Chapter 4: Histology

**Histology** – study of normal structures of __________

**Tissue:**
- Discrete population of ______ related in structure & function
- Have surrounding material: _______________ (ECM)

→ *Module 4.1: Introduction to Tissues*

### TYPES OF TISSUES

Four **primary tissue** types

a. **Epithelial tissues** (epithelia)
   - tightly packed sheets of cells with no visible ECM
   - glands that *manufacture secretions (____________*) or chemical messengers
   (____________)

b. **Connective tissues (CT)**
   - connect tissues to one another;
   - ECM is a *prominent feature* for most CT with cells *scattered throughout*

c. **Muscle tissues**
   - __________

d. **Nervous tissues**
   - consist of cells:
     - neurons
     - neuroglia

### THE EXTRACELLULAR MATRIX

**Extracellular matrix**

- Composed of substances in a liquid, gel, or solid that *surround cells*

- 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

**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 _

**GLANDULAR EPITHELIA**

- **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

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
MUSCLES 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

SKIN STRUCTURE

• Accessory structures:
  - sweat glands, sebaceous glands, hair, nails

• Sensory receptors
  - detect ______, ______, ______, ______

• Arrector pili muscles
  - small bands of SMC associated with hair

• Epidermis is ________________
  – Transport of $O_2$ and nutrients via diffusion

• Dermis is vascular

• Hypodermis – aka superficial fascia or subcutaneous fat, is ________________
  – not part of skin, anchors skin to deeper structures
  – ________________
  – ________________

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**:
  
  ![UV light](precursor to Vit. D \(\xrightarrow{UV\ light}\) Vit. D₃ (cholecalciferol) \(\xrightarrow{in\ skin}\) intermediate product \(\xrightarrow{in\ liver}\) calcitriol (hormone) \(\xrightarrow{in\ kidneys}\))

- 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

Hair

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
  • Nail plate – sits on top of __________
  • Lunula - half-moon shaped region of proximal nail plate
  • Eponychium - __________
  • Hyponychium – St. corneum under free edge of nail

GLANDS

• Sweat (sudoriferous) glands à 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)

SKIN CANCER
• 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