Organization of the Vertebrate Body

- All vertebrates have the same general architecture:
  - Food flows through a long tube from mouth to anus
  - Tube is suspended in coelom, which is divided into:
    - Thoracic cavity – Heart and lungs
    - Abdominal cavity – Stomach and intestines
  - Body is supported by a skeleton made up of jointed bones
  - The skull protects the brain
  - The vertebral column protects the spinal cord

Levels of organization within the body

- **Organs**
  - Structures composed of several different tissues grouped into large structural and functional units

- **Organ systems**
  - Groups of organs that work together to carry out an important function
There Are 11 Principal Organ Systems

- **Integumentary system**: Skin, hair, nails and sweat glands
- **Skeletal system**: Bones, skull, cartilage, ligaments
- **Circulatory system**: Heart, blood vessels, blood

- **Endocrine system**: Pituitary, adrenal, ductless glands
- **Nervous system**: Nerve, sense organs, brain, spinal cord
- **Respiratory system**: Lungs, trachea, other air passages

- **Immune system**: Lymphocytes, macrophages, thymus, lymph nodes
- **Digestive system**: Mouth, esophagus, stomach, intestines
- **Urinary system**: Kidneys, bladder, associated ducts
There Are 11 Principal Organ Systems

<table>
<thead>
<tr>
<th>Muscular system</th>
<th>Reproductive system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skeletal, cardiac and smooth muscles</td>
<td>Testes or ovaries</td>
</tr>
<tr>
<td>Associated structures</td>
<td></td>
</tr>
</tbody>
</table>

The Body is Made of Four Tissue Types

- Tissues are collections of cells and cell products that perform specific, limited functions
- 4 tissue types form all the structures of the human body:
  - **Epithelial Tissue**
    - Covers external surfaces
    - Lines internal passageways
    - Forms glands
  - **Connective Tissue**
    - Fills internal spaces
    - Supports other tissues
    - Transports materials
    - Stores energy
  - **Muscle Tissue**
    - Specialized for contraction
    - Skeletal muscle, heart muscle, and walls of hollow organs
  - **Neural Tissue**
    - Carries electrical signals from 1 part of the body to another

Epithelium is Protective Tissue

- The vertebrate body consists of one tube (digestive tract) suspended into another (body cavity: coelom)
  - The outside of the body is covered with cells (skin) derived from embryonic ectoderm tissue
  - The body cavity is lined with cells derived from embryonic mesoderm tissue
  - The hollow inner core of the digestive tract is lined with cells derived from embryonic endoderm tissue
Epithelia

Characteristics
- Cellularity (cell junctions)
- Polarity (apical and basal surfaces)
- Attachment (basal lamina)
- Avascularity
- Regeneration

Functions
- Provide physical protection
- Control permeability
- Provide sensation
- Produce specialized secretions (glandular epithelium)

Specializations
- Move fluids over the epithelium (protection)
- Move fluids through the epithelium (permeability)
- Produce secretions (protection and messengers)

Classification of Epithelial Cells

- Epithelial cells are classified into three types according to their shape:
  - Squamous
  - Cuboidal
  - Columnar

Three general kinds of epithelial tissue

- Simple epithelium
  - Only a single layer thick
  - Found in the lining of the lungs and major body cavities
- Stratified epithelium
  - Several layers thick
  - Found in the skin
- Glands
  - Involved in secretion
  - Endocrine glands secrete hormones into the blood
  - Exocrine glands use ducts to secrete sweat, milk, saliva, and digestive enzymes out of the body onto epithelial surfaces
Connective Tissue Supports the Body

- **Connective tissue** is derived from the mesoderm
  - Three functional categories
    - 1. **Immune system**: body defense
    - 2. **Skeletal system**: body support
    - 3. **Blood and fat cells**: storage and distribution of substances

Immune Connective Tissue

- Two principal immune cells are
  1. **Macrophages**: Engulf and digest invading microbes
  2. **Lymphocytes**: Make antibodies or Attack virus-infected or cancerous cells

Skeletal Connective Tissue

- **Fibroblasts**: The most common kind
  - Secrete structurally strong proteins such as collagen into spaces between cells
  - Loose & Dense types
- **Cartilage**: Collagen matrix forms in long parallel arrays along lines of mechanical stress
  - Found in joint surfaces
- **Bone**: Collagen fibers are coated with calcium phosphate
**Storage and Transport Connective Tissue**

- Includes
  - Adipose tissue
    - Accumulates fat
  - Erythrocytes (RBC)
    - Transport $O_2$ and $CO_2$ in the blood
- The fluid portion of blood is called **plasma**
  - Contains nutrients, wastes and antibodies

**Types of Connective Tissues by Origin**

**Muscle Tissue Lets the Body Move**

- The distinguishing characteristic of muscle cells is the abundance of contractile protein fibers
  - These **microfilaments** (**myofilaments**) are made up of actin and myosin
    - Muscle contraction occurs when actin and myosin slide past each other
- The vertebrate body possesses three different kinds of muscle cells
  - Smooth
  - Skeletal
  - Cardiac
**Smooth Muscle**

- Cells are long and spindle-shaped
  - Each contains a single nucleus
    - Cellular microfilaments are loosely organized

Found in the walls of blood vessels, stomach and intestines

Power rhythmic involuntary contractions

---

**Skeletal Muscle**

- Produced by fusion of several cells at their ends
  - This creates a very long muscle fiber that contains all the original nuclei

Microfilaments are bunched together into myofibrils

Found in voluntary muscles

Power voluntary contractions

---

**Cardiac Muscle**

- Composed of chains of single cells, each with its own nucleus
  - Chains are interconnected, forming a latticework

Each heart cell is coupled to its neighbors by gap junctions

Allow electrical signals between cells

Cause orderly pulsation of heart
Nerve Tissue Conducts Signals Rapidly

- Nerve tissue is composed of two kinds of cells
  - **1. Neurons**
    - Specialized for the transmission of nerve impulses
  - **2. Glial cells**
    - Support neurons with nutrients, support and insulation

- Neuron plasma membranes are rich in ion-selective channels
  - These maintain a voltage difference between the cell's interior and exterior
  - **Depolarization** is the temporary loss of this voltage difference
  - It results in a wave of electrical activity, or nerve impulse

Each neuron consists of three parts

1. **Cell body** – Contains the nucleus
2. **Dendrites** – Bring nerve impulses to the cell
3. **Axon** – Carry nerve impulses away from the cell

Skin (Integument)

- Largest Organ in Body
  - about 15% of our total weight
  - **Protects** underlying tissues and organs
  - **Excretes** salts, water, and organic wastes (glands)
  - **Maintains** body temperature (insulation and evaporation)
  - **Synthesizes** vitamin D₃
  - **Stores** lipids
  - **Detects** touch, pressure, pain, and temperature

- Consists of three major regions
  - **Epidermis** – outermost superficial region
  - **Dermis** – middle region
  - **Hypodermis** (subcutaneous layer) – deepest region
Skin or Cutaneous Surface

Epidermis
- 10-30 cells thick (epithelial tissue)
- Has no blood vessels
- Stratum corneum – Outermost layer
- Basal layer – Innermost layer

Dermis
- 15-40 times thicker than the epidermis (loose connective & nerve tissue, + blood vessels)
- Provides structural support and nutrients for the epidermis

Subcutaneous layer
- Fat-rich cells that act as shock absorbers and insulators

Epidermal/Dermal Ridges

- Dermal papillae (tiny mounds): increase the area of basal lamina, strengthen attachment between epidermis and dermis
- Epidermal ridges (e.g., fingerprints)

Skin Color

Three pigments contribute to skin color
- Melanin – yellow to reddish-brown to black pigment, responsible for dark skin colors
  - Freckles and pigmented moles result from local accumulations of melanin
  - Melanin protects skin from sun damage (UV radiation)
- Carotene – yellow to orange pigment
  - Most obvious in the palms and soles of the feet
  - Can be converted to vitamin A
- Hemoglobin – reddish pigment responsible for the pinkish hue of the skin
Cutaneous Glands

Sweat (Sudoriferous) Glands
- Different types prevent overheating of the body: secrete cerumen and milk
  - **Eccrine** sweat glands – found in palms, soles of the feet, and forehead
  - **Apocrine** sweat glands – found in axillary and anogenital areas
  - **Ceruminous** glands – modified apocrine glands in external ear canal that secrete cerumen
  - **Mammary** glands – specialized sweat glands that secrete milk

Sebaceous Glands
- Simple alveolar glands found all over the body
- Soften skin when stimulated by hormones
- Secrete an oily secretion called **sebum**
- Acne occurs when these glands become blocked or infected

Basal Cell & Squamous Cell Carcinomas

- **Basal Cell Carcinoma**
  - Least malignant and most common skin cancer
  - Stratum basale cells proliferate and invade the dermis and hypodermis
  - Slow growing and do not often metastasize
  - Can be cured by surgical excision in 99% of the cases

- **Squamous Cell Carcinoma**
  - Arises from keratinocytes of stratum spinosum
  - Arise most often on scalp, ears, and lower lip
  - Grows rapidly and metastasizes if not removed
  - Prognosis is good if treated by radiation therapy or removed surgically

Melanoma

- Cancer of melanocytes is the most dangerous type of skin cancer because it is:
  - Highly metastatic
  - Resistant to chemotherapy
- Melanomas have the following characteristics (ABCD rule)
  - A: **Asymmetry**: the two sides of the pigmented area do not match
  - B: **Border** is irregular and exhibits indentations
  - C: **Color** (pigmented area) is black, brown, tan, and sometimes red or blue
  - D: **Diameter** is larger than 6 mm (size of a pencil eraser)
- Treated by wide surgical excision accompanied by immunotherapy
- Chance of survival is poor if the lesion is over 4 mm thick
**Burns**

- Destruction of proteins of the skin
  - chemicals, electricity, heat
- Problems that result
  - shock due to water, plasma and plasma protein loss
  - circulatory & kidney problems from loss of plasma
  - bacterial infection
- **First-degree** – only the epidermis is damaged
  - Symptoms include localized redness, swelling, and pain
- **Second-degree** – epidermis and upper regions of dermis are damaged
  - Symptoms mimic first degree burns, but blisters also appear
- **Third-degree** – entire thickness of the skin is damaged
  - Burned area appears gray-white, cherry red, or black; there is no initial edema or pain (since nerve endings are destroyed)

---

**Rule of Nines**

- Estimates the severity of burns
- **Burns considered critical if:**
  - Over 25% of the body has second-degree burns
  - Over 10% of the body has third-degree burns
  - There are third-degree burns on face, hands, or feet

---

**Other Epithelial Surfaces**

- **Mucous** – lines body cavities open to the exterior (e.g., digestive and respiratory tracts)
- **Serous** – moist membranes found in closed ventral body cavity