ELEMENTORY TISSUES

Tissues are defined as a **group of cells of the same type** that usually have a **common origin in an embryo** and **function together** to carry out specialized activities.

Histology is the science that deals with the **study of tissues**.

Based on physical nature, tissues may be:

- **Hard** – bone
- **Semisolid** – fat
- **Liquid** – blood

Classification of Tissues

According to **structure and function**, tissues are classified into **four basic types**:

1. **Epithelial tissue**
2. **Connective tissue**
3. **Muscular tissue**
4. **Nervous tissue**

Epithelial tissue:

- Covers body surfaces
- Lines hollow organs, body cavities, and ducts
- Forms glands
- Allows the body to interact with both its **internal and external environments**

Connective tissue:

- Protects and supports the body and its organs
- Various types bind organs together
- Stores energy reserves as fat
- Helps provide immunity against disease-causing organisms

Muscular tissue:

- Contains cells specialized for **contraction**
- Generates force and movement
- Produces heat, which helps **warm the body**

Nervous tissue:

- Detects changes inside and outside the body

- Responds by generating **electrical signals** called nerve action potentials or nerve impulses
- Activates muscular contractions and glandular secretions

EPITHELIAL TISSUE

General Features

- Also called **epithelium**
- Consists of cells arranged in **continuous sheets**
- May be present as a **single layer or multiple layers**
- Cells are **closely packed**
- Cells are held together by many **cell junctions**
- Intercellular substance is minimal
- Covers surfaces, lines cavities, and forms the secreting portion of glands
- Cells usually lie on a **basement membrane**

Functions of Epithelial Tissue

1. Protection of underlying structures from dehydration and chemical or mechanical damage
2. Secretion of mucus, hormones, and enzymes
3. Absorption of nutrients in the gastrointestinal tract
4. Excretion in the urinary tract

Classification of Epithelial Tissue

Epithelial tissue is classified into:

1. **Covering and lining epithelium (surface epithelium)**
2. **Glandular epithelium**

Based on:

- Arrangement of cells into layers, and
- Shape of the cells

Types:

1. **Simple epithelium** – single layer of cells
2. **Stratified epithelium** – several layers of cells

SIMPLE EPITHELIUM

Simple epithelium consists of **a single layer of identical cells**.

Based on the shape of cells, it is classified into:

A. Simple Squamous Epithelium

Description

- Single layer of flattened cells
- Resembles a tiled floor, hence called **pavement epithelium**
- Nucleus is centrally located
- Arrangement allows diffusion

Location

- Lines heart (endocardium)
- Blood vessels and lymph vessels (endothelium)
- Alveoli of lungs
- Bowman's capsule and collecting ducts of nephrons
- Inner surface of eardrum
- Serous membranes such as:
    - Peritoneum
    - Pleura
    - Pericardium (mesothelium)

Functions

- Filtration
- Diffusion
- Secretion

B. Simple Cuboidal Epithelium

Description

- Single layer of cube-shaped cells
- Round, centrally located nucleus

Location

- Covers ovary surface
- Forms walls of kidney tubules
- Secreting portions of thyroid gland
- Ducts of pancreas
- Pigmented epithelium at posterior surface of retina

Functions

- Secretion
- Absorption

- Excretion

C. Simple Columnar Epithelium

1. Non-ciliated Simple Columnar Epithelium

Description

- Single layer of tall, column-like cells
- Oval nuclei near the base
- Nonciliated
- Free surface of small intestine covered with **microvilli**
- **Goblet cells** are present

Location

- Gastrointestinal tract (stomach to anus)
- Ducts of many glands
- Gall bladder

Functions

- Secretion
- Absorption

2. Ciliated Simple Columnar Epithelium

Description

- Single layer of ciliated column-like cells
- Oval nuclei near the base
- Goblet cells present, which secrete mucus

Location

- Trachea
- Some bronchioles of respiratory tract
- Uterine tubes
- Uterus
- Central canal of spinal cord
- Ventricles of brain

Functions

- Movement of mucus and foreign particles toward the throat
- Movement of oocytes through uterine tubes into the uterus

D. Pseudostratified Columnar Epithelium

1. Nonciliated Pseudostratified Columnar Epithelium

Description

- Appears to have several layers
- Nuclei present at different levels
- All cells do not extend to the apical surface
- Cells are nonciliated and lack goblet cells

Location

- Epididymis
- Larger ducts of many glands
- Parts of male urethra

Functions

- Absorption
- Secretion

2. Ciliated Pseudostratified Columnar Epithelium

Description

- Appears multilayered
- Cells extend to the surface
- Cells secrete mucus or bear cilia

Location

- Lines airways of most of the upper respiratory tract

Functions

- Secretion of mucus to trap foreign particles
- Cilia sweep mucus for elimination from the body

STRATIFIED EPITHELIUM

- Consists of **several layers of cells** of various shapes
- Basement membrane is usually absent
- Continuous cell division in the basal layer pushes cells upward
- Superficial cells are shed
- Main function is **protection against mechanical wear and tear**

Stratified Squamous Epithelium

Description

- Apical layers consist of squamous cells
- Deeper layers vary from cuboidal to columnar

Keratinized Stratified Squamous Epithelium

- Develops a tough keratin layer
- Keratin is a tough fibrous protein
- Protects skin from heat, microbes, and injury

Location

- Superficial layer of skin
- Hair
- Nails

Non-keratinized Stratified Squamous Epithelium

- Does not contain keratin
- Kept moist by mucus

Location

- Lining of mouth
- Esophagus
- Part of epiglottis
- Part of pharynx
- Vagina
- Covers tongue

Functions

- Protection from abrasion
- Protection from UV radiation
- Prevention of water loss
- Protection from foreign invasion

Stratified Cuboidal Epithelium

Description

- Two or more layers of cells

- Apical layer is cuboidal
- Rare type

Location

- Ducts of adult sweat glands
- Esophageal glands
- Parts of male urethra

Functions

- Protection
- Limited secretion
- Limited absorption

Stratified Columnar Epithelium

Description

- Basal layers consist of shortened, irregular cells
- Apical layer contains columnar cells
- Uncommon type

Location

- Part of urethra
- Large excretory ducts of some glands
- Small areas in anal mucous membrane
- Part of conjunctiva of eye

Functions

- Protection
- Secretion

Transitional Epithelium (Urothelium)

Description

- Several layers of pear-shaped cells
- In relaxed state, resembles stratified cuboidal epithelium
- When stretched, cells become flattened

Location

- Urinary bladder

- Portions of ureters
- Portions of urethra

Function

- Allows urinary organs to stretch
- Maintains protective lining while holding variable amounts of urine
- Prevents rupture

GLANDULAR EPITHELIUM

General Features

- Function is **secretion**
- Glandular cells lie in clusters deep to covering and lining epithelium
- A **gland** is a group of epithelial cells that produce specialized secretions:
    - Into ducts
    - Onto a surface
    - Or directly into blood (if ducts are absent)

Classification of Glands

All glands are classified into:

1. **Endocrine glands**
2. **Exocrine glands**

Endocrine Glands

Description

- Secretions (hormones) enter interstitial fluid
- Diffuse directly into the bloodstream
- No ducts present

Location

- Pituitary gland
- Pineal gland
- Thyroid and parathyroid glands
- Adrenal glands
- Pancreas
- Ovaries
- Testes
- Thymus

Function

- Regulate metabolic and physiological activities
- Maintain homeostasis

Exocrine Glands

Description

- Secretory products released into ducts
- Ducts open onto:
    - Skin surface, or
    - Lumen of hollow organs

Location

- Sweat, oil, and earwax glands of skin
- Salivary glands
- Pancreas

Functions

- Produce sweat for temperature regulation
- Produce oil and earwax
- Secrete saliva and digestive enzymes

CONNECTIVE TISSUE

Connective tissue is **one of the most abundant and widely distributed tissues** in the body. It performs a **variety of functions** in different forms.

Functions of connective tissue include:

- Binding together, supporting, and strengthening other body tissues
- Protecting and insulating internal organs
- Compartmentalizing skeletal muscles
- Acting as the major transport system within the body
- Serving as the primary location of stored energy reserves
- Acting as the main source of immune responses

General Features of Connective Tissue

Cells in Connective Tissue

Cells vary according to the type of connective tissue and include the following:

Fibroblasts

- Large, flat cells with branching processes
- Present in all general connective tissues
- Most numerous cells of connective tissue
- Manufacture collagen fibers, elastic fibers, and extracellular matrix
- Actively involved in tissue repair and wound healing

Macrophages

- Phagocytic cells that develop from monocytes
- Large, irregular-shaped cells with cytoplasmic granules
- Two types:
    - Fixed (alveolar)
    - Motile
- Important components of the body's defense mechanism
- Engulf and digest cell debris, bacteria, and foreign particles

Plasma Cells

- Found in many parts of the body
- Most commonly located in connective tissue of:
    - Gastrointestinal tract
    - Respiratory tract

Mast Cells

- Similar in appearance to basophils
- Found in loose connective tissue
- Cytoplasm contains granules rich in:
    - Heparin
    - Histamine
    - Other substances released after tissue damage
- Involved in inflammatory response
- Participate in the body's reaction to injury or infection
- Can bind to, ingest, and kill bacteria

Adipocytes (Fat Cells)

- Occur singly or in groups
- Store triglycerides (fats)
- Vary in size and shape depending on fat content
- Found deep to the skin and around organs such as:
    - Heart
    - Kidneys

Leukocytes

- White blood cells are not present in large numbers in normal connective tissue
- Under certain conditions, they migrate from blood into connective tissue

Examples:

- **Neutrophils** gather at sites of infection
- **Eosinophils** migrate to sites of parasitic invasion and allergic responses

Classification of Connective Tissue

Embryonic Connective Tissue

- Mesenchyme
- Mucous (mucoid) connective tissue

Mature Connective Tissue

Connective Tissue Proper

- Flexible tissue
- Has a viscous ground substance with abundant fibers

Loose Connective Tissue

- Fibers are loosely arranged between cells
- Types:
    - Areolar connective tissue
    - Adipose tissue
    - Reticular connective tissue

Dense Connective Tissue

- Contains more fibers and fewer cells than loose connective tissue
- Types:
    - Dense regular connective tissue
    - Dense irregular connective tissue
    - Elastic connective tissue

Supporting Connective Tissue

Cartilage

- Firmer than other connective tissues
- Composed of a dense network of collagen and elastic fibers

- Fibers are firmly embedded in **chondroitin sulfate**, a gel-like component of the ground substance
- Can endure more stress than loose and dense connective tissues
- Strength is due to collagen fibers
- Resilience is due to chondroitin sulfate

Structural features:

- Few cells and large extracellular matrix
- No blood vessels or nerves present in the ECM
- Mature cartilage cells are called **chondrocytes**
- Chondrocytes occur singly or in groups within spaces called **lacunae**

Types of cartilage:

1. Hyaline cartilage
2. Fibrocartilage
3. Elastic cartilage

Bone

- Cartilage, joints, and bones together form the skeletal system
- Bones store:
    - Calcium
    - Phosphorus

Bone contains:

- **Red bone marrow** – produces blood cells
- **Yellow bone marrow** – stores triglycerides

Bone is composed of several connective tissues:

- Bone (osseous) tissue
- Periosteum
- Red and yellow bone marrow
- Endosteum (membrane lining spaces within bone that store yellow bone marrow)

Types of Bone (Based on ECM Organization)

1. **Compact bone**
    - Solid or dense appearance
2. **Spongy (cancellous) bone**
    - Spongy, fine honeycomb appearance

Compact Bone

- Basic structural unit is the **osteon** or **Haversian system**

Each osteon consists of **four parts**:

Lamellae

- Concentric rings of extracellular matrix
- Contain mineral salts, mainly calcium and phosphates
- Provide hardness and compressive strength
- Collagen fibers provide tensile strength
- Responsible for the compact nature of the bone

Lacunae

- Small spaces located between lamellae
- Contain mature bone cells called **osteocytes**

Canaliculi

- Minute canals extending from lacunae
- Contain processes of osteocytes
- Provide pathways for:
    - Nutrient delivery to osteocytes
    - Removal of waste products

Central Canal

- Also called the **Haversian canal**
- Contains:
    - Blood vessels
    - Nerves

Spongy Bone

- Does not contain osteons
- Consists of columns of bone called **trabeculae**
- Trabeculae contain:
    - Lamellae
    - Osteocytes
    - Lacunae
    - Canaliculi
- Spaces between trabeculae are filled with **red bone marrow**

Liquid Connective Tissue

- Has a liquid extracellular matrix

Two types:

1. Blood
2. Lymph

Lymph

- Extracellular fluid that flows through lymphatic vessels
- Contains several types of cells suspended in a clear liquid ECM
- Similar to blood plasma but contains much less protein

The composition of lymph varies in different parts of the body:

- Lymph leaving lymph nodes contains many lymphocytes
- Lymph from the small intestine contains newly absorbed dietary lipids

MUSCLE TISSUE

Muscle tissue consists of **elongated cells** known as **specialised contractile cells** called **muscle fibers** or **myocytes**.
These cells use **ATP** to generate force.

Muscle contraction requires a **rich blood supply**.

Functions of Muscle Tissue

- Able to contract and relax
- Provide movement within the body and of the body itself
- Maintain posture
- Generate heat
- Provide protection

Types of Muscle Tissue

Based on **location**, **structural features**, and **functional characteristics**, muscle tissue is of **three types**:

1. Skeletal muscle
2. Cardiac muscle
3. Smooth muscle

- Smooth muscle and cardiac muscle are **not under voluntary control**
- Skeletal muscle is **under voluntary control**
- Cardiac muscle and skeletal muscle are **striated (striped)**

SKELETAL MUSCLE

- **Skeletal muscle** forms the muscles that move the bones
- **Striated muscle** – fibers show striations, i.e., alternating light and dark bands
- **Voluntary muscle** – contraction and relaxation occur under conscious control

Location

- Attached to bones by **tendons**
- Helps in the movement of the skeleton
- **Diaphragm** – although skeletal muscle, it is under voluntary control during breathing

Description

- Contraction of a whole skeletal muscle occurs due to **coordinated contraction of individual muscle fibers**
- Skeletal muscle cells are:
  - Long
  - Roughly cylindrical in shape
  - Lie parallel to one another
  - Have a distinctive banded appearance with alternate dark and light stripes
- Muscle fiber length varies:
  - A few centimeters in short muscles
  - Up to **30–40 cm** in the longest muscles
- Each muscle fiber:
  - Has several nuclei
  - Nuclei are located just under the cell membrane called the **sarcolemma**
- The cytoplasm, known as **sarcoplasm**, is packed with tiny contractile filaments called **myofilaments**, which run longitudinally along the length of the muscle fiber
- Muscle fibers contain:
  - Numerous **mitochondria**, essential for producing ATP from glucose and oxygen
  - **Myoglobin**, a specialised oxygen-binding substance similar to haemoglobin
- Muscle fibers possess:
  - Extensive intracellular stores of **calcium**
  - Calcium is released into the sarcoplasm when the muscle is stimulated by its motor nerve
  - Calcium is essential for the contractile activity of myofilaments

Functions of Skeletal Muscle

- Motion
- Maintenance of posture
- Heat production
- Protection

SMOOTH MUSCLE

Description

- Consists of **non-striated fibers**
- Cells are:
  - Small
  - Spindle-shaped
  - Thickest in the middle
  - Tapering at each end
  - Contain a **single centrally located nucleus**
- Smooth muscle is **involuntary**
- Produces powerful contractions as fibers contract in unison
- **Gap junctions are absent** in some smooth muscles, so fibers contract individually
  - Example: **iris of the eye**
- Some smooth muscles have an intrinsic ability to initiate their own contractions (**automaticity**)
  - Example: **peristalsis**
- Contraction is regulated by:
  - Autonomic nerve impulses
  - Some hormones
  - Local metabolites
- Smooth muscle:
  - Is rich in mitochondria
  - Fatigues much more slowly than skeletal muscle
- Muscle cells are usually organized in **sheets** in the walls of hollow organs

Location of Smooth Muscle

- Iris of the eye
- Walls of hollow internal structures
- Blood vessels
- Airways of lungs
- Stomach
- Intestines
- Gallbladder
- Urinary bladder
- Uterus

Functions of Smooth Muscle

- Motion
- Regulation of diameter of blood vessels and parts of the respiratory tract
- Propulsion of contents in:
  - Ureters
  - Ducts of glands

    - Alimentary tract
- Contraction of urinary bladder and gall bladder for expulsion of contents
- Expulsion of contents of the uterus

NERVOUS TISSUE

The **nervous system** detects and responds to changes **inside and outside the body**.

Together with the **endocrine system**, it:

- Coordinates and controls vital aspects of body function
- Maintains **homeostasis**

Types of Nervous Tissue Cells

Two types of tissue are found in the nervous system:

Excitable Cells – Neurones

- Initiate, receive, conduct, and transmit information

Non-Excitable Cells – Glial Cells

- Support the neurones

Structure of a Neuron

Most neurons consist of **three basic parts**:

1. Cell body
2. Dendrites
3. Axon

Cell Body

- Contains the nucleus and other organelles

Dendrites

- Short, tapering, and highly branched cell processes
- Function as the **receiving or input portion** of the neuron

Axon

- Single, thin, cylindrical process

- May be very long
- Functions as the **output portion** of the neuron