Body Organization and Homeostasis
Body Organization and Homeostasis

OUTLINE:

- From Cells to Organ Systems
- Skin: An Organ System
- Homeostasis
From Cells to Organ Systems

- **Tissue**
  - A group of cells of similar type that work together to serve a common function

- **Humans have four primary tissue types**
  - Epithelial
  - Connective
  - Muscle
  - Nervous
Tissues

- Humans have four types of tissues:
  - Epithelial tissue (Epi: on, upon)
    - Covers the body surfaces
    - Lines cavities and organs
    - Forms glands
  - Connective tissue
    - Provides support and protection for organs
    - Serves as a storage site for fat
    - Participates in our immunity
Tissues

Humans have four types of tissues (cont’d):

- Muscle tissue, responsible for:
  - Body movement
  - Movement of fluids through the body

- Nervous tissue
  - Conducts nerve impulses through the body
Epithelial Tissue

- All epithelial tissues share two structural characteristics
  - A free surface that may be specialized for protection, secretion, or absorption
  - A basement membrane that binds the epithelial cells to underlying connective tissue and helps the epithelial tissue resist stretching
Epithelial Tissue

- The three basic shapes of epithelial cells are suited to their functions
  1. Squamous epithelium
  2. Cuboidal epithelium
  3. Columnar epithelium

- These cells can be either simple (a single layer of cells) or stratified (multiple layers of cells)
Epithelial Tissue

- Squamous epithelium
  - Has flattened cells
  - Shape allows for diffusion of materials and can provide a slick surface to reduce friction

- Cuboidal epithelium
  - Has cube-shaped cells
  - Specialized for secretion and absorption
Epithelial Tissue

- Columnar epithelium
  - Has tall, column-shaped cells
  - Specialized for secretion and absorption
  - Lines the small intestine
Figure 4.1 Types of epithelial tissue. These are named for the shape of the cell and the number of cell layers.

**Simple Squamous**
- One layer of flattened cells
- Located in air sacs of lungs, heart and blood vessel linings
- Allows exchange of nutrients, gases, and wastes

**Stratified Squamous**
- Several layers of flattened cells
- Located on surface of skin, lining of mouth, esophagus, and vagina
- Provides protection against abrasion, infection, and drying out

**Simple Cuboidal**
- One layer of cube-shaped cells
- Located in linings of kidney tubules and glands
- Functions in absorption and secretion

**Stratified Cuboidal**
- Usually two layers of cube-shaped cells
- Located in ducts of mammary glands, sweat glands, and salivary glands
- Functions in protection

**Simple Columnar**
- One layer of tall, slender cells
- Located in lining of gut and respiratory tract
- Functions in absorption and secretion

**Stratified Columnar**
- Several layers of tall, slender cells
- Rare, located in urethra (tube through which urine leaves the body)
- Functions in protection and secretion
Table 4.1 *Review of epithelial tissue*

<table>
<thead>
<tr>
<th>Shape</th>
<th>Number of Layers</th>
<th>Example Locations</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squamous (flat, scale-like cells)</td>
<td>Simple (single layer)</td>
<td>Lining of heart and blood vessels, air sacs of lungs</td>
<td>Allows passage of materials by diffusion</td>
</tr>
<tr>
<td></td>
<td>Stratified (more than one layer)</td>
<td>Linings of mouth, esophagus, and vagina; outer layer of skin</td>
<td>Protects underlying areas</td>
</tr>
<tr>
<td>Cuboidal (cube-shaped cells)</td>
<td>Simple</td>
<td>Kidney tubules, secretory portion of glands and their ducts</td>
<td>Secretes; absorbs</td>
</tr>
<tr>
<td></td>
<td>Stratified</td>
<td>Ducts of sweat glands, mammary glands, and salivary glands</td>
<td>Protects underlying areas</td>
</tr>
<tr>
<td>Columnar</td>
<td>Simple</td>
<td>Most of digestive tract (stomach to anus), air tubes of lungs (bronchi), excretory ducts of some glands, uterus</td>
<td>Absorbs; secretes mucus, enzymes, and other substances</td>
</tr>
<tr>
<td></td>
<td>Stratified</td>
<td>Rare; urethra, junction of esophagus and stomach</td>
<td>Protects underlying areas, secretes</td>
</tr>
</tbody>
</table>
Epithelial Glands

- A gland is composed of epithelial tissue that secretes a product
  - **Exocrine** glands secrete into ducts leading to body surfaces, cavities or organs (exo: out)
  - **Endocrine** glands lack ducts and secrete their products, hormones into spaces just outside the cells but in the body (endo: inside)
Connective Tissue

- The most abundant and widely distributed tissue in the body

- Cells are contained in an extracellular matrix of protein fibers and ground substance

  - Protein fibers
    - Collagen, elastic, and reticular fibers
    - Produced by fibroblasts, which are also responsible for tissue repair

  - Ground substance
    - Noncellular material
    - May be solid (bone), fluid (blood), or gelatinous (cartilage)
Connective Tissue

- Two categories
  - Connective tissue proper
  - Specialized connective tissue
Connective Tissue

- **Connective tissue proper**
  - Loose and dense connective tissues, differ in the ratio of cells to extracellular fibers
  - **Loose connective tissue** (areolar connective tissue, adipose tissue)
    - Contains many cells and fewer, loosely woven fibers
    - Cushion organs and provide insulation
  - **Dense connective tissue** (in ligaments, tendons, dermis)
    - Made of tightly woven fibers

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Connective Tissue

- Specialized connective tissue
  - Cartilage
  - Bone
  - Blood
Connective Tissue

- Cartilage
  - Tough but flexible
  - Serves as a cushion between bones
  - Lacks blood vessels and nerves
    - Heals more slowly than bone
  - Three types differ in flexibility and location
    - Hyaline
    - Elastic
    - Fibrocartilage
Connective Tissue

- Bone
  - Protects and supports internal structures
  - Facilitates movement along with muscles
  - Stores lipids (in yellow marrow), calcium, and phosphorus
  - Produces blood cells (in red marrow)
Figure 4.2 Types of connective tissue.

**CONNECTIVE TISSUE PROPER**

- **Areolar connective tissue**
  - Widely distributed; found under skin, around organs, between muscles
  - Wraps and cushions organs

- **Adipose (fat) tissue**
  - Found under skin, around kidneys and heart
  - Functions in energy storage and insulation; cushioning for organs

**SPECIALIZED CONNECTIVE TISSUE**

- **Cartilage**
  - Found in rings of respiratory air tubes, external ear, tip of nose
  - Provides flexible support; cushions

- **Bone**
  - Found in the skeleton
  - Functions in support, protection (by enclosing organs), and movement

- **Dense connective tissue**
  - Found in tendons and ligaments
  - Forms strong bands that attach bone to muscle or bone to bone

- **Blood**
  - Found within blood vessels
  - Transports nutrients, gases, hormones, wastes; fights infections
Muscle Tissue

- Three types vary in structure, location, and whether voluntary or involuntary
  - Skeletal
  - Cardiac
  - Smooth
# Table 4.3 Review of muscle tissue

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Example Locations</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skeletal</td>
<td>Long, cylindrical cells; multiple nuclei per cell; obvious striations</td>
<td>Muscles attached to bones</td>
<td>Provides voluntary movement</td>
</tr>
<tr>
<td>Cardiac</td>
<td>Branching, striated cells; one nucleus; specialized junctions between cells</td>
<td>Wall of heart</td>
<td>Contracts and propels blood through the circulatory system</td>
</tr>
<tr>
<td>Smooth</td>
<td>Cells taper at each end; single nucleus; arranged in sheets; no striations</td>
<td>Walls of digestive system, blood vessels, and tubules of urinary system</td>
<td>Propels substances or objects through internal passageways</td>
</tr>
</tbody>
</table>
**Figure 4.3 Types of muscle tissue.**

**Skeletal muscle**
- Long cylindrical striated cells with many nuclei
- Voluntary contraction
- Most are found attached to the skeleton
- Responsible for voluntary movement

**Cardiac muscle**
- Branching striated cells, one nucleus
- Involuntary contraction
- Found in wall of heart
- Pumps blood through the body

**Smooth muscle**
- Cells tapered at each end, one nucleus
- Involuntary contraction
- Found in walls of hollow internal organs, such as the intestines, and tubes, such as blood vessels
- Contractions in digestive system move food along
- When arranged in circle, controls diameter of tube
Nervous Tissue

- Makes up the brain, spinal cord, and nerves
  - Consists of neurons and neuroglia
    - Neurons
      - Generate nerve impulses and conduct them to other neurons, muscle cells, or glands
    - Neuroglia
      - Support, insulate, and protect neurons
Figure 4.4 *Neurons and neuroglia.*
Cell Junctions

- Attachments between adjacent cells. Three types of cell junctions:
  - Tight junctions
    - Form a leak-proof seal
    - Found between cells lining the urinary tract
  - Adhesion junctions
    - Resemble a riveted joint
    - Found between skin cells
  - Gap junctions
    - Have small holes connecting the cytoplasm of adjacent cells
    - Found between cardiac muscle cells
Figure 4.5 *Specialized cell junctions.*

**(a) Tight junction**
- Creates an impermeable junction that prevents the exchange of materials between cells
- Found between epithelial cells of the digestive tract, where they prevent digestive enzymes and microorganisms from entering the blood

**(b) Adhesion junction**
- Holds cells together despite stretching
- Found in tissues that are often stretched, such as the skin and the opening of the uterus

**(c) Gap junction**
- Allows cells to communicate by allowing small molecules and ions to pass from cell to cell
- Found in epithelia in which the movement of ions coordinates functions, such as the beating of cilia; found in excitable tissue such as heart and smooth muscle
Body Cavities Lined with Membranes

- Sheets of epithelium supported by connective tissues called membranes cover body cavities and organ surfaces. There are four types of membranes:
  - **Mucous membranes** line passageways that open to the exterior of the body
  - **Serous membranes** line the thoracic and abdominal cavities and the organs within them
  - **Synovial membranes** line the cavities of freely moveable joints
  - **Cutaneous membrane** (skin) covers the outside of the body
Organs and Organ Systems

- Organs
  - Composed of two or more different tissues that work together to perform a specific function

- Organ system
  - Composed of organs with a common function
  - There are eleven major organ systems in the human body
Figure 4.7 Major organ systems of the human body (1of 2).

**Integumentary system**
- Protects underlying tissues
- Provides skin sensation
- Helps regulate body temperature
- Synthesizes vitamin D

**Skeletal system**
- Attachment for muscles
- Protects organs
- Stores calcium and phosphorus
- Produces blood cells

**Muscular system**
- Moves body and maintains posture
- Internal transport of fluids
- Generation of heat

**Nervous system**
- Regulates and integrates body functions via neurons

**Endocrine system**
- Regulates and integrates body functions via hormones

**Cardiovascular system**
- Transports nutrients, respiratory gases, wastes, and heat
- Transports immune cells and antibodies
- Transports hormones
- Regulates pH
Figure 4.7 Major organ systems of the human body (2 of 2).

**Lymphatic system**
- Returns tissue fluids to bloodstream
- Protects against infection and disease

**Respiratory system**
- Exchanges respiratory gases with the environment

**Digestive system**
- Physical and chemical breakdown of food
- Absorbs, processes, stores food

**Urinary system**
- Maintains constant internal environment through the excretion of nitrogenous waste

**Reproductive system**
- Produces and secretes hormones
- Produces and releases egg and sperm cells
- Houses embryo/fetus (females only)
- Produces milk to nourish offspring (females only)
Body Cavities Lined with Membranes

- Most of our organs are suspended in internal body cavities that protect vital organs and allow them to slide past one another and change shape. There are two main body cavities:
  - Ventral cavity
    - Thoracic cavity
    - Abdominal cavity
    - The diaphragm separates them
  - Dorsal cavity
    - Cranial cavity (encloses the brain)
    - Spinal cavity (houses the spinal cord)
Figure 4.6 Body cavities. The internal organs are suspended in body cavities that protect the organs and allow organs to slide past one another as the body moves. Ventral means “toward the abdomen,” and dorsal means “toward the back.”
Skin: An Organ System

- The integumentary system is composed of
  - Skin
  - Derivatives of the skin
    - Hair
    - Nails
    - Sweat glands
    - Oil glands
    - Wax glands
Skin Functions

- The skin is our largest organ

- Functions of the skin
  - Protects against bacterial invasion, UV radiation, and physical and chemical stress
  - Prevents water loss
  - Regulates body temperature
  - Synthesizes vitamin D
  - Receives stimuli
Skin Layers

- The skin has two major layers
  - Epidermis (epi: on, over)
    - Thin outer layer
  - Dermis
    - Thicker inner layer containing nerves, blood vessels, and glands
  - Hypodermis or subcutaneous layer
    - Layer of loose connective tissue just below the epidermis and dermis
The Epidermis

- Consists of several layers of epithelial cells
  - Deepest layer of rapidly dividing cells
- No blood vessels
  - Cells receive nourishment from the dermis, but die as they move toward the surface
- Outer surface is made up of dead skin cells
- Protective properties come from keratin
The Dermis

- Consists primarily of connective tissue
- Has blood vessels, nerves, glands, and hair follicles
- Does not wear away
- Collagen and elastic fibers are found in the lower layer, which allows the skin to stretch and return to its original shape
Hypodermis

- Also called subcutaneous level
- Anchors skin to the tissues of other organ systems that lie beneath

 Functions:
  - Protection
  - Temperature regulation
  - Fat storage
- Not usually considered part of the skin
Figure 4.8 *Structures of the skin and underlying hypodermis.*
Skin Color

- Skin color is determined by
  - Blood flow
  - Distribution and quantity of the pigment melanin
    - Melanin
      - Produced by melanocytes at the base of the epidermis
      - Comes in two forms
        - Yellow-to-red
        - Black-to-brown
      - In tanning, the melanocytes respond to UV radiation by increasing production of melanin
The epidermis gives rise to diverse structures:

- Hair
- Nails
- Oil glands
- Sweat glands
- Wax glands
- Teeth (will be covered with the digestive system)
Hair, Nails, and Glands

- Hair
  - Primary function is protection
  - Grows over most of the body
- Components
  - Shaft—extends above the skin surface
  - Root—extends into the dermis or hypodermis where it is embedded in a follicle
Hair, Nails, and Glands

- Nails
  - Protect the tips of our toes and fingers
  - Because nails are embedded in very sensitive tissue, they also function as sensory antennas
Hair, Nails, and Glands

- Oil glands
  - Found all over the body except the palms of the hands and soles of the feet
  - Oil lubricates hair and skin and contains substances that inhibit bacteria
- Sweat glands
  - Produce sweat that helps in the regulation of body temperature
  - Some metabolic wastes are excreted in sweat
- Wax glands
  - Modified sweat glands found in external ear canal
  - Wax protects the ear by trapping small particles
The ultraviolet (UV) radiation of sunlight causes the melanocytes of the skin to increase their production of the pigment melanin, which absorbs UV radiation before it can damage the genetic information of deeper layers of cells. Unfortunately, this protective buildup of melanin is not instantaneous. In skin cancer, UV radiation alters the genetic material in skin cells so that the cells grow and divide uncontrollably, forming a tumor.
Health Issue: Fun in the Sun?

- Three types of skin cancer are caused by over exposure to the sun:
  - **Basal cell carcinoma**, the most common arises in the rapidly dividing cells of the deepest layer of epidermis
  - **Squamous cell carcinoma**, the second most common, arises in the newly formed skin cells as they flatten and move toward the skin surface
  - **Melanoma** is the least common and most dangerous type of skin cancer
Health Issue: Fun in the Sun?

- Limiting the risks
  - Avoid prolonged exposure to the sun
  - If you must be out in the sun, wear a hat, long sleeves, and sunglasses
  - Use a sunscreen with a sun protection factor (SPF) of at least 15 and apply about 45 minutes before going out into the sun
  - Use sunscreen even when it is overcast
  - Avoid tanning salons
Simple acne is a condition that affects hair follicles associated with oil glands. During the teenage years, oil glands increase in size and produce larger amounts of oily sebum. These changes are prompted, in both males and females, by increasing levels of “male” hormones called androgens in the blood.

Acne is the inflammation that results when sebum and dead cells clog the duct where the oil gland opens onto the hair follicle.
Health Issue: Acne: The Miseries and Myths

- There are many misconceptions about the causes of acne. Eating nuts, chocolate, pizza, potato chips, or any of the other “staples” of the teenage diet does not cause acne.

- Also, acne is not caused by poor hygiene. Follicles plug from below, so dirt or oil on the skin surface is not responsible.
Figure 4.B *The stages of acne.*

(a) A normal follicle
Note the tiny hair and cells of the oil gland.

(b) A follicle with sebum
The canal becomes clogged with sebum, dead cells, and bacteria.

(c) A whitehead
Sebum, cells, and bacteria accumulate in the follicle.

(d) A blackhead
Sebum in the clogged follicle oxidizes and mixes with melanin.

(e) An inflamed pimple
The follicle wall ruptures, releasing the contents of a whitehead or blackhead into the surrounding epidermis.
Homeostasis

- Homeostasis is the constant adjustment made by the organ systems to respond to changes in the internal and external environments while limiting too large variations of the internal condition required for life
  - Depends on the nervous and endocrine systems, which are responsible for internal communication
  - Maintained primarily through negative feedback mechanisms
Negative Feedback Mechanisms

- Negative in the sense of removing “–”
  - Corrective measures that slow or reverse variation from a normal value
  - Once the normal value is reached, corrective measures cease

- Positive feedback mechanisms
  - Positive in the sense of adding “+”
  - Cause a change that promotes continued change in the same direction
Negative Feedback Mechanisms

- Homeostatic mechanisms have three components
  - Receptor
    - Detects a change in the internal or external environment
  - Control center (such as the brain)
    - Integrates the information coming from all receptors and selects an appropriate response
  - Effector (such as a muscle or gland)
    - Carries out the response
Homeostasis

The stable equilibrium conditions associated with animal homeostasis are maintained through feedback systems. This tutorial describes the key elements of feedback systems and uses several examples to illustrate how feedback loops help maintain homeostasis.

Press "PLAY" to begin Animation.
Figure 4.12 The components of a homeostatic control system maintained by negative feedback mechanisms.

- **Step 1**: A receptor detects a change and sends information to the control center.
- **Step 2**: The control center integrates information from the receptors and directs the appropriate responses.
- **Step 3**: The effector brings about the necessary adjustment.

**Variable Factor to Be Controlled in Homeostasis**

Imbalance

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Hypothalamus and Body Temperature

- An example: homeostatic regulation of body temperature by negative feedback mechanisms

- In this system
  - Receptors = thermoreceptors
  - Control center = hypothalamus (a region of the brain)
  - Effectors = sweat glands, blood vessels in the skin, and skeletal muscles
Hyperthermia and hypothermia are life-threatening conditions

- Hyperthermia: Abnormally elevated body temperature
- Hypothermia: Abnormally low body temperature
You Should Now Be Able To:

- Know the four types of tissues in the human body and their structure and functions
- Know the three types of cell junctions
- Understand how organs are combined into organ systems
- Know the human body cavities
- Know the structure and function of the skin and list its derivative
- Understand the risks of excessive sun exposure
- Understand the mechanisms involved in homeostasis and compare negative and positive feedback loops