Tissues: types & functions

APL, BPH

First sem, PU

Human tissues & their development

- **Definition**: Groups of cells and surrounding materials (Intercellular matrix) that work together to perform a specific function are referred to as tissue. All basic tissue types are present in a single organ.

- The science that deals with the study of tissues is called **histology.**
- The cells of tissue are derived from the **3 cellular layers, of the embryo, namely ectoderm, mesoderm, endoderm.**

Among different tissues,

- the cells of epithelial tissue are derived from all 3 germ layers
- where as cells of connective tissue are derived from mesodermal layer of embryo
- and the cells of nervous tissue are derived from ectoderm

Types of human tissue

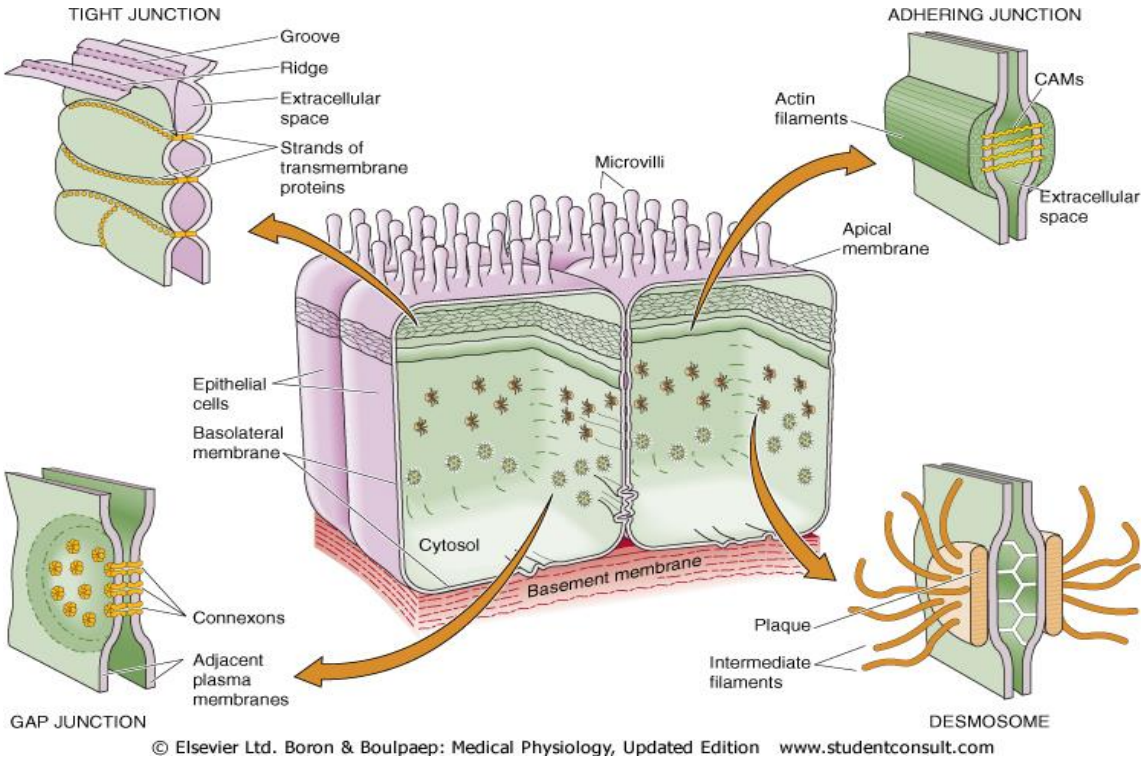
There are four basic types of tissues in our body:

1. **Epithelial tissue** covers body surfaces, forms glands, and lines body cavities, hollow organs, and ducts.
2. **Connective tissue** protects and supports the body and its organs, binds organs together, stores energy reserves as fat, and provides immunity.
3. **Muscular tissue** generates the physical force needed to make body structures move.
4. **Nervous tissue** detects changes inside and outside the body and generates transmits nerve impulses that coordinate body activities to help maintain homeostasis.

Most epithelial cells and some muscle and nerve cells are tightly joined into functional units by points of contact between their plasma membranes called **cell junctions.**

- **Tight junctions** fuse cells together tightly to **prevent substances from passing between the cells.**

In tissues that line the stomach, intestines, and urinary bladder, tight junctions prevent the contents of these organs from leaking out.



- Some cell junctions **hold cells together so that they don't separate while performing their functions**: **Adhering junction, desmosomes**.
- **Gap junctions** form channels that allow ions and molecules to pass between cells.

1. Epithelial tissue: covers body surface, cavities

- Epithelial tissue, or an **epithelium** is a sheet of cells that covers a body surface or lines a body cavity. It occurs in the body as (1) **covering and lining epithelium** and (2) **glandular epithelium**.

- Covering and lining epithelium forms the outer layer of the skin and lines the open cavities of the cardiovascular, digestive, and respiratory systems, and covers the walls and organs (heart, lungs, kidney, liver, spleen etc.) of the closed ventral cavities (pericardial, pleural, peritoneum cavity).

- Glandular epithelium forms secretory glands, such as sweat glands.

general features of epithelial tissue

1. Consist of continuous sheets (single or multiple layers-stratified) of closely packed cells with little extracellular material between them

2. Have three types of surfaces:

   Apical (free surface): Exposed to body cavity, lining of an internal organ, or exterior of the body

   Lateral surface: Faces adjacent surrounding cells.

   Basal surface. Attached to a **basement membrane**; which is a thin, extracellular structure made of protein fibers and which lies between the epithelial cells and the underlying connective tissue.

In stratified (multilayer) epithelia, the uppermost layer is the apical layer, while the deepest layer is the basal layer.

3. Lack blood vessels and get their nutrients from the connective tissue below by diffusion

4. Have a nerve supply

5. Divide rapidly and continuously to replace worn-out and injured cells

Functions of epithelial tissue

(1) protection: The epithelium of the **skin** protects underlying tissues from mechanical and chemical injury and bacterial invasion

(2) absorption: The epithelium lining the **digestive tract** is specialized to absorb substances

(3) filtration
(4) excretion,

} **kidneys** performs nearly the whole functional "menu"—excretion, absorption, secretion, and filtration.

(5) secretion: Secretion is the specialty of **glands** which secrete **hormones.**

(6) sensory reception: Epithelium contains nerve endings that respond to various stimuli acting at the skin surface (**pressure, heat,** etc.) also sensory epithelia are seen in **olfactory (smell), vestibulocochlear (hearing & balance- internal ear)**

Types of epithelial tissue

Each epithelium is given two names. The first name indicates the **number of cell layers present**; the second describes the **shape of its cells**.

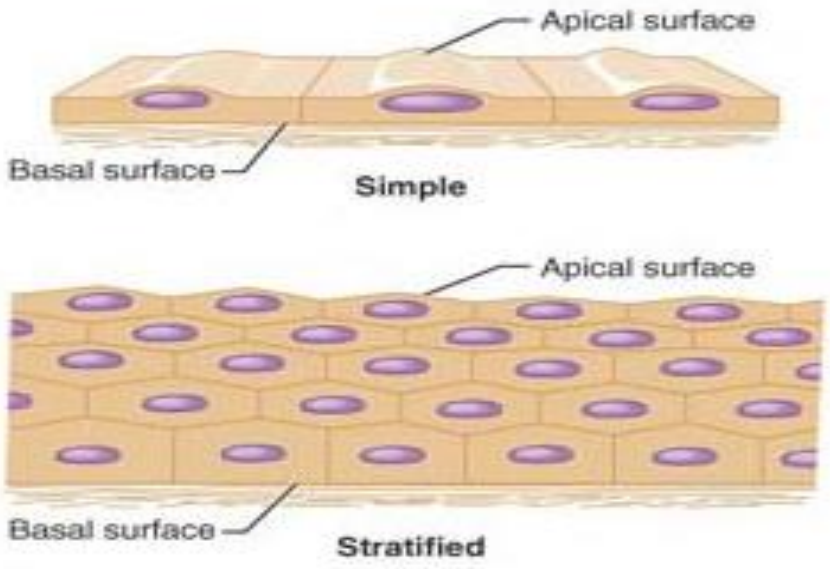
1. **Based on the number of cell layers**, there are **simple and stratified epithelia**.

a. Simple epithelia

are composed of a single cell layer. They are typically found where absorption and filtration occur and a thin epithelial barrier is desirable.

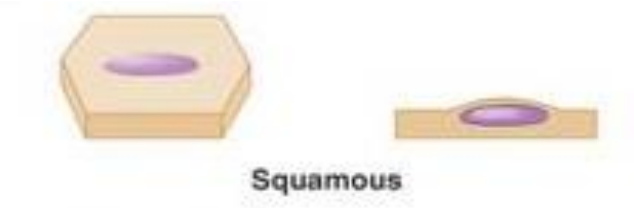
b. Stratified epithelia,

consisting of two or more cell layers stacked one on top of the other, are common in high-abrasion areas where protection is important, such as the skin surface and the lining of the mouth.

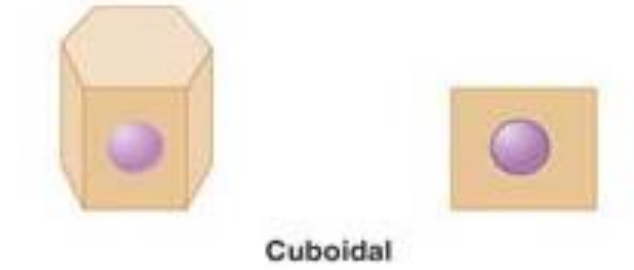


2. <u>Based on the shape & height</u>, there are three common shapes of epithelial cells.

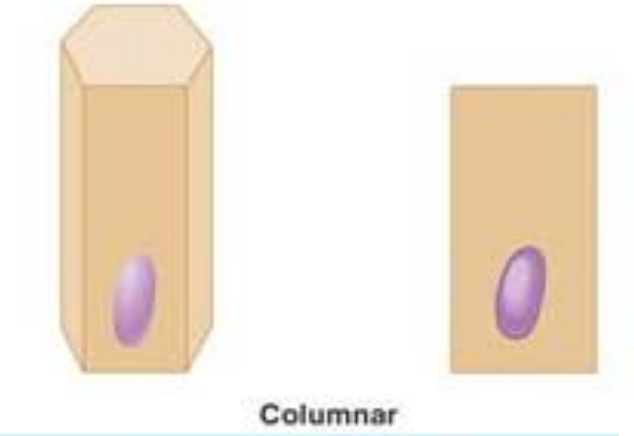
a. Squamous cells: flattened and scale like (squam = scale) and nucleus is flattened disc.



b. cuboidal cells: boxlike, approximately as tall as they are wide and nucleus is spherical.



c. columnar cells: tall and column shaped. Nucleus is elongated from top to bottom and usually located close to the cell base.



a. Simple Squamous Epithelium

(a) Simple squamous epithelium

Description: Single layer of flattened cells with disc-shaped central nuclei and sparse cytoplasm; the simplest of the epithelia.

Function: Allows passage of materials by diffusion and filtration in sites where protection is not important; secretes lubricating substances in serosae.

Location: Kidney glomeruli; air sacs of lungs; lining of heart, blood vessels, and lymphatic vessels; lining of ventral body cavity (serosae).

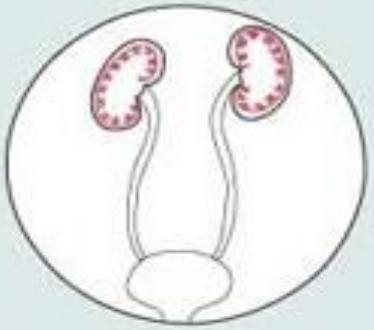
b. Simple cuboidal epithelium

(b) Simple cuboidal epithelium

Description: Single layer of cubelike cells with large, spherical central nuclei.

Function: Secretion and absorption.

Location: Kidney tubules; ducts and secretory portions of small glands; ovary surface.



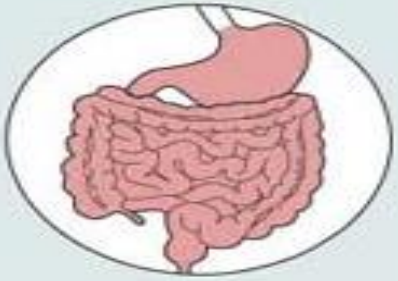
C. Simple columnar epithelium

(c) Simple columnar epithelium

Description: Single layer of tall cells with *round* to *oval* nuclei; some cells bear cilia; layer may contain mucus-secreting unicellular glands (goblet cells).

Function: Absorption; secretion of mucus, enzymes, and other substances; ciliated type propels mucus (or reproductive cells) by ciliary action.

Location: Nonciliated type lines most of the digestive tract (stomach to anal canal), gallbladder, and excretory ducts of some glands; ciliated variety lines small bronchi, uterine tubes, and some regions of the uterus.



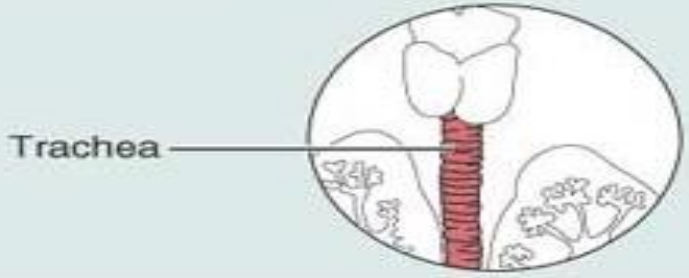
d. Pseudo- stratified columnar epithelium

(d) Pseudostratified columnar epithelium

Description: Single layer of cells of differing heights, some not reaching the free surface; nuclei seen at different levels; may contain goblet cells and bear cilia.

Function: Secretion, particularly of mucus; propulsion of mucus by ciliary action.

Location: Nonciliated type in male's sperm-carrying ducts and ducts of large glands; ciliated variety lines the trachea, most of the upper respiratory tract.

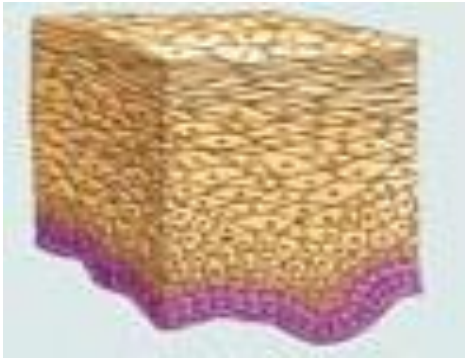


cell nuclei lie at different levels above the basement membrane, the tissue gives the **false (pseudo)** impression that several cell layers are present; hence "pseudostratified."

e. Stratified epithelium

Stratified epithelium is thick membrane which contains two or more cell layers. They regenerate from below; that is, the basal cells divide and push apically to replace the older surface cells.

Basal cells are cuboidal or columnar but apical cells are squamous (flattened) type.



4 types have been found:

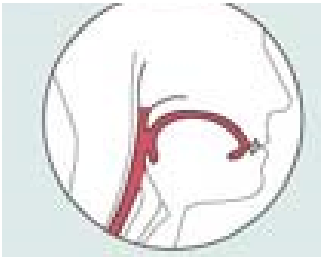
1. Stratified squamous
   i. Keratinizing
   ii. Non-keratinizing
2. Stratified cuboidal: is quite rare in the body, mostly found in the ducts of some of the larger glands (sweat glands, mammary glands). It typically has two layers of cuboidal cells.
3. Stratified columnar: also has a limited distribution in the body. Small amounts are found in the pharynx & the male urethra.
4. Transitional epithelium: forms the lining of hollow urinary organs, which stretch as they fill with urine

1. stratified squamous epithelium

- These are multilayered epithelia in which there is a constant formation, maturation, and loss of cells.

- The cells are formed at the innermost or basal layer; gradually move superficially (apically) and eventually shed from the surface.
- This epithelium is found in areas subjected to wear and tear, this epithelium forms the external part of the skin and extends a short distance into every body opening (buccal cavity, oropharynx, anal canal, vagina) that is directly continuous with the skin.

- The basal cells are columnar; intermediate cells are cuboidal or polygonal; superficial cells are flattened (squamous).



- Two major types: **keratinized** and **non keratinized.**

Keratinized stratified epithelium

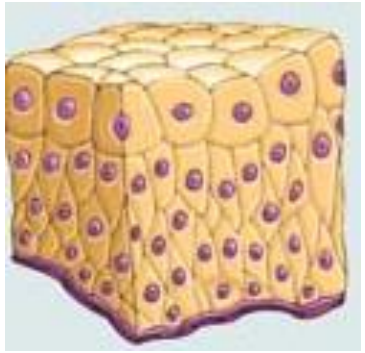
- Found on dry surfaces subjected to wear and tear, i.e. skin, hair, nail.
- Surface layer; dead epithelial that have lost their nuclei and contain the protein called keratin.
- The keratin filament forms a coat on the cell surface.
- This forms a tough, relatively waterproof protective layer that prevents drying of the live cells underneath.

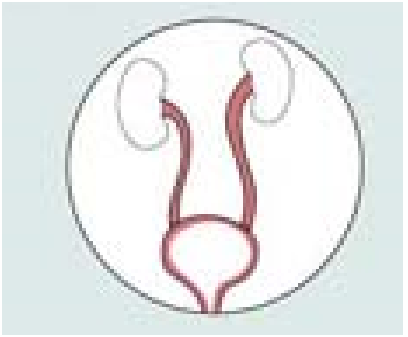
Non-keratinized stratified epithelium

- This protect moist surface subjected to wear and tear , and prevents them from drying out.
- There are 6-10 layers of cells
- e.g. the conjunctiva of eyes, the lining of the mouth, the pharynx, the esophagus and the vagina

Transitional Epithelium:

- Forms the lining of hollow urinary organs, which stretch as they fill with urine.
- Exclusively lines the urinary tract (renal pelvis, ureter, bladder and part of urethra) so exposed to internal pressure and capacity.
- Its appearance varies with degree of distension. When the organ is distended with urine, the transitional epithelium thins from about six cell layers to three, and its domelike apical cells (superficial cells) flatten and become squamous like but cuboidal when relaxed.
- The superficial cells are also known as “umbrella cells”
- The ability of transitional cells to change their shape (undergo “transitions”) allows a greater volume of urine to flow through a tube like organ. In the bladder, it allows more urine to be stored.





Connective tissues

- Found everywhere in the body. It is the **most abundant** and widely distributed of the primary tissues, skin consists primarily of connective tissue, while the **brain contains very little**. The connective tissue cells are more widely separated from each other than in epithelial tissue.
- Intercellular substance (matrix); abundant in connective tissue.
- Unlike epithelium, most connective tissue has a rich supply of blood vessels.

It has various forms and performs the **following functions:**

- Binds together, supports, and strengthens other tissues
- Protects and insulates internal organs
- Divides structures into compartments
- Transports materials throughout the body
- Stores energy (in fat tissues and cells)
- Protects the body by destroying invading microorganisms and eliminating cellular debris

Components of connective tissues

Connective tissue consists of two major components, **cells** and **the extracellular matrix.**

The cells include fibroblasts, macrophages, plasma cells, mast cells, and adipocytes, as well as some white blood cells (neutrophils, eosinophils).

The extracellular matrix includes various fibers—for example, collagen, elastic fibers, and ground substance made up of water and various organic molecules.

The main classes of connective tissues are

(1) connective tissue proper (which includes fat and the fibrous tissue of ligaments),

(2) cartilage

(3) bone tissue,

(4) blood.

Components of connective tissue • Figure 3.23

Connective tissue consists of various cells, fibers, and other substances (ground substance).

Reticular fibers
(re-TIK-ū-lar) are made of collagen and glycoproteins. They provide support in blood vessel walls and form branching networks around various cells (fat, smooth muscle, nerve).

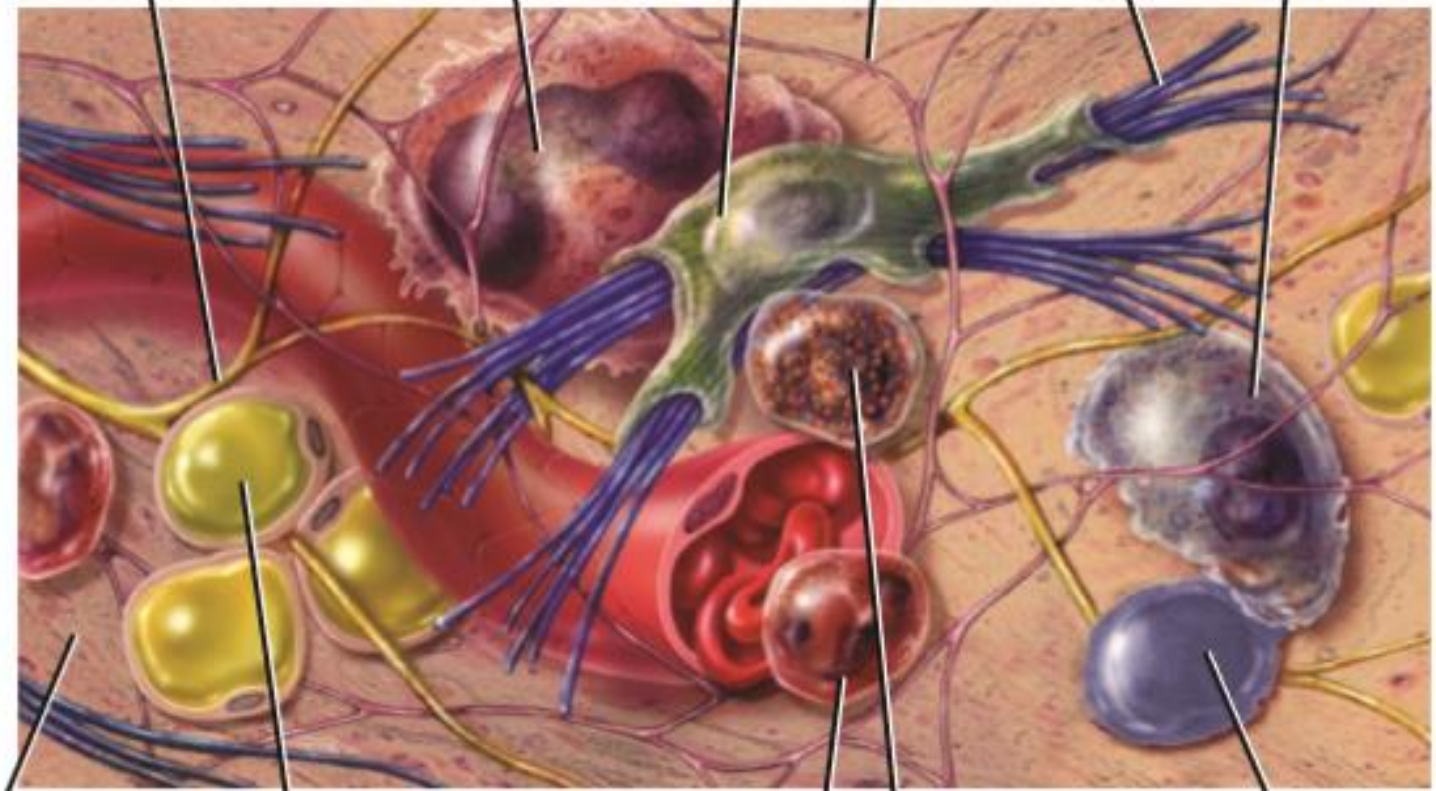
Fibroblasts
(FI-brō-blasts) are large flat cells that move and secrete fibers and ground substance.

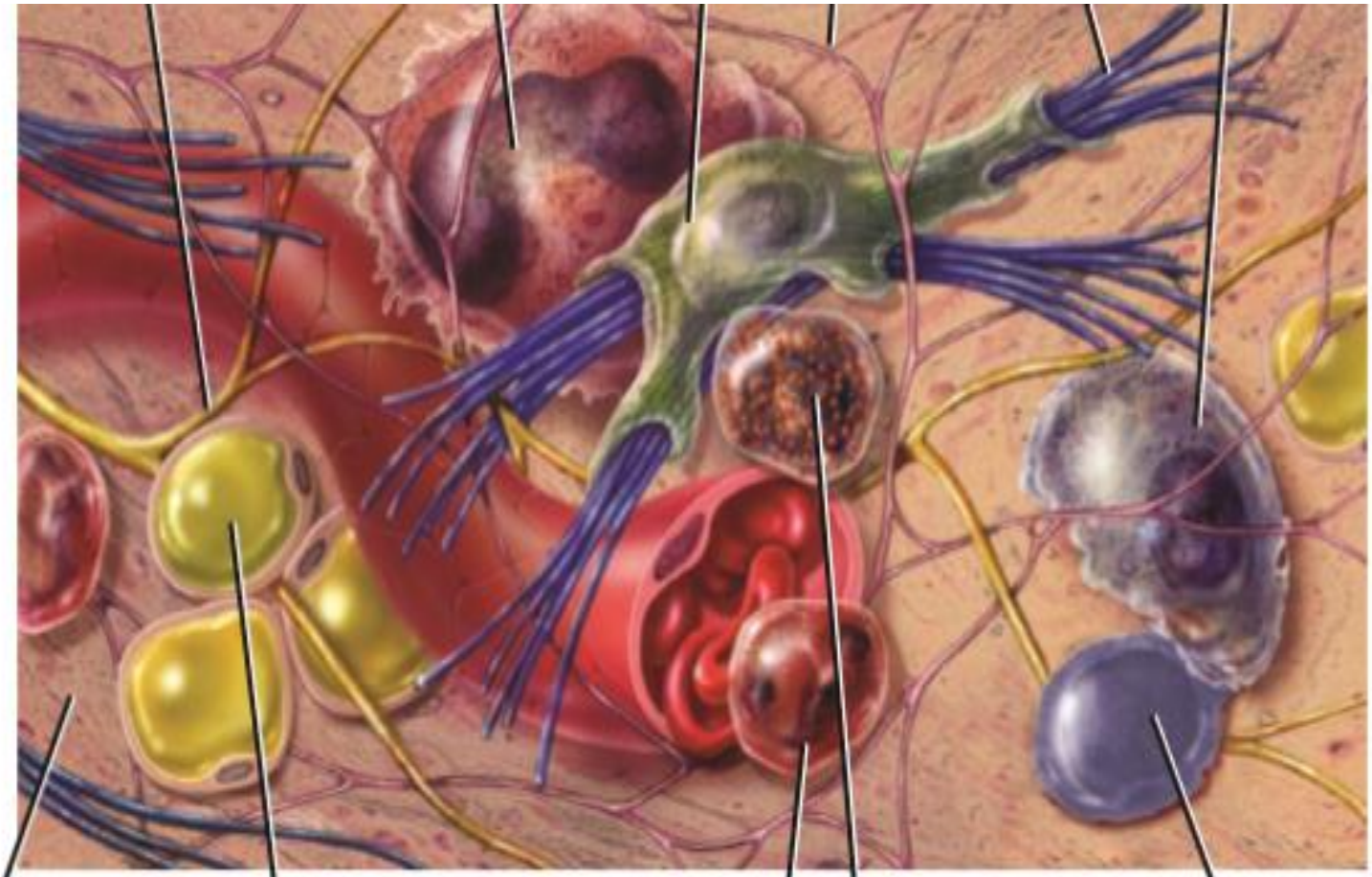
Collagen fibers
(KOL-a-jen) are strong, flexible bundles of the protein collagen, the most abundant protein in your body.

Macrophages
(MAK-rō-fāj-es) develop from white blood cells. They eat bacteria and cell debris by phagocytosis.

Mast cells
are abundant along blood vessels. They produce histamine, which dilates small blood vessels during inflammation and kill bacteria.

Elastic fibers
are stretchable but strong fibers made of proteins, elastin, and fibrillin. They are found in skin, blood vessels, and lung tissue.





Adipocytes

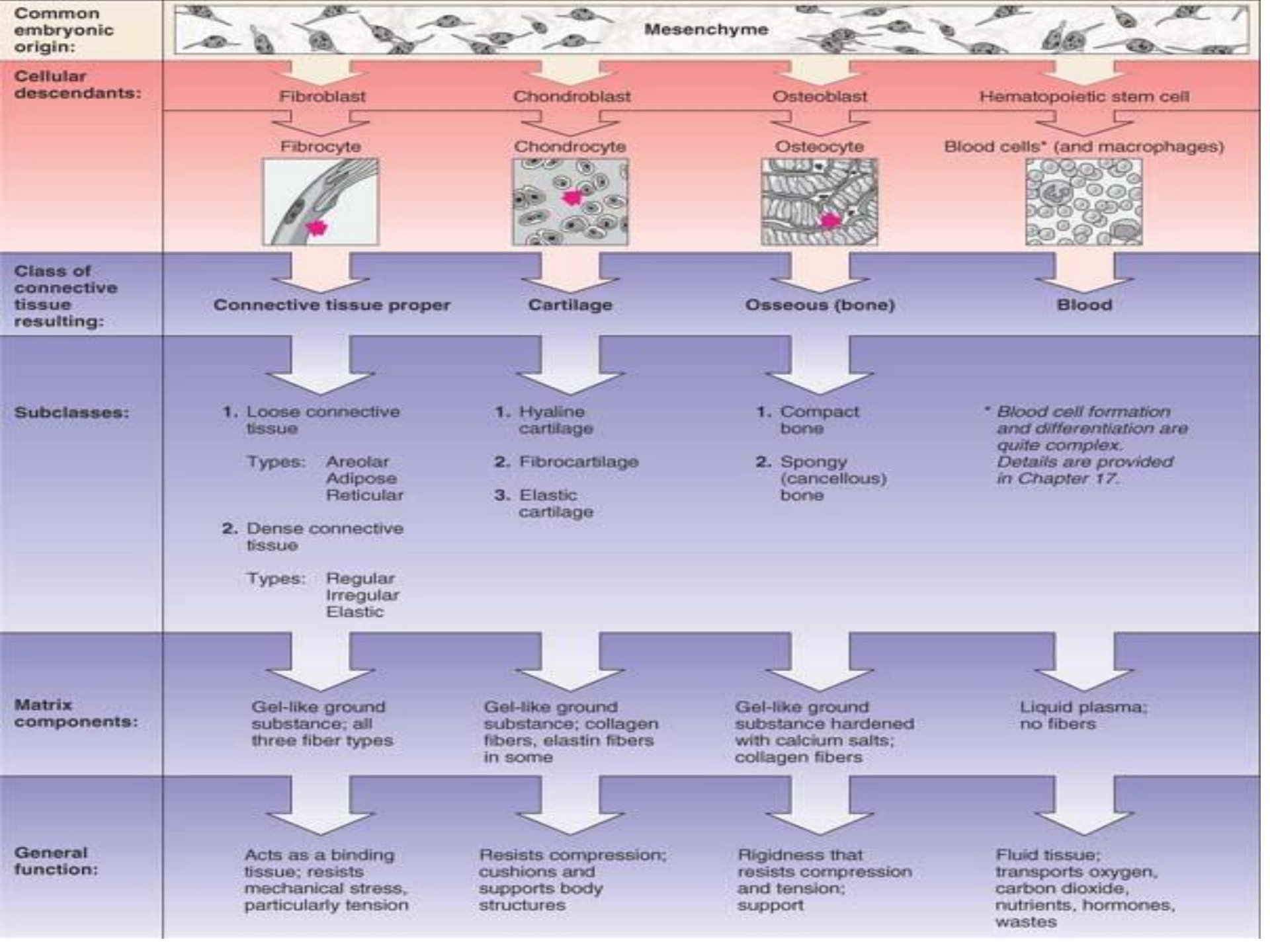
They are found below the skin and around organs (heart, kidney).

Ground substance
is the stuff between cells and fibers. It is made of water and organic molecules (hyaluronic acid, chondroitin sulfate, glucosamine). It supports cells and fibers, binds them together, and provides a medium for exchanging substances between blood and cells.

Eosinophils
(e-ō-SIN-ō-filz) are white blood cells that migrate to sites of parasitic infection and allergic responses.

Neutrophils
(NOO-trō-filz) are white blood cells that migrate to sites of infection.

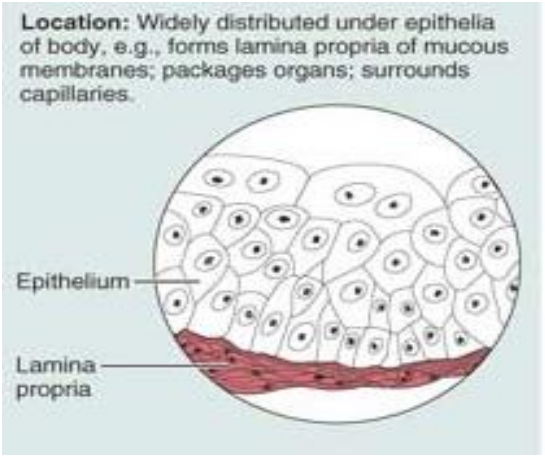
Plasma cells
are small cells that develop from a white blood cell. They secrete antibodies that attack and neutralize foreign substances.


Common embryonic origin:
Mesenchyme
Cellular descendants:
Fibroblast
Chondroblast
Osteoblast
Hematopoietic stem cell
Fibrocyte
Chondrocyte
Osteocyte
Blood cells* (and macrophages)
Class of connective tissue resulting:
Connective tissue proper
Cartilage
Osseous (bone)
Blood
Subclasses:
1. Loose connective tissue
Types: Areolar
Adipose
Reticular
2. Dense connective tissue
Types: Regular
Irregular
Elastic
1. Hyaline cartilage
2. Fibrocartilage
3. Elastic cartilage
1. Compact bone
2. Spongy (cancellous) bone
* Blood cell formation and differentiation are quite complex. Details are provided in Chapter 17.
Matrix components:
Gel-like ground substance; all three fiber types
Gel-like ground substance; collagen fibers, elastin fibers in some
Gel-like ground substance hardened with calcium salts; collagen fibers
Liquid plasma; no fibers
General function:
Acts as a binding tissue; resists mechanical stress, particularly tension
Resists compression; cushions and supports body structures
Rigidness that resists compression and tension; support
Fluid tissue; transports oxygen, carbon dioxide, nutrients, hormones, wastes

1. **<u>Connective Tissue Proper</u>** :two subclasses:

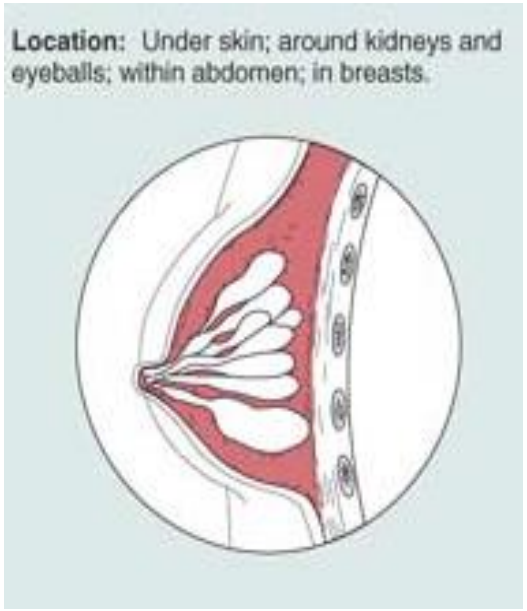
- ❑ the loose connective tissues (areolar, adipose, and reticular) and
- ❑ dense connective tissues (dense regular, dense irregular, and elastic).

Loose, areolar

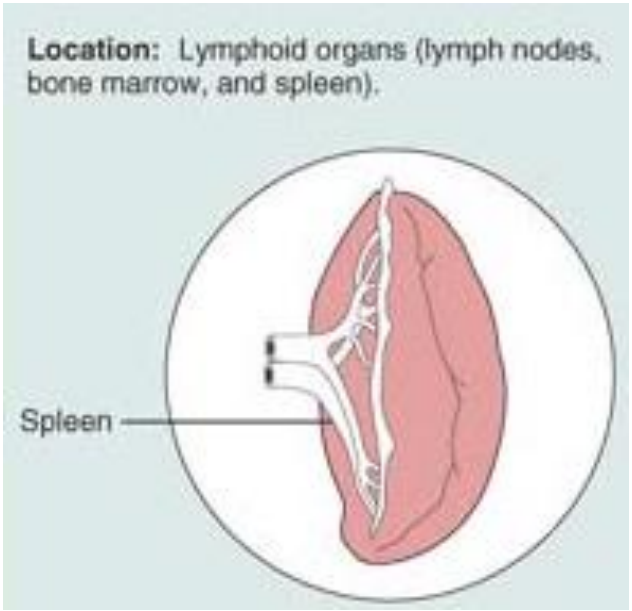


Except for bone, cartilage, and blood, all mature connective tissues belong to this class.

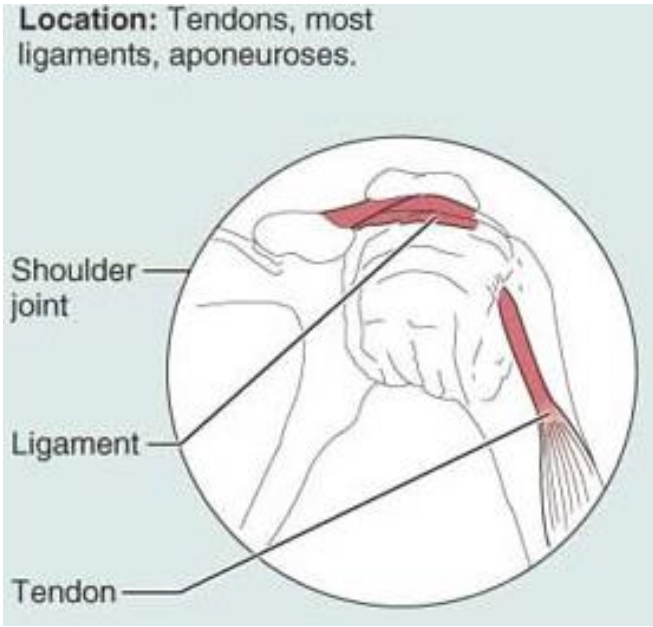
Loose, adipose



Loose, reticular



Dense connective



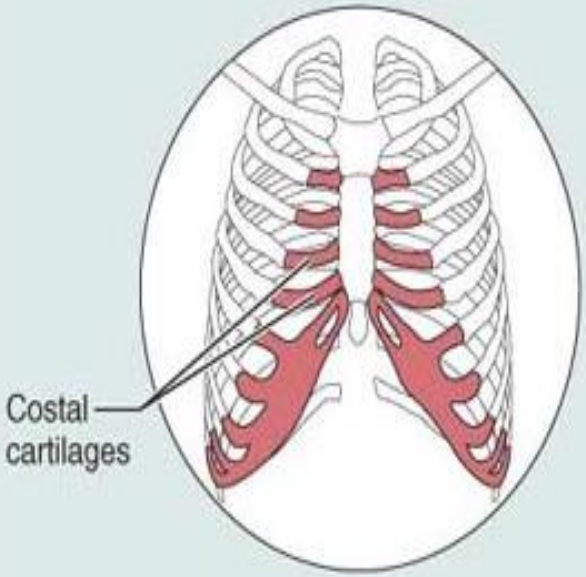
Two types of adipose: **White adipose**: support kidneys, eyes, thermal insulator and energy store. **Brown adipose**: newborn, produce less energy but more heat

2. Cartilage:

Hyaline

Function: Supports and reinforces; has resilient cushioning properties; resists compressive stress.

Location: Forms most of the embryonic skeleton; covers the ends of long bones in joint cavities; forms costal cartilages of the ribs; cartilages of the nose, trachea, and larynx.



Elastic

Description: Similar to hyaline cartilage, but more elastic fibers in matrix.

Function: Maintains the shape of a structure while allowing great flexibility.

Location: Supports the external ear (pinna); epiglottis.

fibrocartilage

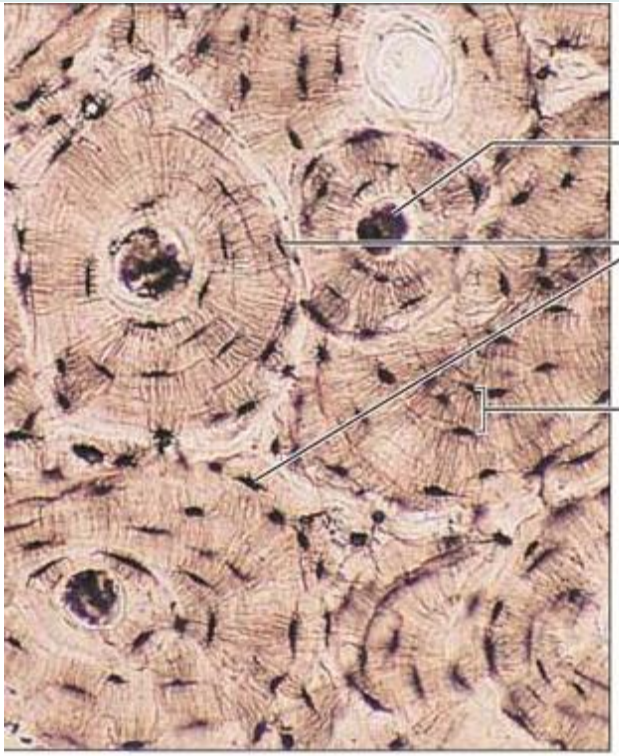
Function: Tensile strength with the ability to absorb compressive shock.

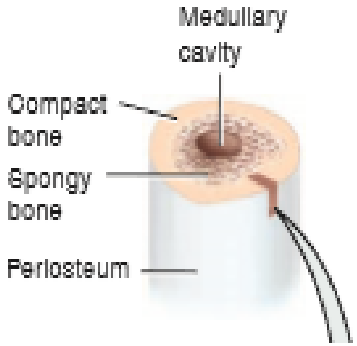
Location: Intervertebral discs; pubic symphysis; discs of knee joint.

3. Bone tissue

Description: Hard, calcified matrix containing many collagen fibers; osteocytes lie in lacunae. Very well vascularized.

Function: Bone supports and protects (by enclosing); provides levers for the muscles to act on; stores calcium and other minerals and fat; marrow inside bones is the site for blood cell formation (hematopoiesis).





ograph: Cross-sectional view of bone (70×).

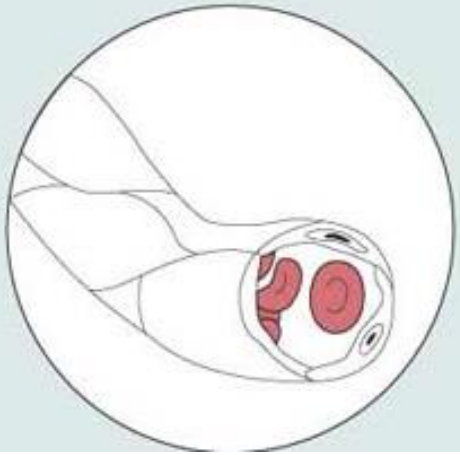
Note: Because cartilage is avascular and aging cartilage cells lose their ability to divide, cartilages heal slowly when injured.

4. Blood cells

Description: Red and white blood cells in a fluid matrix (plasma).

Function: Transport of respiratory gases, nutrients, wastes, and other substances.

Location: Contained within blood vessels.



Muscular Tissue Generates Force for Movement

Muscular tissue is composed of elongated muscle cells called muscle fibers. The job of muscular tissue is to generate force, which produces motion, maintains posture, and generates heat. There are three types of muscular tissue: skeletal, smooth & cardiac.

1. Skeletal muscle.

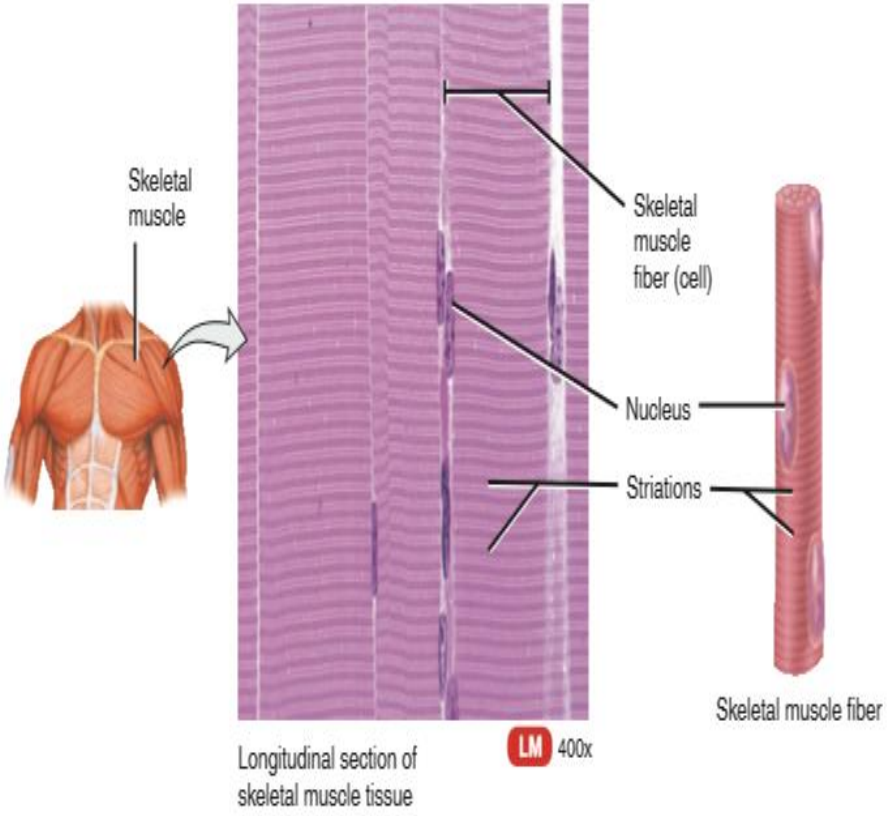
- These groups of long (up to 35 cm),
- multi- nucleated cells with

regular bands or striations.

- generate force upon voluntary commands, under our control.
- This muscle is usually attached to

the skeleton and contracts voluntarily.

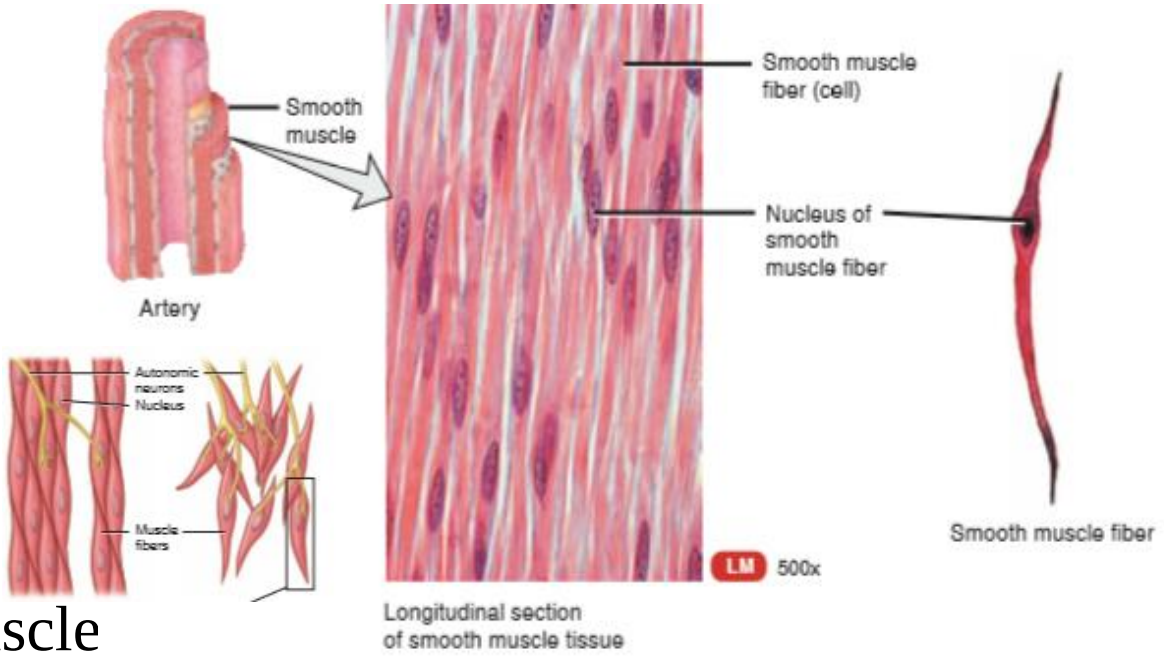
Note: Skeletal muscle contraction is stimulated by motor nerve impulses from brain.

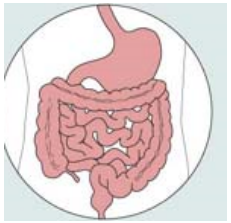


Note Striations are apparent in skeletal muscle and are due to the highly organized arrangement of thick and thin filaments in the myofibrils of the skeletal muscle fibers.

2. **Smooth muscle**.

- Small cells with **one nucleus**.
- capable of stretching
- part of blood vessels, the stomach, intestines uterus, and bladder.
- Individual smooth muscle cells are **spindle shaped**
- **no striations** and
- contracts **involuntarily**, not under our conscious control
- Smooth muscle activity is controlled by nerves (principally **autonomic**), circulating hormones, locally generated signaling substances, junctions with other smooth muscle cells, and even junctions with other non-smooth muscle cells.

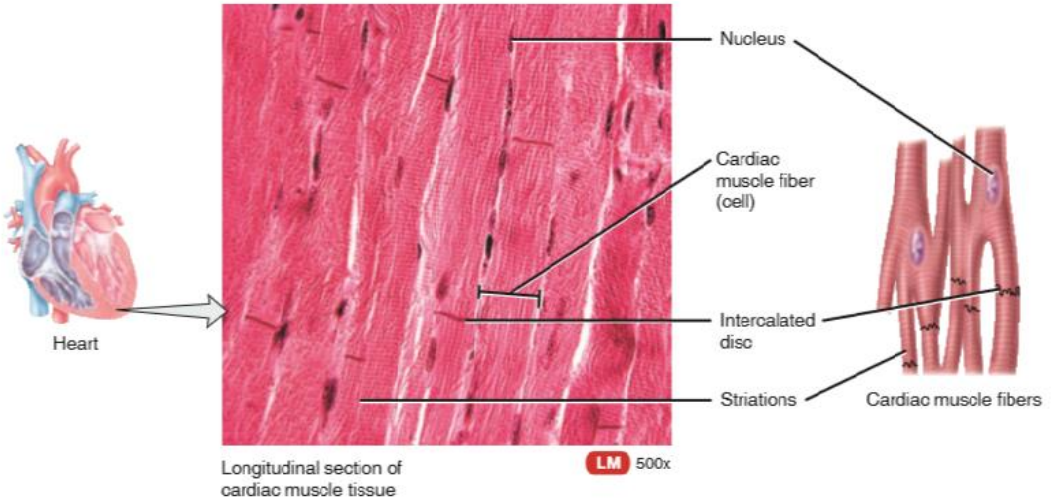




3. Cardiac muscle

- found only in the wall

of the heart. Its contractions help propel blood through the blood vessels to all parts of the body



- The intermediate-sized cells that make up this tissue are connected to one another by cell junctions called **intercalated discs.**
- Cardiac muscle has striations like that of skeletal muscle however they **differ** structurally in that cardiac cells

(1) are **uninucleate**

(2) are branching cells that fit together tightly at unique junctions called **intercalated disc** and

(3) contracts **involuntarily**

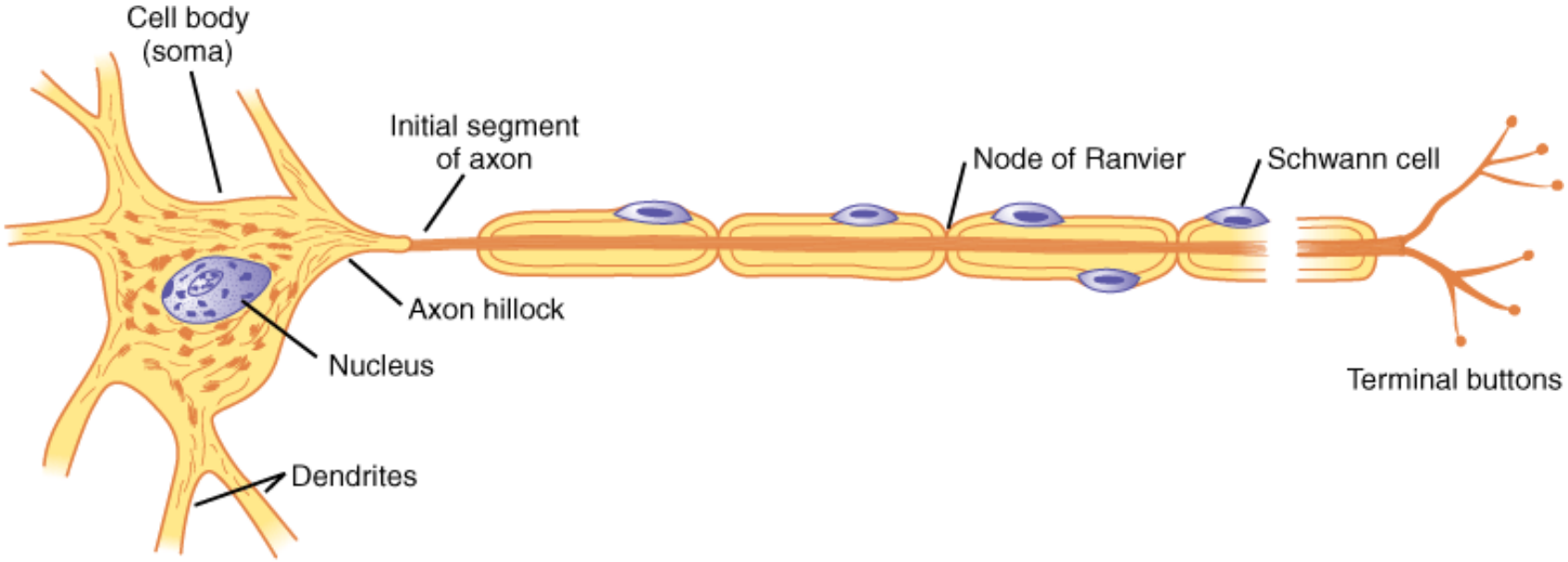
Summary

Type	functions	location
Skeletal muscle tissue (striated)	Voluntary movements of skeletal parts	Muscles usually attached to bones
Smooth muscle Tissue (lack striated)	Involuntary movements of internal organs	Walls of hollow organs
Cardiac muscle tissue (striated)	Heart movements	Heart muscles

- **nervous tissue consists of only two types of cells**: **<u>neurons and neuroglia .</u>**
- The basic unit of the nervous system is the individual nerve cell, or neuron. **Neurons** operate by generating electrical signals that move from one part of the cell to another part of the same cell or to neighboring cells.
- Neurons, or nerve cells, are specialized cells that are sensitive to various **stimuli (pain, temp, sound, heat, light).** They convert stimuli into nerve impulses and conduct these impulses to other neurons, to muscle fibers, or to glands.
- Neurons can be small or large. For example, some neurons within the brain may extend only a few inches, while a spinal neuron from the spinal cord to a muscle in your foot may extend well over a foot.
- **Neuroglia** are supporting cells that do not generate or conduct nerve impulses but have many other important **supportive functions.** For many years following their discovery, **glial cells (or glia)** were viewed as **CNS connective tissue**. In fact, the word *glia* is Greek for *glue*. However, today theses cells are recognized for their role in communication within the CNS in **partnership with neurons**.

Nerve cell of nervous tissue (neurons): never dividing cells

Numerous projections of the cell body of the neuron called **dendrites** receive nerve impulses from other cells.
Increase a cell's capacity to receive signals from many other neurons.
A long projection of the neuron cell body called an **axon/** called a **nerve fiber** conducts each impulse away from the cell body to other cells/ target cells



Source: Barrett KE, Barman SM, Boitano S, Brooks H: *Ganong's Review of Medical Physiology, 23rd Edition*: http://www.accessmedicine.com

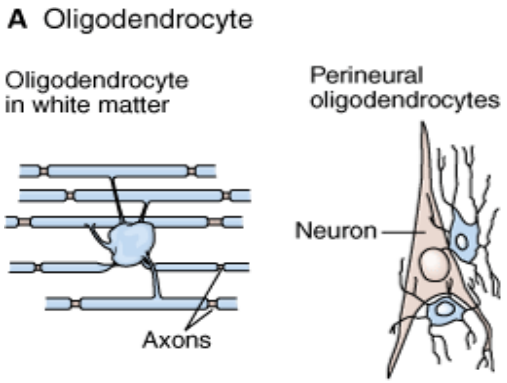
Neuroglial Cells (supporting cells of nervous tissue)

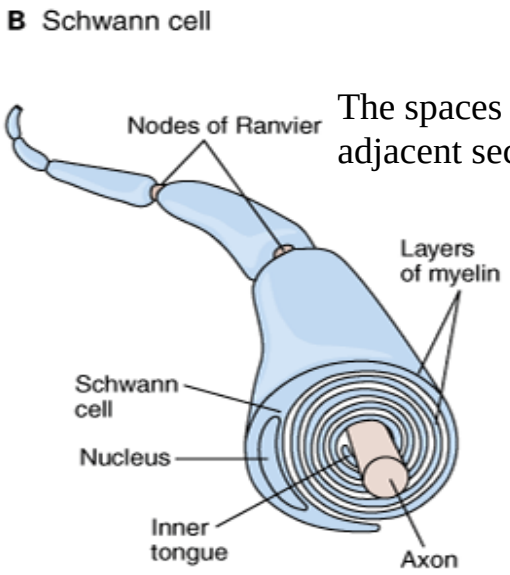
The neurons of the central nervous system are **supported by** several varieties of **nonexcitable cells**, which together are called neuroglia. Neuroglial cells are generally **smaller than neurons** and **more than five to ten times than neurons**; they comprise about **half the total volume of the brain and spinal cord.**

- glial cells (*glia* is Greek for *glue)* unlike neurons, continue to undergo **cell division**
- There are **two major types of glial cells** in the vertebrate nervous system: **microglia** and **macroglia**

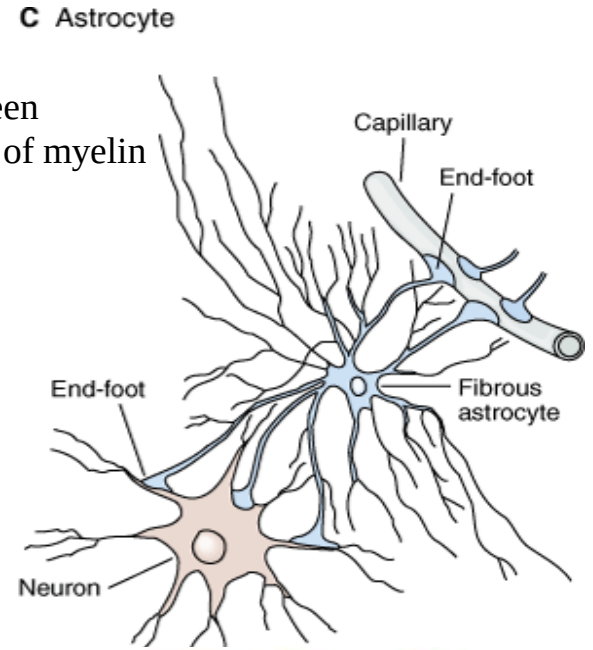
1. **Microglia** are scavenger (hunter) cells that resemble tissue macrophages and remove debris resulting from injury, infection, and disease (eg, multiple sclerosis, AIDS-related dementia, Parkinson disease, and Alzheimer disease). Microglia arse from macrophages outside of the nervous system.

2. **Macroglia**: 3 types
   a) oligodendrocytes,
   b) Schwann cells, and
   c) astrocytes





The spaces between adjacent sections of myelin



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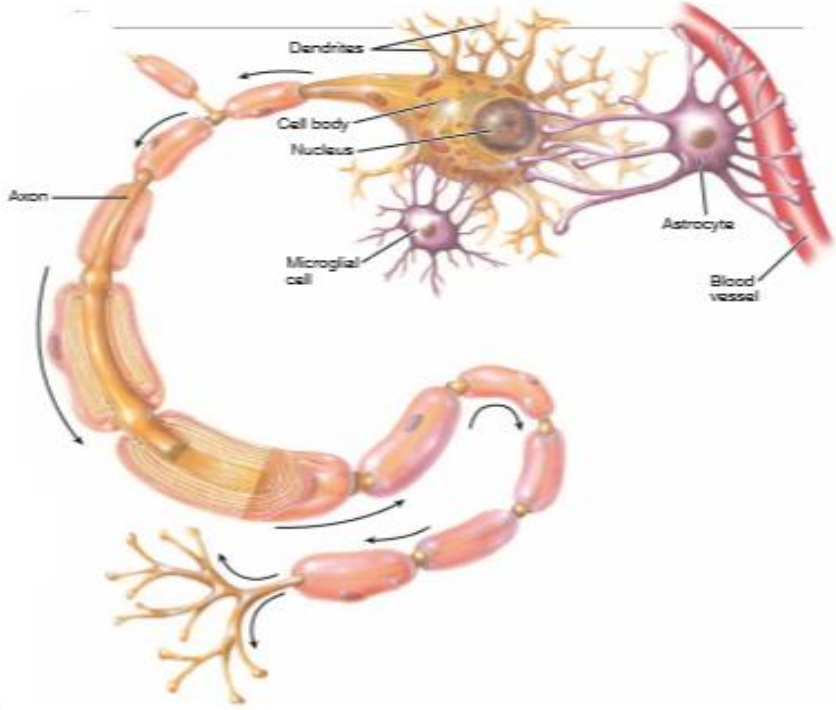

Astrocytes induce capillaries to form the tight junctions making up the **blood–brain barrier.**

Oligodendrocites and schwan cells form Myelin sheath around axon. The myelin sheath **speeds up conduction of the electrical signals** along the axon and conserves energy

Origin and Principal Functions of Neuroglial Cells.

Glial Cell Type	Origin	Location	Main Functions
Oligodendrocyte	Neural tube	Central nervous system	Myelin production, electric insulation
Schwann cell	Neural tube	Peripheral nerves	Myelin production, electric insulation
Astrocyte	Neural tube	Central nervous system	Structural support, repair processes
			Blood–brain barrier, metabolic exchanges
Ependymal cell	Neural tube	Central nervous system	Lining cavities of central nervous system
Microglia	Bone marrow	Central nervous system	Macrophagic activity