **extracellular matrix** (**ECM**)

TYPES OF TISSUES

Four **primary tissue types** are defined by *kind* and *number* of cells, *amount* and *composition* of ECM, and their specific *functions*:

- **Epithelial tissues** (epithelia) – tightly packed sheets of cells with no visible ECM; *cover* and *line* all body surfaces and cavities; specialized epithelia form **glands** that *manufacture secretions* such as sweat, saliva, or chemical messengers called **hormones**
- **Connective tissues** – connect all other tissues in body to one another; ECM is a *prominent feature* for most connective tissue types with cells *scattered throughout*; bind, support, protect, and allow for transportation of substances

TYPES OF TISSUES

Types of Tissues (continued):

- **Muscle tissues**, capable of *generating force* by contracting; little ECM between cells
- **Nervous tissues** consist of cells capable of *generating*, *sending*, *receiving messages*, and cells that support this activity all within a unique ECM

THE EXTRACELLULAR MATRIX

Extracellular matrix – composed of substances in a liquid, thick gel, or solid that *surround cells* of a tissue; consist of two main components, **ground substance** and **protein fibers** (**Figure 4.1**):

- ECM performs a variety of functions:
  - Provides tissue with strength to resist **tensile** (stretching) and **compressive** forces
  - *Directs* cells to their *proper positions* within a tissue and *holds* those cells *in place*
  - Regulates *development*, *mitotic activity*, and *survival* of cells in a tissue

THE EXTRACELLULAR MATRIX

- **Ground substance** makes up most of ECM and consists of **extracellular fluid** (**ECF** or **interstitial** fluid); components include water, nutrients, ions, and three families of *macromolecules*:
  - **Glycosaminoglycans** (**GAGs**) – examples are **chondroitin sulfate** (small) and **hyaluronic acid** (enormous)
    - Negative charges of certain sugars in a GAG *attract* positively charged ions in ECF
    - Ions create *concentration gradient* within ECF; draws water out of cells and blood vessels by *osmosis*
    - Effectively "traps" water in ECM; helps ECM to *resist compression*; example of **Gradients Core Principle**

THE EXTRACELLULAR MATRIX

- **Ground substance** (continued):
  - **Proteoglycans** are GAGs bound to a *protein core* (structure resembles bottle brush)
    - Thousands of proteoglycans bind to a very long GAG such as **hyaluronic acid**, forming huge **proteoglycan** "**aggregates**"
    - Helps make ECM firmer, more solid, and *resistant to compression*
    - Aggregates form *barrier to diffusion* of substances through ECM; protects underlying tissue from invading microorganisms

THE EXTRACELLULAR MATRIX

- **Ground substance** (continued):
  - **Cell-adhesion molecules** (**CAMs**) – made up of different types of **glycoproteins**
    - Adhere cell to cell and cells to surroundings; hold everything in place within ECM
    - CAMS bind to cell surface proteins as well as protein fibers and proteoglycans; maintain *normal tissue architecture*

THE EXTRACELLULAR MATRIX

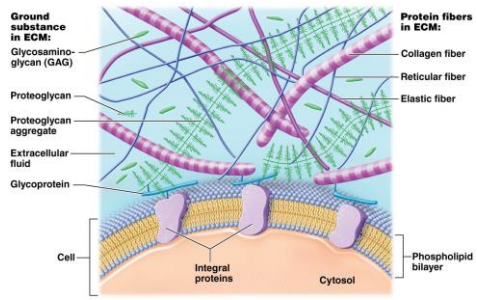


Figure 4.1 Extracellular matrix.

THE EXTRACELLULAR MATRIX

- **Protein fibers** – embedded within ground substance; long molecules composed of *multiple fibrous subunits* with a ropelike structure; enormous *tensile strength*; three protein fiber types are found within ECM:
  - **Collagen fibers**, make up 20–25% of all proteins in body; composed of *multiple repeating subunits* that form a white fibrous protein; resistant to *tension* (pulling and stretching forces) and *pressure*

THE EXTRACELLULAR MATRIX

- **Protein fibers** (continued):
  - **Elastic fibers** – composed of protein **elastin** surrounded by glycoproteins; extensibility allows fiber to *stretch* up to one and a half times resting length *without breaking*; once stretched, fibers return to resting length (called **elasticity**)
  - **Reticular fibers** – thin, short collagen fibers; form a meshwork or scaffold that *supports cells* and *ground substance* of many tissues; form a weblike structure in organs like spleen that help *trap foreign cells*

The Extracellular Matrix

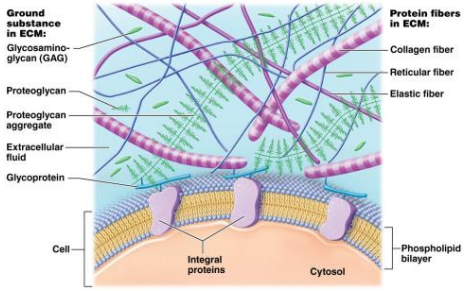


Figure 4.1 Extracellular matrix.

Diseases of Collagen and Elastic Fibers

- Protein fibers of ECM are vital to *structural integrity* of many tissues and organs, as illustrated by:
  - **Ehlers-Danlos syndrome** – *abnormal collagen fibers*; recurrent joint dislocations, hyperextensibility of skin, fragility of blood vessels, easy bruising, plus various effects in intestines, heart, and lungs
  - **Marfan syndrome** – *abnormal elastic fibers*; tall stature with long limbs and fingers; multiple skeletal abnormalities, recurrent joint dislocations, heart valve and lens (eye) abnormalities and dilation of aorta; **aortic dissection** (rupture) is most lethal complication

Cell Junctions

Cell junctions – another way cells *bind to one another* where neighboring cell's plasma membranes are linked by **integral proteins**; three major types of cell junctions are:

- **Tight junctions**
- **Desmosomes**
- **Gap junctions**

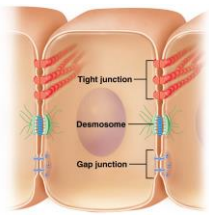


Figure 4.2 Cell junctions.

Cell Junctions

- **Tight junctions**, also known as **occluding junctions**, hold cells closely together such that space between is *impermeable to movement of macromolecules*
  - Integral proteins of adjacent cells' plasma membranes are *locked together* forming a seal around apical perimeter of cell
  - Seal may not be complete allowing for *leakage* in some tissues
  - Example – found between cells in blood vessels; prevent blood from *exiting vessels*

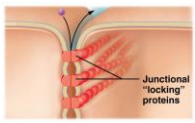


Figure 4.2a Cell junctions.

Cell Junctions

- **Desmosomes** – composed of *linking integral proteins*; allow for materials in extracellular fluid to *pass through space* between cells
  - Increase strength of a tissue by holding cells together so mechanical stress is more *evenly distributed*
  - Integral "linker" proteins are attached to **intermediate filaments** of cytoskeleton for structural reinforcement
  - Found in tissues subjected to a great deal of *mechanical stress* such as epithelia of skin

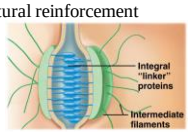


Figure 4.2b Cell junctions.

Cell Junctions

- **Gap junctions** are *small pores* formed by protein channels between adjacent cells that allow small substances to *flow freely* between each cell's cytoplasm
  - Found in between cells that communicate with *electrical signals* such as cardiac muscle cells
  - Gap junctions illustrate the **Cell-Cell Communication Core Principle**

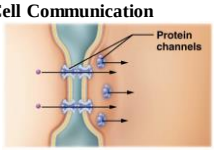


Figure 4.2c Cell junctions.

CELL JUNCTIONS

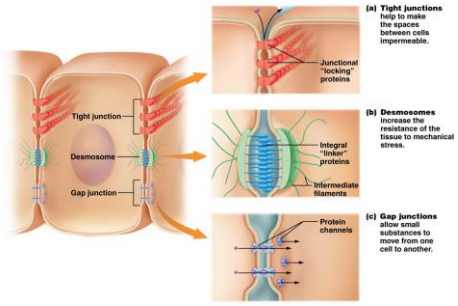


Figure 4.2 Cell junctions.

MODULE 4.2 EPITHELIAL TISSUES

EPITHELIAL TISSUES

Epithelial tissues – found on <u>every</u> internal and external *body surface*; barriers between body and external environment; line organs and fluid-filled cavities; serve following additional functions:

- **Protection** – shield underlying tissues from *mechanical* and *thermal injury*
- **Immune defenses** – form *physical barriers*; prevent invasion by microorganisms; house cells of immune system enhancing protective function

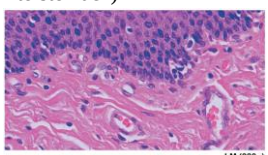
EPITHELIAL TISSUES

Epithelial tissues – additional functions (continued)

- **Secretion** – form glands that produce substances like *hormones* and *oils*; secreted into blood or through ducts respectively
- **Transport into other tissues** – *selectively permeable membranes*; certain substances are able to cross these barriers by passive or active transport and enter other tissues
- **Sensation** – most associated with a rich nerve supply; detects *changes in internal and external environments*; **taste buds** are examples of specialized sensory epithelial cells

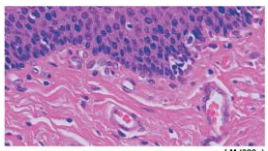
CONCEPT BOOST: BUT IT ALL LOOKS PINK!

- Key to identifying tissues is to reduce every tissue to *simplest components*: cells and extracellular regions containing different types of chemicals
- Shown here is a section of **esophagus** (tubular organ; transports food from mouth to stomach)
  - Each structure that contains a *dark purple nucleus* is a cell



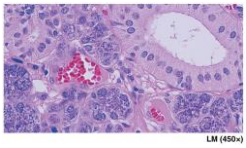
CONCEPT BOOST: BUT IT ALL LOOKS PINK!

- Shown here is a section of **esophagus** (continued):
  - Ground substance generally either looks clear or has just a slight tinge of color; protein fibers generally look like *wavy or straight lines*
  - Occasionally, collagen fibers form bundles that might resemble certain cell types; easiest way to differentiate them is to look for nuclei; if bundles <u>lack</u> nuclei, then they are likely to be collagen fibers



Concept Boost: But It All Looks Pink!

- Next section is **sublingual gland** (**salivary gland** that produces **saliva**) under tongue



- Contains clusters of small, light red, round discs that lack nuclei
- You may not immediately recognize these discs as cells because they lack nuclei, but they are in fact cells called **red blood cells** or **erythrocytes**; located in blood vessels; will be visible in many different tissue sections

Components and Classification of Epithelia

- Epithelial tissues consist of *tightly packed cells* linked together by **tight junctions** and **desmosomes**
- Structural arrangement make sheets of cells fairly *impermeable* and *resistant* to *physical stresses* and *mechanical injury*

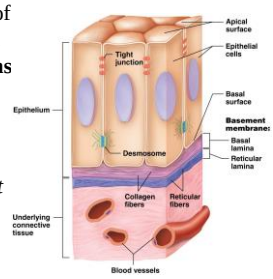


Figure 4.3 Structure of epithelial tissue.

Components and Classification of Epithelia

- Epithelial tissues are **avascular** (lack blood vessels and must obtain oxygen and nutrients by diffusion from deeper tissues); limits their *thickness*
- ECM is found beneath cells in a thin **basement membrane**; has two components:
  - **Basal lamina** – ECM synthesized by *epithelial cells*; consists of *collagen fibers* and ground substance
  - **Reticular lamina** – synthesized by *underlying connective tissue*; consists of *reticular fibers* and ground substance
  - Together these two layers "*glue*" epithelial tissue to underlying connective tissue; *anchor* underlying blood vessels in place; provide a *barrier* between epithelia and underlying tissues

Components and Classification of Epithelia

- Epithelial tissue – classified based on two criteria: number of cell layers and shape of cells in those layers; both have functional significance
  - **Simple epithelia** consist of a single cell layer
  - **Stratified epithelia** consist of more than one cell layer

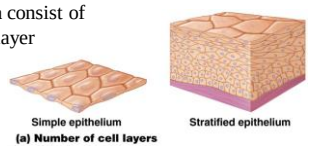


Figure 4.4a Classification of epithelial cells.

Components and Classification of Epithelia

- Epithelial tissue – classification (continued):
  - **Squamous cells** are flattened
  - **Cuboidal cells** are short
  - **Columnar cells** are tall and elongated

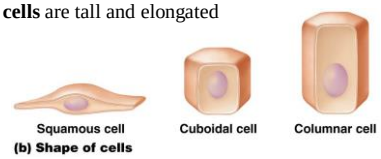


Figure 4.4b Classification of epithelial cells.

Components and Classification of Epithelia

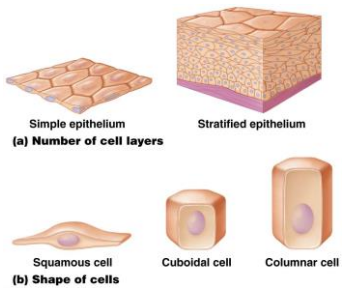


Figure 4.4 Classification of epithelial cells.

COVERING AND LINING EPITHELIA

Covering and lining epithelia – found on inner and outer body surfaces; each cell shape can be found in varying thicknesses in broad, flat sheets; often called **membranes** when the **basement membrane** is included (**Figures 4.5**, **4.6**, **4.7**, **4.8**):

- **Simple epithelia** – one cell-layer thick, adapted for *transportation of substances* between different tissues
  - Some have **microvilli** for increased **surface area**; some have **cilia** for *moving substances* through hollow organs; good example of **Structure-Function Core Principle**

COVERING AND LINING EPITHELIA

- Four types of simple epithelia:
  - **Simple squamous epithelium** – *very thin single layer* of cells with a "fried egg" appearance; adapted for *rapid diffusion of substances* like oxygen, carbon dioxide, fluids, and ions; found in air sacs of lung, specific segments of kidney tubules, and lining blood vessels

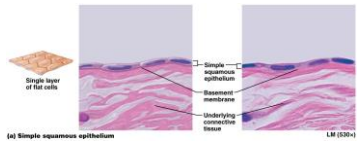


Figure 4.5a Structure of simple epithelia.

COVERING AND LINING EPITHELIA

- Four types of simple epithelia (continued):
  - **Simple cuboidal epithelium** – single layer of *cube-shaped cells* with large central nucleus; thin enough for rapid substance diffusion; found in segments of renal tubules, respiratory passages, ducts of many glands, and thyroid gland

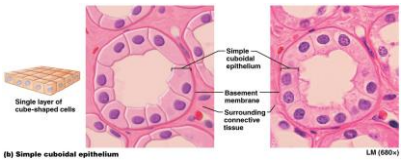


Figure 4.5b Structure of simple epithelia.

COVERING AND LINING EPITHELIA

- Four types of simple epithelia (continued):
  - **Simple columnar epithelium** – single layer of *rectangular-shaped cells* with nuclei located in *basal portion* of cell; often has **microvilli** on apical plasma membrane (drastically *increases surface area* for absorption of substances) or **cilia** (propel substances through hollow organs); cells with microvilli are found in small intestine and ciliated cells are found in uterine tubes and segments of respiratory tract

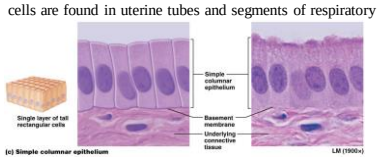


Figure 4.5c Structure of simple epithelia.

COVERING AND LINING EPITHELIA

- Four types of simple epithelia (continued):
  - **Pseudostratified columnar epithelium** *appears* to be *layered* because nuclei are found at *various heights*, but only one cell-layer thick with basal plasma membranes firmly in contact with basement membrane; found in segments of respiratory tract and nasal cavity; ciliated

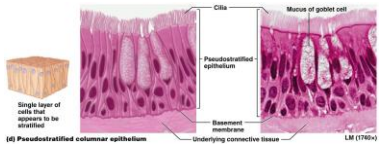


Figure 4.5d Structure of simple epithelia.

COVERING AND LINING EPITHELIA

- **Transport across simple epithelia** occurs via one of two routes (**Figure 4.6**):
  - **Paracellular transportation** – where substances leak between cells in an epithelial membrane; limited due to tight junctions that make spaces between cells nearly impermeable
  - **Transcellular transportation** – where a substance enters a cell by crossing plasma membrane, diffusing across cytosol, and exiting cell through the plasma membrane at opposite side

COVERING AND LINING EPITHELIA

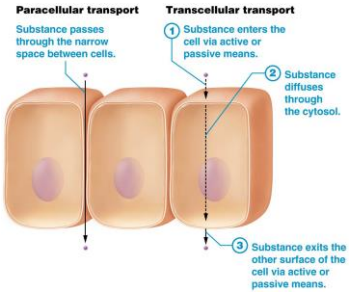


Figure 4.6 Transport across simple epithelia.

COVERING AND LINING EPITHELIA

- **Stratified epithelium** – more than one layer of cells; best suited as *protective barriers* in locations subjected to *high degrees of mechanical stress*; types include:
  - **Keratinized stratified squamous epithelium** – apical cellular layers are *dead*; lack nuclei; filled with protein **keratin**; makes tissue tough and resistant to friction; well adapted for *outer layers of skin*

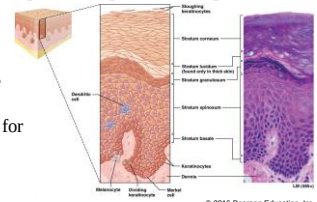


Figure 5.3 Structure of the epidermis.

COVERING AND LINING EPITHELIA

- **Stratified epithelium** (continued):
  - **Nonkeratinized stratified squamous epithelium** – apical cellular layers retain nuclei; still *alive*; found in regions subjected to mechanical stress where surface must *remain moist*; mouth, throat, esophagus, anus, and vagina

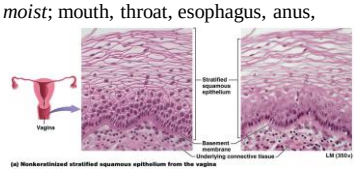


Figure 4.7a Structure of stratified epithelia.

COVERING AND LINING EPITHELIA

- **Stratified cuboidal epithelium**, *rare* in humans, consists of two cell layers and lines ducts of sweat glands

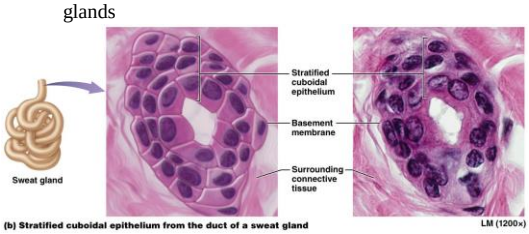


Figure 4.7b Structure of stratified epithelia.

COVERING AND LINING EPITHELIA

- **Stratified columnar epithelium** – also *rare* in humans; consists of only a few layers; *apical cell layer is columnar* and *basal cell layer is cuboidal*; found in male urethra, cornea of eye, and in ducts of certain glands like salivary glands

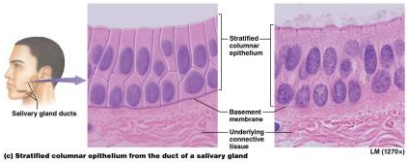


Figure 4.7c Structure of stratified epithelia.

COVERING AND LINING EPITHELIA

- **Transitional epithelium** – only found in urinary system; lines interior of kidney, ureters, urinary bladder, and urethra; *basal cell layers are cuboidal* while *apical cell layers are dome-shaped* when tissue is relaxed; ability of apical cells to flatten contributes to ability of urinary tissues to *stretch*

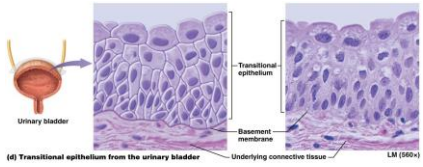


Figure 4.7d Structure of stratified epithelia.

Covering and Lining Epithelia

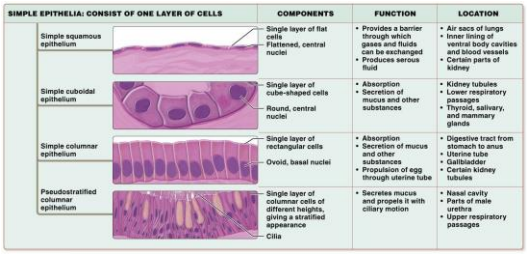


Figure 4.8 Summary of epithelial tissues.

Covering and Lining Epithelia

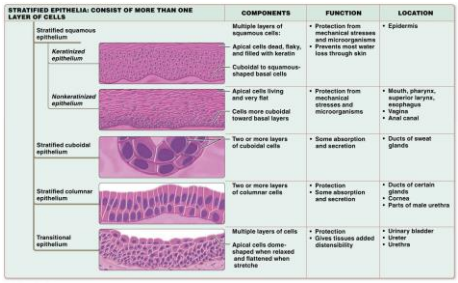


Figure 4.8 Summary of epithelial tissues.

Glandular Epithelia

- **Gland** – structure of epithelial origin that *synthesizes* and *secretes* a product from designated secretory cells
  - Arise from epithelial tissue that *migrated into deeper connective tissue* instead of remaining at surface
  - Can be classified either by their *shape* or by how they *release products*
  - Products are released by two mechanisms:
    - **Endocrine**
    - **Exocrine**

Glandular Epithelia

- **Endocrine glands** secrete their products, usually hormones, *directly into the bloodstream* without the use of ducts:
  - Allows products to have widespread systemic effects on *distant cells* in different areas of body
  - Example of **Cell-Cell Communication Core Principle**

Glandular Epithelia

- **Exocrine glands** release products onto *apical surfaces* of epithelium located on *external surface* of body or lining a hollow organ that *opens to outside* of body:
  - Products, secreted from gland through an epithelial-lined duct, have <u>only</u> *local effects* on cells in general vicinity
  - Glands vary in complexity from single cells to large multicellular glands with branching ducts and many secretory units

Glandular Epithelia

Goblet cells – most common *unicellular exocrine gland*; found in digestive and respiratory tracts; secrete **mucus**, a thick sticky liquid that protects underlying epithelium

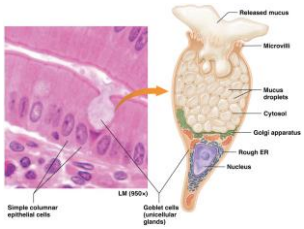


Figure 4.9 Unicellular exocrine glands.

GLANDULAR EPITHELIA

- Most **exocrine glands** are *multicellular glands* made up of clusters of secretory cells arranged in different ways
- Multicellular glands are classified according to *structure of their ducts* and *shape of clusters of secretory cells* (**Figure 4.10**)
  - **Duct structure** – **simple glands**—ducts don't *branch*; **compound glands**—*branched ducts*
  - Clusters of secretory cells are arranged in three possible configurations: **tubular** (long and straight or coiled), **acinar** (spherical), or **tubuloacinar** (with both tubular and acinar sections)

GLANDULAR EPITHELIA

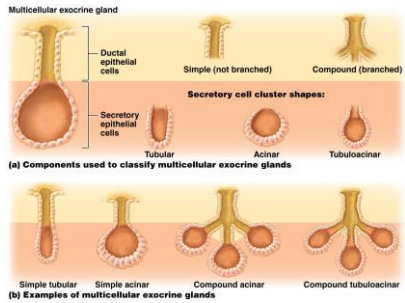


Figure 4.10 Multicellular exocrine glands.

GLANDULAR EPITHELIA

- Exocrine glands have two methods for *secreting products*:
  - **Merocrine secretion**, used by majority of exocrine glands in body including salivary and sweat glands; secretory cells package products in secretory vesicles for release by exocytosis into ducts

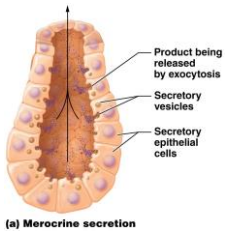


Figure 4.11a Modes of secretion in exocrine glands.

GLANDULAR EPITHELIA

- Exocrine gland methods for secreting products (continued):
  - **Holocrine secretion** – used by sebaceous gland in skin to secrete sebum; secretory cells accumulate product in cytosol; only release product when *cell ruptures and dies*

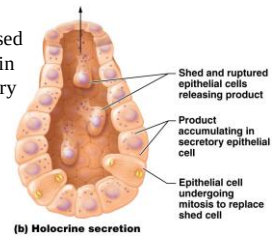


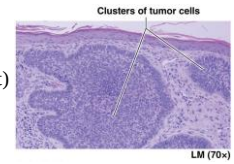
Figure 4.11b Modes of secretion in exocrine glands.

CARCINOGENS AND EPITHELIAL TISSUES

- Epithelia *cover all body surfaces*; therefore more *subject to injury* than most other tissues
- **Carcinogens** – agents that *induce DNA changes* (injury); can lead to **cancer**
- **Carcinoma** – term for epithelial cancer; common examples include:
  - Lung Adenocarcinoma
  - Ductal and Papillary Carcinoma – cancer of breast

CARCINOGENS AND EPITHELIAL TISSUES

- **Carcinoma** – term for epithelial cancer; common examples include (continued):
  - Basal Cell Carcinoma – cancer of skin (shown at right)



- Basement membrane provides barrier to *prevent/slow spread of carcinomas*; cancers that have not invaded other tissues are termed "**pre-malignant**"; cancer cells often produce enzymes that *degrade basement membrane*, facilitating spread

MODULE 4.3 CONNECTIVE TISSUES

CONNECTIVE TISSUE

Connective tissues are divided into two basic groups that differ in their *cell types* and *ECM components*:

- Connective tissue proper
- Specialized connective tissue

CONNECTIVE TISSUE

Connective tissue functions:

- **Connecting and binding** – anchor tissue layers in organs and link organs together
- **Support** – bone and cartilage support weight of the body
- **Protection** – bone tissue protects certain internal organs and cartilage and fat provide shock absorption; components of immune system are found throughout connective tissues

CONNECTIVE TISSUE

Connective tissue functions (continued):

- **Transport** – blood is a fluid connective tissue that is main transport medium in body
- Connective tissue consists of cells and ECM, like all tissues
  - Cells are surrounded by protein fibers and embedded in ground substance
  - ECM is a *characteristic feature*; plays an extensive role in the function of connective tissue type

CONNECTIVE TISSUE PROPER

Connective tissue proper

- Also known as **general connective tissue**
- Widely distributed in body
- Connect tissues and organs to one another
- Components of internal architecture of some organs

CONNECTIVE TISSUE PROPER

- **Cells of connective tissue proper – resident cells** permanently inhabit tissue in which they are found; **migrant cells** migrate into different areas of body depending on situation; cells in connective tissue proper include:
  - **Fibroblasts**
  - **Adipocytes**
  - **Mast cells**
  - **Phagocytes**
  - **Other immune system cells**

CONNECTIVE TISSUE PROPER

- **Cells of connective tissue proper** (continued):
  - **Fibroblasts** – most common resident cell
  - Mature cells that have properties of an immature "blast" cell
  - Make protein fibers and ground substance (components of ECM); continually produce collagen proteins

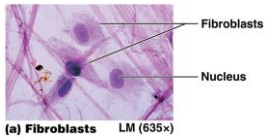


Figure 4.12a Cells of connective tissue proper.

CONNECTIVE TISSUE PROPER

- **Cells of connective tissue proper** (continued):
  - **Adipocytes** (fat cells) – found in many different connective tissues; cytoplasm of each cell is filled with a single large *lipid inclusion*

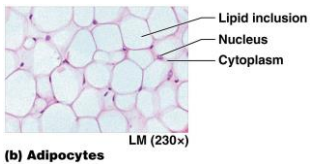


Figure 4.12b Cells of connective tissue proper.

CONNECTIVE TISSUE PROPER

- **Cells of connective tissue proper** (continued):
  - **Mast cells** – largest resident cell
    - Immune system cells filled with cytosolic inclusions (**granules**) of inflammatory mediators such as **histamine**
    - Release mediators (**degranulate**) when stimulated, causing **inflammation** (protective response that *activates immune system*)

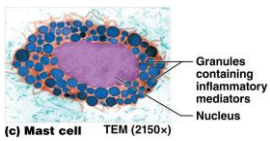


Figure 4.12c Cells of connective tissue proper.

CONNECTIVE TISSUE PROPER

- **Cells of connective tissue proper** (continued):
  - **Phagocytes** – also immune system cells; can ingest foreign substances, microorganisms, and dead or damaged cells by **phagocytosis**; include **macrophages** (either resident or migrant) and **neutrophils** (migrant cells)
  - **Other immune system cells** can migrate in and out of connective tissues depending on body's needs

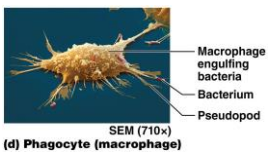


Figure 4.12d Cells of connective tissue proper.

CONNECTIVE TISSUE PROPER

- Four basic **types of connective tissue proper**:
  - Loose connective tissue
  - Dense connective tissue
  - Reticular tissue
  - Adipose tissue

CONNECTIVE TISSUE PROPER

- Four basic **types of connective tissue proper** (continued):
  - **Loose connective tissue** (**areolar** tissue) – mostly ground substance, with all three types of protein fibers, fibroblasts, and occasionally adipocytes, suspended in ground substance (**Figure 4.13**):
    - Found beneath epithelium of skin, in membranes lining body cavities, and within walls of hollow organs
    - Contains and supports blood vessels vital to avascular epithelial tissues; houses immune system cells that protect body from microorganisms

CONNECTIVE TISSUE PROPER

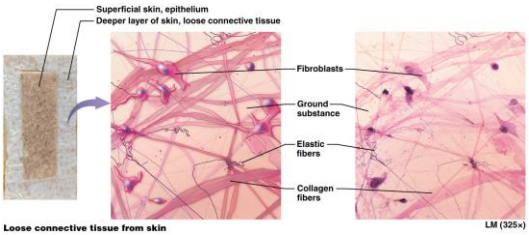


Figure 4.13 Structure of loose connective tissue.

CONNECTIVE TISSUE PROPER

- Four basic **types of connective tissue proper** (continued):
  - **Dense connective tissue** (**fibrous connective tissue**) – mostly protein fibers; grouped into three classes:
    - **Dense irregular connective tissue** – predominantly *disorganized collagen bundles* (**Figure 4.14a**)
      - Strong and resists tension in *all three planes of movement*
      - Found in *high tension areas* like **dermis** (deep to skin) and surrounding organs and joints

CONNECTIVE TISSUE PROPER

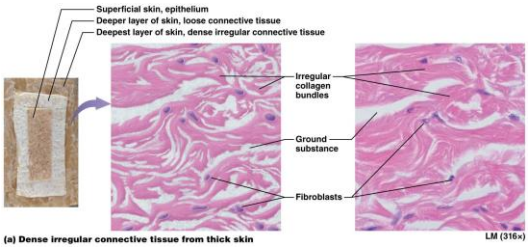


Figure 4.14a Structure of dense connective tissue.

CONNECTIVE TISSUE PROPER

- Four basic **types of connective tissue proper** (continued):
  - **Dense connective tissue** (continued):
    - **Dense regular connective tissue** (**Figure 4.14b**)
      - Predominantly organized into *parallel collagen bundles*; resistant to tension in <u>one</u> *plane*
      - Found in tendons and ligaments that are subject to tension in one plane of movement

CONNECTIVE TISSUE PROPER

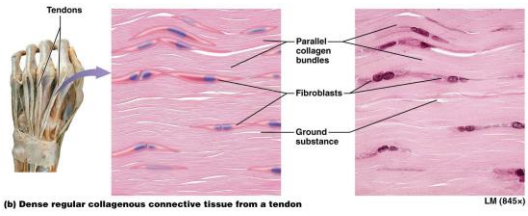


Figure 4.14b Structure of dense connective tissue.

CONNECTIVE TISSUE PROPER

- Four basic **types of connective tissue proper** (continued):
  - **Dense connective tissue** (continued):
    - **Dense regular elastic connective tissue** (**elastic tissue**) (**Figure 4.14c**)
      - Mostly *parallel-oriented elastic fibers* with *randomly oriented collagen fibers*
      - Found in walls of organs that must *stretch* to perform their function, such as large blood vessels and certain ligaments

CONNECTIVE TISSUE PROPER

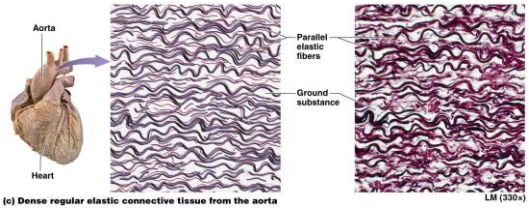


Figure 4.14c Structure of dense connective tissue.

CONNECTIVE TISSUE PROPER

Note: *arrangement of fibers* in dense regular and irregular connective tissues is another example of the **Structure-Function Core Principle**

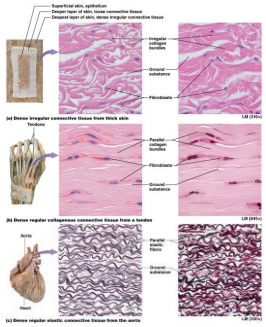


Figure 4.14 Structure of dense connective tissue.

CONNECTIVE TISSUE PROPER

- Four basic **types of connective tissue proper** (continued):
  - **Reticular tissue** – composed mostly of **reticular fibers** produced by fibroblasts (**reticular cells**); form fine networks that can *support small structures* like blood and lymphatic vessels (**Figure 4.15**)
    - Also found in lymph nodes and spleen; form weblike nets that trap old and foreign cells
    - Forms part of basement membrane that supports all epithelia and internal structure of liver and bone marrow

CONNECTIVE TISSUE PROPER

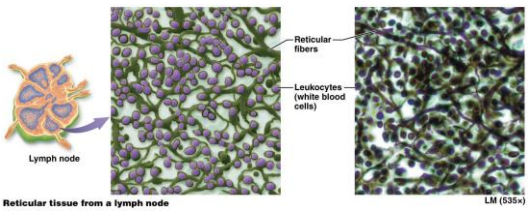


Figure 4.15 Structure of reticular tissue.

CONNECTIVE TISSUE PROPER

- Four basic **types of connective tissue proper** (continued):
  - **Adipose tissue** (fat tissue) – consists of fat-storing **adipocytes** and surrounding fibroblasts and ECM; adipocytes can increase in size to point where fibroblasts and ECM are scarcely visible (**Figure 4.16**); functions include:
    - Fat storage (major energy reserve of body)
    - Insulation (retains warmth)
    - Shock absorption and protection

CONNECTIVE TISSUE PROPER

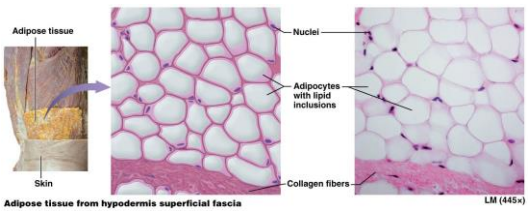


Figure 4.16 Structure of adipose tissue.

Connective Tissue Proper

- Four basic **types of connective tissue proper** (continued):
  - **Adipose tissue** (continued):
    - **White adipose tissue** – predominant fat tissue; appears white; consists of adipocytes with one *large lipid inclusion* in cytosol; found deep to skin as subcutaneous fat, and in abdomen, breasts, hips, buttocks, and thighs; white adipose that surrounds heart and abdominal organs is known as **visceral fat**
    - **Brown adipose tissue** – less common; has a brown appearance due to *numerous mitochondria* in cytoplasm and a *vast blood supply*; contain multiple *lipid inclusions* that are more readily converted to energy by body to produce heat in cold temperatures

Adipose Tissue and Obesity

- **Obesity** – condition of having *excess adipose tissue* in proportion to lean body mass; two forms:
  - **Hypertrophic** – lipid inclusions accumulate excess fatty acids and increase in size up to 4× normal; *number of adipocytes* remains unchanged
  - **Hypercellular** – generally severe; *number of adipocytes* increases; correlates with development of obesity in infancy or early childhood and not adulthood; adult adipocytes *lack ability to divide* to form new cells
- Both forms increase risk for certain health problems; development of related disorders is *complex*; depends on *distribution of adipose tissue* and *genetic factors*

Specialized Connective Tissues

Specialized connective tissues have more specific functions and include the following three types of tissue (**Figures 4.17**, **4.18**, **4.19**):

- **Cartilage** – found in joints between bones, in ear, nose, and segments of respiratory tract
- **Bone tissue** (**osseous tissue**) – supports body; protects vital organs; provides attachments for muscles that allow for movement; stores calcium, and houses bone marrow (produces blood cells and stores fat)
- **Blood** – unique connective tissue with a liquid ECM called **plasma**; consists of mostly water, dissolved solutes, and proteins

Specialized Connective Tissues

Specialized connective tissues (continued):

- **Cartilage** – tough, flexible tissue; absorbs shock and resists tension, compression, and shearing forces; ECM consists of collagen and elastic fibers, glycosaminoglycans, and proteoglycans
  - Populated with two cell types:
    - **Chondroblasts** – immature cells that *divide by mitosis* and *make most of ECM*
    - Eventually surround themselves in small cavities (**lacunae**) in ECM to become mature, largely *inactive* **chondrocytes**

Specialized Connective Tissues

Specialized connective tissues (continued):

- **Cartilage** (continued):
  - Essentially *avascular*, unlike most connective tissues; blood supply is limited to outer sheath (**perichondrium**) of dense irregular collagenous connective tissue
  - Oxygen and nutrients must diffuse from blood vessels in perichondrium through ECM to supply chondroblasts and chondrocytes; limits *thickness* of living cartilage

Specialized Connective Tissues

Specialized connective tissues (continued):

- Cartilage can be further divided into three classes based on *ECM composition* (**Figure 4.17**):
  - **Hyaline cartilage** – most abundant cartilage
    - ECM mostly ground substance made of small bundles of fine collagen; give tissue a glossy bluish-gray appearance
    - Found on ends of bones in joints (**articular cartilage**), linking sternum to ribs, framing sections of respiratory tract, and in nose
    - Most of fetal skeleton is hyaline cartilage; replaced with bone during development

Specialized Connective Tissues

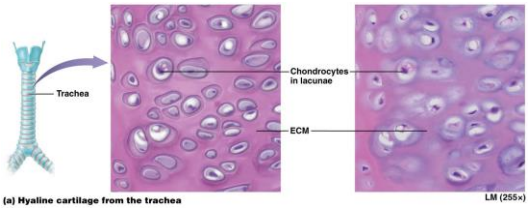


Figure 4.17a Structure of cartilage.

Specialized Connective Tissues

Specialized connective tissues (continued):

- Cartilage can be further divided into three classes based on ECM composition (continued):
  - **Fibrocartilage** – filled with bundles of collagen fibers with little room for ground substance in ECM (**Figure 4.17b**)
    - Fibroblasts reside in tissue in addition to chondroblasts and chondrocytes; fill ECM with collagen and some elastic fibers
    - Tissue has great *tensile strength* with some degree of elasticity
    - Found in *between* bones of fibrous joints; forms **articular discs** that improve fit of bones in joints

Specialized Connective Tissues

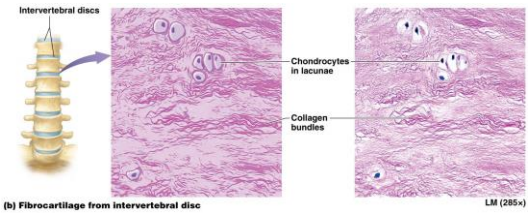


Figure 4.17b Structure of cartilage.

Specialized Connective Tissues

Specialized connective tissues (continued):

- Cartilage can be further divided into three classes based on ECM composition (continued):
  - **Elastic cartilage** – mostly *elastic fibers* in its ECM (**Figure 4.17c**)
    - Allows this tissue to *vibrate*
    - Found in a limited number of structures; **external ear** assists with *detection* of sound in air; **larynx** assists with *production* of sound

Specialized Connective Tissues

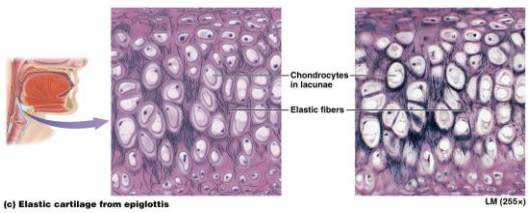


Figure 4.17c Elastic cartilage from epiglottis.

Specialized Connective Tissues

Specialized connective tissues (continued):

- **Bone**
  - Bone ECM is composed of about 35% organic components consisting of collagen fibers and ground substance called **osteoid**; remaining 65% of ECM is *inorganic calcium phosphate crystals* making bone one of hardest substances in body (**Figure 4.18a**)
  - Bone is a *dynamic tissue* capable of *remodeling*; occurs in regions of stress or inactivity; tension increases *osteoblast activity* and bone *deposition*; compression increases *osteoclast activity* and bone *resorption*

Specialized Connective Tissues

Specialized connective tissues (continued):

- **Bone** (continued):
  - **Osteoblasts** (**Figure 4.18b**)
    - "Bone-builders" found on outer surface of bones; closely associated with dense irregular collagenous connective tissue covering called **periosteum**
    - Carry out process of bone *deposition*; synthesize and secrete *organic ECM* and chemicals involved in *trapping calcium* in ECM

Specialized Connective Tissues

Specialized connective tissues (continued):

- **Bone** (continued):
  - **Osteocytes** – osteoblasts that have *surrounded themselves with ECM* in lacunae; mature cells, *mostly inactive* but continue to make and secrete substances important for bone *maintenance*
  - **Osteoclasts** – large, *multinucleated* bone destroyers; carry out process of bone *resorption*; secrete hydrogen ions and enzymes that *break down both inorganic and organic ECM*

Specialized Connective Tissues

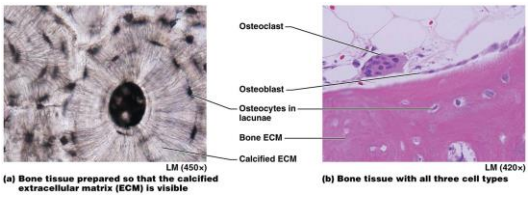


Figure 4.18 Structure of bone.

Specialized Connective Tissues

Specialized connective tissues (continued):

- **Blood** – unique in that ECM is *fluid* (**Figure 4.19**)
  - **Plasma proteins** – <u>not</u> like fibers found in other connective tissues; smaller with a variety of functions including *transport* of substances and *blood clotting*
  - **Erythrocytes** (**red blood cells**) bind to and *transport oxygen* through body
  - **Leukocytes** (**white blood cells**) function in *immunity*
  - **Platelets** – cell fragments; major role in *blood clotting*

Specialized Connective Tissues

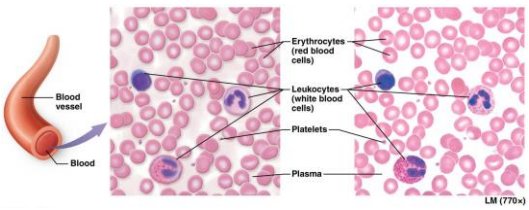


Figure 4.19 Components of blood.

Osteoarthritis and Glucosamine Supplements

- **Osteoarthritis** – caused by age, joint trauma, genetic disorders, and infection
  - Develops as hyaline cartilage lining joints degenerates
  - Leads to destruction of proteoglycan and collagen fibers; may continue until bone is exposed
  - Bones grind painfully together as motion occurs
- Chondroblasts use **glucosamine** in synthesis of proteoglycans; further studies needed to determine if glucosamine supplementation will *slow osteoarthritic degeneration* of joints

CONNECTIVE TISSUES

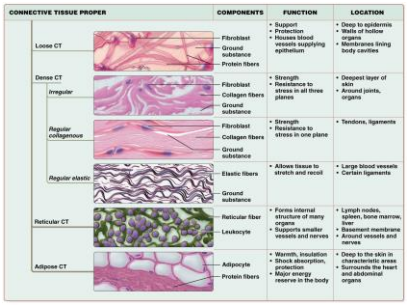


Figure 4.20 Summary of connective tissues.

CONNECTIVE TISSUES

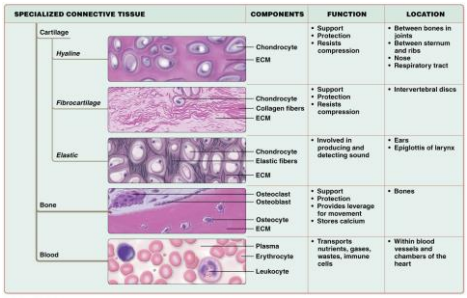


Figure 4.20 Summary of connective tissues.

MODULE 4.4 MUSCLE TISSUES

MUSCLE TISSUES

- **Muscle tissues** are specialized for **contraction**
- Three muscle tissue types share common ability to turn *chemical energy* of ATP into mechanical *energy of movement*
- Walking, breathing, heart beating, and propulsion of substances through hollow organs all result from contractions of different muscle tissues
- Main component of muscle tissue is **muscle cell** or **myocyte**; **excitable** (ability to respond to electrical or chemical stimulation)

COMPONENTS OF MUSCLE TISSUE

- Two forms of muscle cells based on arrangement of **myofilaments** (protein bundles) in cytoplasm:
  - **Striated muscle cells** – myofilaments arranged in *alternating light and dark regions*; appear striped or striated under microscope
  - **Smooth muscle cells** – have myofilaments arranged in *irregular bundles* instead of repeating light and dark regions; so different appearance
- **Endomysium** – small amount of ECM that surrounds muscle tissue; helps to hold muscle cells together in tissue

TYPES OF MUSCLE TISSUE

- There are three *types of muscle tissue* that feature different structural and functional characteristics:
  - Skeletal muscle
  - Cardiac muscle
  - Smooth muscle
- Skeletal and cardiac muscle tissue are *striated* while smooth muscle tissue is <u>not</u> (**Figure 4.21**)

TYPES OF MUSCLE TISSUE

- **Skeletal muscle tissue** – found mostly attached to skeleton where its contraction produces *body movement* (**Figure 4.21a**):
  - Skeletal muscle must be *stimulated by the nervous system* to contract; under **voluntary** or conscious control
  - Most skeletal muscle cells are long, extending nearly length of whole muscle; often called **muscle fibers**
  - Form by *fusion* of embryonic **myoblasts** resulting in cells with more than one nucleus (**multinucleate**); useful for nearly constant synthesis of *enzymes*, *structural proteins*, and *contractile proteins*

COMPONENTS OF MUSCLE TISSUE

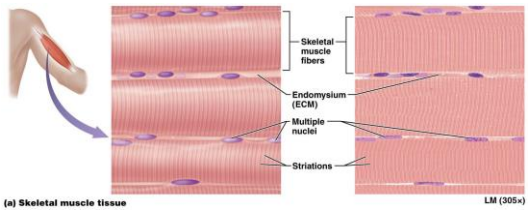


Figure 4.21a Summary of muscle tissues.

TYPES OF MUSCLE TISSUE

- **Cardiac muscle tissue** – found only in heart; composed of **cardiac muscle cells**; although these cells are striated like skeletal muscle cell, many differences can be seen (**Figure 4.21b**):
  - Cardiac muscle tissue is **involuntary**; brain does not have *conscious control* over its contraction
  - Cells are *short*, *branched*, and usually have only *one nucleus* (**uninucleate**)
  - **Intercalated disc** – dark line separating individual cardiac muscle cells; not seen in skeletal muscle; contain **gap junctions** and modified **tight junctions**; allow heart muscle to *contract as a unit*

TYPES OF MUSCLE TISSUE

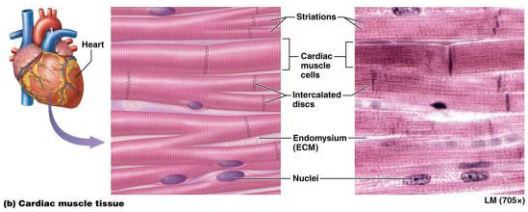


Figure 4.21b Summary of muscle tissues.

TYPES OF MUSCLE TISSUE

- **Smooth muscle tissue** – consists of smooth muscle cells whose contractions are *involuntary* like cardiac muscle cells (**Figure 4.21c**):
  - Found in walls of *nearly every hollow organ*, *blood vessels*, *eyes*, *skin*, and *ducts* of certain glands
  - Flattened cells with one centrally located ovoid nucleus
  - In most smooth muscle tissue, plasma membranes of neighboring cells are *linked together* by **gap junctions**

TYPES OF MUSCLE TISSUE

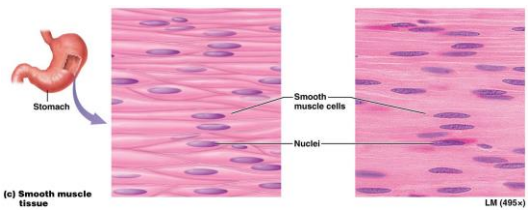


Figure 4.21c Summary of muscle tissues.

MODULE 4.5 NERVOUS TISSUES

NERVOUS TISSUES

- **Nervous tissue** makes up majority of brain, spinal cord, and nerves; composed of two main cell types and their surrounding ECM
  - **Neurons** – capable of sending and receiving messages
  - **Neuroglial cells** – perform various functions that *support* neuron activities
- ECM is unique; made up of ground substance with *unique proteoglycans* not found in other tissues of body; contains *very few protein fibers*

NEURONS

- **Neurons** (like muscle cells) are *excitable cells*; once mature, no longer divide by mitosis; three main components (**Figure 4.22**):
  - **Cell body** or **soma** – *biosynthetic center* of neuron where nucleus and most organelles are found
  - Solitary **axon** extends from *one end of soma*; responsible for moving a **nerve impulse** from soma to a **target cell** (may be another neuron, muscle cell, or gland); axons illustrate **Cell-Cell Communication Core Principle**
  - **Dendrites** – other extensions protruding from soma; typically *short* with multiple branches; *receive impulses* from axons of neighboring neurons; *deliver impulses* to soma

NEURONS

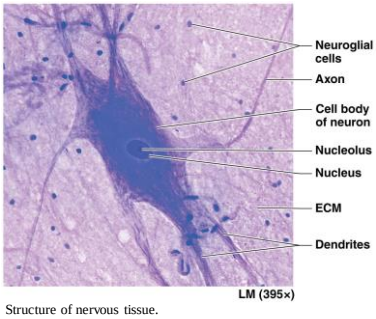


Figure 4.22 Structure of nervous tissue.

NEUROGLIAL CELLS

- **Neuroglial** cells – diverse group of smaller cells; variety of functions ultimately meant to *support activity* of neurons:
  - Functions:
    - Anchoring neurons and blood vessels in place
    - Monitoring composition of extracellular fluid
    - Speeding up rate of nerve impulse transmission
    - Circulating fluid surrounding brain and spinal cord
  - Able to *divide by mitosis* (unlike neurons)

CONCEPT BOOST: BUT IT ALL LOOKS PINK! PART 2

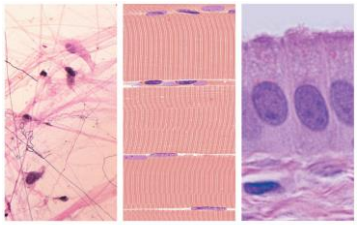
In Examples A, B, and C:

1. **Identify the cells, protein fibers, and ground substance** (review basics from Concept Boost Part 1 as needed)
2. **Notice how the cells are shaped and arranged:**
   - Are the cells packed tightly together, or are they widely spaced?
   - Do they form a continuous sheet, as in epithelial tissue—or do they seem to be surrounded by ECM, as in connective tissue?
   - Are the cells all identical, or are there clearly different types?
   - Do the cells have "arms" extending from a central body?

Concept Boost: But It All Looks Pink! Part 2

3. **Notice how the ECM is arranged:**
   - Is the ECM confined to one specific part of the tissue, or is it spaced evenly between the cells?
   - Does ground substance predominate, or are protein fibers the main elements?
   - What types of protein fibers can you see?
4. **Determine the class of tissue.** Using your analysis in the preceding steps, now you are ready to identify the class of tissue (answers are in text)

Concept Boost: But It All Looks Pink! Part 2



Module 4.6 Putting It All Together: The Big Picture of Tissues in Organs

The Big Picture of Tissues in Organs

Two or more tissues that combine structurally and functionally form an **organ**:

- Simple organ example – *skeletal muscle*:
  - Composed of two main tissues—skeletal muscle and dense irregular collagenous connective
  - Each has distinct functional role; skeletal muscle tissue allows it to contract; surrounding connective tissue binds muscle cells together and supports them so that their activity produces a contraction of *whole organ*

The Big Picture of Tissues in Organs

- More complex organ; consists of many different tissue types – *trachea*
  - Hollow organ; provides passageway through which air passes on its way into/out of lungs
  - **Figure 4.23** (next slide) – illustration of tissues of trachea from *superficial to deep* with list of their main functions
  - Each tissue layer serves an important role in overall function of trachea: *conducting air*

The Big Picture of Tissues in Organs

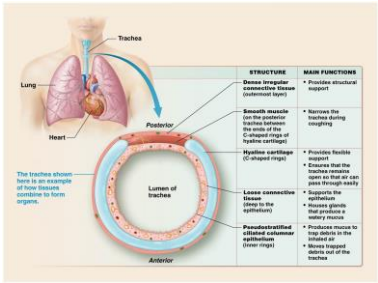


Figure 4.23 The Big Picture of Tissues in Organs.

MODULE 4.7 MEMBRANES

MEMBRANES

Membranes – thin sheets of one or more tissues that *line a body surface or cavity*:

- Most consist of a superficial *epithelial layer* resting on a *connective tissue layer*; sometimes contains smooth muscle
- Functions: anchor organs in place, serve as barriers, function in immunity, and secrete various substances
- **True membranes** – include **serous** and **synovial membranes**; fit above structural and functional definitions
- **Membrane-like structures** – include **mucous** and **cutaneous** membranes; don't fit above structural and functional definitions but perform many of same functions

TRUE MEMBRANES

True membranes do not open to outside of body; two examples:

- **Serous membranes** or **serosae** – line pericardial, peritoneal, and pleural body cavities; structural and functional features (**Figure 4.24a**):
  - Consist of a **mesothelium** (thin layer of simple squamous epithelium) associated basement membrane, and a layer of connective tissue

TRUE MEMBRANES

True membranes do not open to outside of body; two examples (continued):

- **Serous membranes** or **serosae** (continued):
  - Fold over themselves giving appearance of two layers; outer *parietal* layer *lines body wall*; inner *visceral* layer *covers organ* within body cavity
  - Mesothelial cells produce a thin, watery **serous fluid**; fills space between parietal and visceral layers; reduces **friction** created when organs (like heart or lungs) move within respective membranes

TRUE MEMBRANES

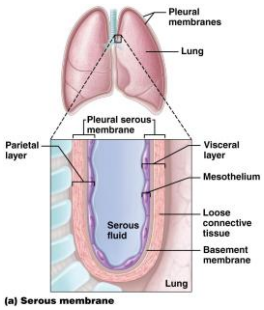


Figure 4.24a True membranes.

TRUE MEMBRANES

True membranes (continued):

- **Synovial membranes** – *line cavities* surrounding freely moveable joints like knee or shoulder; made up of two connective tissue layers without a layer of epithelial cells (**Figure 4.24b**):
  - *Outer layer* – usually composed of a mixture of loose and dense irregular connective tissue
  - *Inner layer* – **synoviocytes** (modified fibroblasts) secrete **synovial fluid**, a watery, slippery fluid; primarily functions to *lubricate* joint

TRUE MEMBRANES

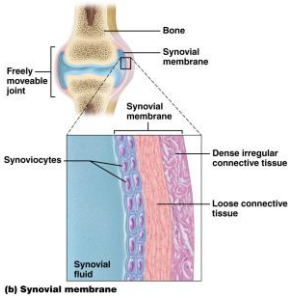


Figure 4.24b True membranes.

MEMBRANE-LIKE STRUCTURES

Cutaneous membranes and **mucous membranes** are **membrane-like structures** (do not fit full description of a true membrane):

- **Mucous Membranes** (**mucosae**) *line all body passages* as components of walls of hollow organs that *open to outside* of body; includes respiratory passages, mouth, nasal cavity, digestive tract, and male and female reproductive tracts (**Figure 4.25a**):
  - Consist of a layer of epithelium and its basement membrane (layer of connective tissue called the **lamina propria**) and occasionally a thin layer of smooth muscle
  - Contain glands with **goblet cells**; produce and secrete **mucus**; serves several functions, primarily protection

MEMBRANE-LIKE STRUCTURES

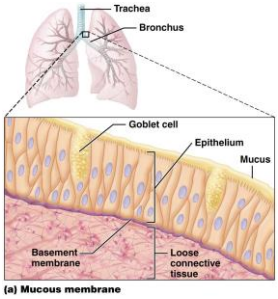


Figure 4.25a Membrane-like structures.

MEMBRANE-LIKE STRUCTURES

- **Cutaneous membrane** – refers to **skin**; largest organ of body (**Figure 4.25b**); consists of:
  - Outer layer of *keratinized stratified squamous epithelium* called **epidermis**; tough, continuous protective surface that protects structures deep to it
  - **Dermis**
    - Layer of *loose connective tissue* is found beneath epidermis plus even deeper layer of *dense irregular connective tissue*
    - Home to many blood vessels; provide a means for *oxygen and nutrients to diffuse* into **avascular** epidermis

MEMBRANE-LIKE STRUCTURES

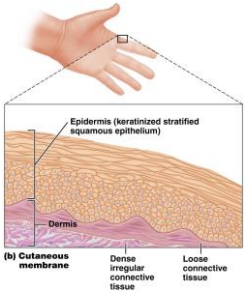


Figure 4.25b Membrane-like structures.

FRICTION RUBS

- *Inflammation* of serous membranes of pleural or pericardial cavities may result from *viral or bacterial infection*
- Serous fluid secreted for lubrication becomes inadequate to reduce friction; layers *rub together* as organs contract and expand
- Resulting *grating sound* is termed a **friction rub**; can be heard with stethoscope
- Cause *chest pain*; worsens with inhalation, body movement, and swallowing
- Usually resolve with treatment of underlying condition

MODULE 4.7 TISSUE REPAIR

TISSUE REPAIR

- **Tissue repair** – process of *wound healing*; dead and damaged cells are removed and replaced with new cells or tissues to fill in gap for maintenance of homeostasis; process differs with different tissues:
  - Some tissues are capable of **regeneration** where dead and damaged cells are replaced with cells of <u>same</u> *type*; when process is finished tissue has returned to a *normal functional level* (**Figure 4.26a**)

TISSUE REPAIR

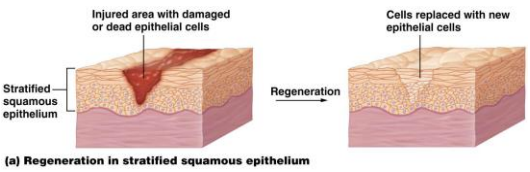


Figure 4.26a Tissue repair by regeneration or fibrosis.

TISSUE REPAIR

- Other tissues are <u>not</u> capable of *full* regeneration; fibroblasts fill in gaps left from injury by a process called **fibrosis** (**Figure 4.26b**):
  - Fibroblasts divide by mitosis and produce *collagen* that fills in gap and tissue *loses* some level of *functional ability*
  - End result of fibrosis is development of **scar tissue** composed of *dense irregular connective tissue*

TISSUE REPAIR

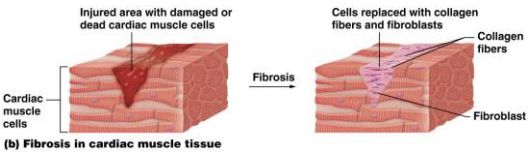


Figure 4.26b Tissue repair by regeneration or fibrosis.

CAPACITY FOR TISSUE REPAIR

Capacity of specific tissue for repair is largely dependent on tissue's resident cells *ability to undergo mitosis*:

- **Epithelial tissues typically undergo regeneration:**
  - Skin and digestive tract lining are subjected to a great deal of stress; must have a mechanism for *replacing dead, damaged or worn out cells*; new cells are derived from **stem cells** (immature cells capable of mitosis)
  - Other epithelial tissues (like liver and blood vessels) – mature cells in vicinity of injuries are capable of replacing dead and damaged cells by dividing

Capacity for Tissue Repair

Capacity of specific tissues for tissue repair (continued):

- **Most connective tissues heal by regeneration**:
  - Connective tissue proper, bone, and blood *regenerate easily* through division of resident immature cells
  - Cartilage is exception as resident cells have a limited capacity for regeneration; this tissue *heals by fibrosis*

Capacity for Tissue Repair

Capacity of specific tissues for tissue repair (continued):

- **Smooth muscle tissue usually regenerates; cardiac and skeletal muscle tissues generally heal by fibrosis**
  - Smooth muscle cells retain ability to undergo mitosis; readily *heal by regeneration*
  - Mature skeletal muscle fibers and cardiac muscle cells have lost ability to divide by mitosis; cannot regenerate themselves
  - **Satellite cells** in skeletal muscle tissue can divide and mature into skeletal muscle cells providing a *limited degree of regeneration*
  - No satellite cells associated with cardiac muscle tissue; injuries are *healed by fibrosis*

Capacity for Tissue Repair

Capacity of specific tissues for tissue repair (continued):

- **Nervous tissue generally undergoes fibrosis.** Neurons have lost their ability to divide by mitosis so are incapable of regeneration:
  - Neuroglial cells retain the ability to divide by mitosis and replace dead and damaged neurons with scar tissue
  - The axons of neurons outside the brain and spinal cord are able to regenerate given the right conditions

Other Factors Affecting Tissue Repair

- **Other factors affecting tissue repair** (beside ability to undergo mitosis) include **nutrition** and **blood supply**:
  - Tissue repair involves production of *large quantities of protein*, such as collagen; requires an adequate supply of amino acids to proceed
  - **Vitamin C** is required by fibroblasts to *produce functional collagen*
  - Blood supply to injured region *must be adequate* to deliver much-needed oxygen and nutrients and cells of immune system (critical for tissue repair)