Chapter 4: Histology

**Histology** – study of normal structures of ________

**Tissue:**
- a. Discrete population of ______ related in structure & function
- b. Have surrounding material: ________________ (ECM)

→ *Module 4.1: Introduction to Tissues*

<table>
<thead>
<tr>
<th>TYPES OF TISSUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four <strong>primary tissue</strong> types</td>
</tr>
<tr>
<td><strong>a. Epithelial tissues</strong> (epithelia)</td>
</tr>
<tr>
<td>- tightly packed sheets of cells with no visible ECM</td>
</tr>
<tr>
<td>- <strong>glands</strong> that <em>manufacture secretions</em> (<strong><strong><strong><strong><strong><strong>) or chemical messengers (</strong></strong></strong></strong></strong></strong>)</td>
</tr>
<tr>
<td><strong>b. Connective tissues (CT)</strong></td>
</tr>
<tr>
<td>- connect tissues to one another;</td>
</tr>
<tr>
<td>- ECM is a <em>prominent feature</em> for most CT with cells <em>scattered throughout</em></td>
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<tr>
<td><strong>c. Muscle tissues</strong></td>
</tr>
<tr>
<td>- __________</td>
</tr>
<tr>
<td><strong>d. Nervous tissues</strong></td>
</tr>
<tr>
<td>- consist of cells:</td>
</tr>
<tr>
<td>- neurons</td>
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<tr>
<td>- neuroglia</td>
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**THE EXTRACELLULAR MATRIX**

**Extracellular matrix**
- a. Composed of substances in a liquid, gel, or solid that *surround cells*
- b. Functions:
  - Provides tissue with strength to resist **tensile** (stretching) and **compressive** forces
  - *Directs* cells to *proper positions* within tissue and *holds* those cells *in place*
  - Regulates *development, mitotic activity, and survival* of cells
c. 2 main components
   [ground substance & protein fibers]

1) **Ground substance**
   - makes up most of ECM *extracellular fluid* *(ECF or interstitial fluid)*
   - components:

   **Macromolecules:**
   a. **Glycosaminoglycans (GAGs)**
      - ex. *chondroitin sulfate* (cartilage) and *hyaluronic acid*
   b. **Proteoglycans**
      - GAGs bound to a *protein core* *(bottle brush)*
   c. **Cell-adhesion molecules (CAMs)**
      - made up of different types of glycoproteins
      - bind surface proteins

2) **Protein fibers**
   a. **Collagen fibers** *(white, fibrous)*
      - 20–25% of all proteins in body
   b. **Elastic fibers** *(yellow)*
      - protein *elastin* surrounded by glycoproteins
   c. **Reticular fibers** *(weblike)*
      - meshwork or scaffold that *supports cells* and *ground substance* of many tissues

**Diseases of Collagen and Elastic Fibers**

- Protein fibers vital to *structural integrity* of many tissues and organs

  **Ehlers-Danlos syndrome**

  **Marfan syndrome**
Module 4.2: Epithelial Tissues

Functions:

1. Protection –
2. Immune defenses – form physical barriers; contain cells of immune system
3. Secretion –
4. Transport into other tissues – form selectively permeable membranes
5. Sensation – detects changes in internal and external environments (ex. )

Components and Classification of Epithelia

• Consist of tightly packed cells that form continuous sheets
• Fairly impermeable and resistant to physical stresses and mechanical injury
•
• BM (basement membrane)

Classified based on:

• Simple epithelia consist of a ________ cell layer
• Stratified epithelia consist of __________ layers
• Pseudostratified looks layered but is not

• Squamous cells
• Cuboidal cells
• Columnar cells

Covering and Lining Epithelia

• Four types of simple epithelia:

1. Simple squamous epithelium
   – very thin single layer of cells with a “fried egg” appearance;
   - adapted for ____________________________
- found in air sacs of lung, parts of kidney, and lining blood vessel walls

(endothelium)

2. Simple cuboidal epithelium
   – single layer of ________________
   - found in renal tubules, respiratory passages, ducts of glands, and thyroid gland

3. Simple columnar epithelium
   – single layer of rectangular-shaped cells
   - often has _____________ (increases surface area for absorption of substances) or _______ (propel substances through hollow organs)

4. Pseudostratified columnar epithelium
   - appears to be layered because nuclei are found at various heights, but only one cell-layer thick
   - found in segments of respiratory tract and nasal cavity; ciliated

Stratified epithelium
   – more than one layer of cells;
   - protective barriers due to wear and tear

1. Stratified squamous epithelium
   a. Keratinized stratified squamous epithelium
      • outer cellular layers are dead
        • lack nuclei
        • filled with protein _________
        • outer layers of skin (epidermis)
   b. Nonkeratinized stratified squamous epithelium
      • apical cellular layers retain nuclei; still alive
      • _________________________ (ex. mouth, throat, esophagus, anus, and vagina)

2. Stratified cuboidal epithelium
   • rare in humans
   • lines ________________

3. Stratified columnar epithelium
   • relatively rare in humans
   • found in male urethra, cornea of eye, ducts of salivary glands
4. Transitional epithelium
- only found in urinary system ___________________________
- *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 _

**Gland** – specialized cells that *produce secretions*
Products are released by two mechanisms:
- **Endocrine**
- **Exocrine**

**Endocrine glands** secrete ____________, *directly into bloodstream* (no ducts)
- Allows products to have widespread systemic effects on *distant cells* in different areas of body
- Glands vary in complexity from single cells to large multicellular glands with branching
- Ex.

**Exocrine glands**
- ___________
- Secretions have only *local effects* on cells in general vicinity
- Unicellular (__________ → mucus)
  - digestive & respiratory tracts
  - protects underlying epithelia
- Multicellular (sweat glands, salivary glands)

Types of Exocrine glands secretions:
- **Merocrine secretion**
  - fluid product in vesicles
  - salivary and sweat glands

- **Holocrine secretion**
  - entire cells released
  - sebaceous gland
Carcinogens and Epithelial Tissues

• Epithelia cover all body surfaces; therefore more subject to injury than most other tissues

• Carcinogens

• Carcinoma –

• Basal Cell Carcinoma –

→ Module 4.3: Connective Tissues

Connective Tissues

• Connective tissue proper
  – Loose
  – Dense (regular & irregular)
  – Reticular
  – Adipose

• Specialized connective tissue
  – Cartilage
  – Bone
  – Blood

Connective tissue functions:

• ________________
  – anchor tissue layers in organs and link organs together

• Support
  – bone and cartilage support weight of the body

• ________________
  – bone tissue protects certain internal organs
  - cartilage and fat provide shock absorption
  - components of immune system found throughout CT

• Transport – blood main transport medium in body

• Characteristics of CT:
  – Cells are surrounded by protein fibers and embedded in ground substance
  – ECM plays an extensive role in the function of CT
  – Usually vascular
**CONNECTIVE TISSUE CELLS**

- Fibroblasts – ____________
- Adipocytes – _________
- Mast cells – produce histamine that causes inflammation
- Phagocytes - includes macrophages that ingest foreign invaders

**CONNECTIVE TISSUE PROPER**

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

1. **Loose connective tissue (__________________)**
   - mostly ground substance, also fibers, fibroblasts, and occasionally adipocytes
   - located beneath epithelium of skin, in membranes lining body cavities, and within walls of hollow organs

2. **Dense connective tissue (fibrous connective tissue)**
   a. **Dense irregular connective tissue**
      - mostly disorganized collagen bundles
      - located in ___________, surround organs and joints
   b. **Dense regular connective tissue**
      - Organized into parallel collagen bundles
      - Located in ______________________
   c. **Dense regular elastic CT(elastic tissue)**
      - Mostly parallel-oriented elastic fibers with some collagen fibers
      - Found in walls of organs that need to _________ (large blood vessels and some ligaments)

3. **Reticular tissue**
   - composed mostly of reticular fibers produced by fibroblasts (reticular cells);
   - form fine networks that support vessels
     - Also found in _______________________
     - Forms part of B.M. that supports epithelia, internal structure of liver and bone marrow
4. **Adipose tissue** (fat tissue)
   – consists of fat-storing ____________ (& surrounding fibroblasts and ECM)
     • Fat storage (major energy reserve)
     •
     • Shock absorption and protection

**Adipose Tissue and Obesity**

• **Obesity** – condition of having *excess adipose tissue* in proportion to lean body mass:
  – **Hypertrophic**
  – **Hypercellular**

Both types increase risk for certain health problems; depends on *distribution of adipose tissue* and *genetic factors*

**Specialized connective tissues**

• **Cartilage**
  • Bone tissue (osseous tissue) – ____________:
    muscle attachments; stores calcium, and bone marrow (produces blood cells and stores fat)
  • **Blood** – liquid ECM called ____________; consists of mostly water, dissolved solutes, and proteins

**Cartilage**

  – Rigid matrix
  – **Chondroblasts** – immature cells that *divide by mitosis* → ECM
  – ________________ in lacunae
  – Mostly avascular (blood supply limited to outer sheath - *perichondrium*)

3 types of cartilage:

• **Hyaline cartilage**
  – - ends of long bone, trachea, nose, most of fetal skeleton
• **Fibrocartilage**
  - great tensile strength
  - _________________, menisci of knee, symphysis pubis
• **Elastic**
  - _________________
  - *external* ear, auditory tube, epiglottis
• Bone
  – Hard matrix
  – Supports and protects
  – Hemopoiesis
  – Skeleton
  – Osteoblasts, osteocytes in lacunae, osteoclasts

• Blood
  – ECM is fluid = plasma
  – Plasma proteins – not like fibers in other CT; smaller and involved in transport & blood clotting
  – Erythrocytes (___________) transport oxygen
  – Leukocytes (___________) function in immunity
  – Thrombocytes (___________) – cell fragments; major role in blood clotting

Osteoarthritis and Glucosamine Supplements
• Osteoarthritis

• Glucosamine

→ Module 4.4: Muscle Tissues

• Muscle tissues are specialized for ____________
  (use ATP as energy source)

• Movement of skeleton, heart beating, and propulsion of substances through hollow

• Muscle cell or myocyte; ____________ (ability to respond to electrical or chemical stimulation)

• 3 types of muscle tissue:
  - Skeletal muscle
  - Cardiac muscle
  - Smooth muscle
• **Skeletal muscle**
  – Attached to bone
  – Striated
  – ___________

• **Cardiac**
  - Heart
  - Striated
  - ___________
  - Intercalated discs

• **Smooth**
  - Walls of hollow organs, blood vessels
  - Non-striated
  - ___________

→ **Module 4.5: Nervous Tissue**

NERVOUS TISSUES

• **Nervous tissue**
  - brain, spinal cord, nerves
  - two main cell types:
    - **Neurons** –
    - **Neuroglial cells** –

→ **Module 4.6: 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 CT
  – 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

• 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
  – 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
Module 4.7: Membranes

Membranes – thin sheets of tissues that ____________________:

• Serous membranes
  – line pericardial, peritoneal, and pleural cavities ________________

• Synovial membranes
  - composed of CT
  - ______________

• Mucous
  – line tubes/organs that connect to outside of body
  – ______________
  – secrete mucus

• Cutaneous
  - _______
Chapter 5: Integumentary System

Skin (__________________) = largest organ (10-15% of TBW)
2 main regions:
   Epidermis – keratinized stratified squamous epithelium
   Dermis – ________________

→ Module 5.1: Overview of Integumentary System

<table>
<thead>
<tr>
<th>SKIN STRUCTURE</th>
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<tbody>
<tr>
<td><strong>Accessory structures:</strong></td>
</tr>
<tr>
<td>- sweat glands, sebaceous glands, hair, nails</td>
</tr>
<tr>
<td><strong>Sensory receptors</strong></td>
</tr>
<tr>
<td>- detect ______, ______, ______, ______</td>
</tr>
<tr>
<td><strong>Arrector pili muscles</strong></td>
</tr>
<tr>
<td>- small bands of SMC associated with hair</td>
</tr>
<tr>
<td><strong>Epidermis</strong> is ________________</td>
</tr>
<tr>
<td>- Transport of O₂ and nutrients via diffusion</td>
</tr>
<tr>
<td><strong>Dermis</strong> is vascular</td>
</tr>
<tr>
<td><strong>Hypodermis</strong> – aka superficial fascia or subcutaneous fat, is ________________</td>
</tr>
<tr>
<td>- not part of skin, anchors skin to deeper structures</td>
</tr>
<tr>
<td>- ________________</td>
</tr>
<tr>
<td>- ________________</td>
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</tbody>
</table>

**Cellulite**
- Dimpled or “orange peel” appearance
- Thighs, hips, and gluteal area
due to:
- Normal condition

**FUNCTIONS OF THE INTEGUMENTARY SYSTEM**

1. **Protection** - mechanical trauma, pathogens, and ____________
2. **Sensation** – perceive changes in the body’s ________________ environment
3. **Thermoregulation**
   – relies on _______________ loops to maintain *stable internal temperature* (due to muscle activity and metabolism)

4. **Excretion** – process where *waste products and toxins* are eliminated (sweat)

5. **Synthesis** – Vitamin D, calcitriol

**[Body Temperature above normal]**

- **Stimulus**: body is too HOT (due to weather extremes or fever)
- **Receptors**: thermoreceptors detect an increase in _______________
- **Control center**: thermoregulatory center in brain (_______________) acts as a thermostat
- **Effector/Response**: Control center stimulates sweating and vasodilation (VD) of vessels in dermis
- **Homeostasis and negative feedback**:
  - body temp. returns to normal
  - thermoregulatory center decreases output to glands and vessels

**[Body Temperature below normal]**

- **Stimulus**: body temperature drops below normal range; too COLD
- **Thermoreceptors**: detect drop in temperature and relay information to hypothalamus
- **Control center** reacts
- **Effector/response**: blood vessels in dermis vasoconstrict (VC); decreased sweating; __________
- **Homeostasis and negative feedback**:
  - body temp. returns to normal
  - thermoregulatory center decreases output to vessels and muscles (reduce shivering)
- **Lose heat**: ______________
- **Conserve heat**: ______________
- **Produce heat**: ______________

**Vitamin D synthesis**:

\[
\text{ precursor to Vit. D (dehydrocholesterol) } \rightarrow \text{ Vit. D}_3 (\text{cholecalciferol}) \quad \text{(active form)}
\]

\[
\text{ (in skin) } \rightarrow \text{ intermediate product } \rightarrow \text{ calcitriol (hormone)} \quad \text{(in kidneys)}
\]

- Calcitriol - nec. for absorption of Ca++ by S.I.
- Ca++ nec. for ______________, ______________, _______
Module 5.2: The Epidermis

THE EPIDERMIS

• Epidermis
  – most superficial region
  - composed of mostly keratinocytes
  - produce _________ (protein)

Organized into 5 layers (strata):

• Stratum basale (stratum germinativum)
  - most metabolically and mitotically active

• Stratum spinosum
  – still close to blood supply
  - metabolically and mitotically active

• Stratum granulosum
  - three to five layers of cells
  - keratin filled cells (provides water resistance)

• Stratum lucidum
  – narrow layer of clear, dead keratinocytes
  - found _____________

• Stratum corneum (outermost)
  – outermost layer of epidermis
  - several layers of dead flattened
  - sloughed off or exfoliated mechanically

• Keratinocyte life cycle:
  - Dead keratinocytes are replaced by ________ of cells in stratum basale and spinosum close to blood supply
  - As keratinocytes in deeper strata divide they push cells above them into more superficial
    layers (40-50 days)
  - Mitosis takes place at night?!
OTHER CELLS OF THE EPIDERMIS

• Dendritic (Langerhans) cells
  – located in ______________
  - ______________ of immune system
  - protect skin and deeper tissues from pathogens

• Merkel cells
  - located in ______________
  - sensory receptors detect ______________
  - fingertips, lips, and at base of hairs

• Melanocytes
  – located in ______________
  - produce ______________ (protein skin pigment)

THICK AND THIN SKIN

• Thick skin
  - all five epidermal layers
  - thick stratum corneum
  - ______________, many sweat glands

• Thin skin
  - has only four layers (no ______________)
  - Many hairs, sweat glands, and sebaceous glands
  ______________ – additional layers of st. corneum; form in either thick or thin skin
due to repetitive pressure

➔ Module 5.3: The Dermis

THE DERMIS

Dermis – highly vascular layer deep to __________

• Functions:
  – Provides
  – Contains
  – Anchors epidermis in place

• Composed of two distinct layers:
  – Papillary
  – Reticular
THE PAPILLARY LAYER

Papillary layer
– composed of _______________

Dermal papillae
- tiny projections
- capillary loops
- Tactile (Meissner) corpuscles (______________)

THE RETICULAR LAYER

Reticular layer
– deepest thicker layer of dermis
- mostly ________________ (collagen and elastic fibers)
- rich in proteoglycans (keeps skin firm and hydrated)
- Lamellated (Pacinian) corpuscles (__________________________)
- Blood vessels, sweat glands, hairs, sebaceous glands, and adipose tissue are found in reticular layer

SKIN MARKINGS

Epidermal ridges
- enhance ______________________
  – characteristic patterns; loops, arches, and whorls;
  – Sweat pores open along these ridges and leave a thin film or ________________ on most surfaces

Skin Wrinkles
• Due to age-related decrease in collagen and elastic fibers, proteoglycans, and adipose tissue in the ______________

• Reduces

• Appearance can be minimized by:
  – Botox
  – Fillers
  – Topical creams

Delay wrinkles:
Module 5.4: Skin Pigmentation

Skin color

- **Melanin** (melanocytes)
  - Protect keratinocyte DNA from mutations induced by UV rays
  - Number of melanocytes is ____________________
  - Spectrum of skin tones due to ____________________

- **Carotene** (ingest yellow orange vegetables)
  - Imparts yellowish color to ______________

- **Hemoglobin** (RBCs)
  - Coloration depends on blood flow to dermis

- Increased melanin synthesis with exposure to natural or artificial UV radiation (tan)
- **Erythema** – __________ blood flow
- **Pallor** – __________ blood flow
- **Cyanosis** - low __________ blood

Common variations of pigmentation:
- **Freckle** – small area of __________ pigmentation (melanin production)
- **Mole** or **nevus** – area of increased pigmentation due to ____________________
  (not increase in melanin production)
- **Albinism** – melanocytes fail to manufacture tyrosinase ____________ results in lack of pigmentation

Tanning and a “Healthy Tan”

- Tanning – salons promote notion of “healthy tan”
- THERE IS NO SUCH THING AS A HEALTHY TAN!

- UVA and UVB rays are associated

- ANY amount of tanning damages
Module 5.5: Accessory Structures of Integument: Hair, Nails, and Glands

Accessory structures (appendages):
- derived from epithelium only

• Hair (pili)
  – protrude from surface of skin over entire body except thick skin, lips, and parts of external genitalia
  Cuticle -
  Cortex -
  Medulla -

Hair
  – Protect by preventing ________________________________
  – Protect underlying skin of scalp from __________________________
  - Sensory neuron detect changes in environment

HAIR STRUCTURE
• Hair - stratified squamous keratinized epithelial
  – Shaft
    • dead keratinized cells
  – Root
    • surrounded by sensory neuron
    • hair papilla - projection of blood vessels in indented base
    • hair bulb = root and hair papilla
    • many epithelial cells are still alive (have not completed keratinization process)

  – Matrix – small number of actively dividing keratinocytes found at base of root
  – Root is embedded in hair follicle

  – Strand of hair has three visible regions:
    • Inner medulla – soft keratin
    • Middle cortex – hard keratin provides strength
    • Outermost cuticle – single layer of overlapping keratinocytes containing hard keratin; provides mechanical strength
• arrector pili muscles = _______________

• “goosebumps” = hair stands up (piloerection)

• hair growth varies, averages ~ 1-1.5 cm per month

HAIR PIGMENT AND TEXTURE

• Hair color is determined by ______________
  • Blond hair has _________ melanin
  • Black hair which contains _________ of melanin
  • Red hair has a special reddish pigment containing iron
  • Gray or white hair melanocytes produce

NAILS

Nails – composed of stratified squamous epithelium filled with hard keratin
  o Nail plate – sits on top of __________
  o Lunula - half-moon shaped region of proximal nail plate
  o Eponychium - __________
  o Hyponychium – St. corneum under free edge of nail

GLANDS

• Sweat (sudoriferous) glands à sweat
  – Eccrine: widespread, mostly water, wastes, electrolytes
  – Apocrine: axillary, & anal regions, ________________, odoriferous, associated with hair follicle

Modified sweat glands:
  – Ceruminous: __________ (ear canal)
  – Mammary: __________

• Sebaceous glands \( \rightarrow \) __________
  – Thin skin only
  – Hydrophobic barrier
Module 5.6: Pathology of Skin

Acne
• **Acne vulgaris**

• **Cause**
  – accumulation of ___________________
  - may be infected by bacteria → _____________
  - _______________ (testosterone)

**Cancer** – one of most common diseases in world; caused by mutations in DNA that induce a cell to lose control of cell cycle (Figure 5.14):
– **Unchecked cell division** eventually leads to formation of a large population of undifferentiated cells known as a ____________
– Cancerous tumors are able to **metastasize**; tumor cells **spread** through _______________________________
– Damage caused by metastatic tumor cells **alters function** of invaded organs

• Three cancers affect skin
  - linked to **UV radiation exposure**
  - **carcinogens** (Cancer-inducing chemicals, toxins)

1. **Basal cell carcinoma**
  – Most **common** of all cancer types, including skin cancer
  – Arises from keratinocytes in stratum basale

2. **Squamous cell carcinoma**
  – **Second most common** skin cancer
  – Cancer of keratinocytes of stratum spinosum

3. **Malignant melanoma**
  – cancer of ____________
  - Arms" of cancerous melanocytes extend down into dermis and access dermal blood vessels (metastasis)

**Malignant melanoma** can be distinguished from other skin cancers and normal moles using **ABCDE rule**:
– (A): _______________ (two sides do not match)
– (B): _______________ irregularity
– (C): _____________ , usually blue-black or a variety of colors
– (D): _____________ generally larger than 6 mm (pencil eraser size)
– (E): _______________ (changing) shape and size