Lecture 16

BT 636
Tissue Engineering and Regenerative Medicine
(3-0-0-6)

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Tissue

- The body contains at least 200-220 distinct cell types. These cells contain essentially the same internal structures, yet they vary enormously in shape and function.

- The different types of cells are not randomly distributed throughout the body; rather, they occur in organized layers, a level of organization referred to as tissue.

- The term tissue is used to describe a group of cells found together in the body and serves a common function. The cells within a tissue share a common embryonic origin. Microscopic observation reveals that the cells in a tissue share morphological features and are arranged in an orderly pattern that achieves the tissue's functions.

- From the evolutionary perspective, tissues appear in more complex organisms. For example, multicellular protists, ancient eukaryotes, do not have cells organized into tissues.

- Having tissue-level organization increases the efficiency of the body, as different shapes and internal structures are better suited to carry out different functions.

- Having different tissues for different functions allows for a greater speed of activity and greater effectiveness in performing the various activities.

Different types of tissues present in a human body

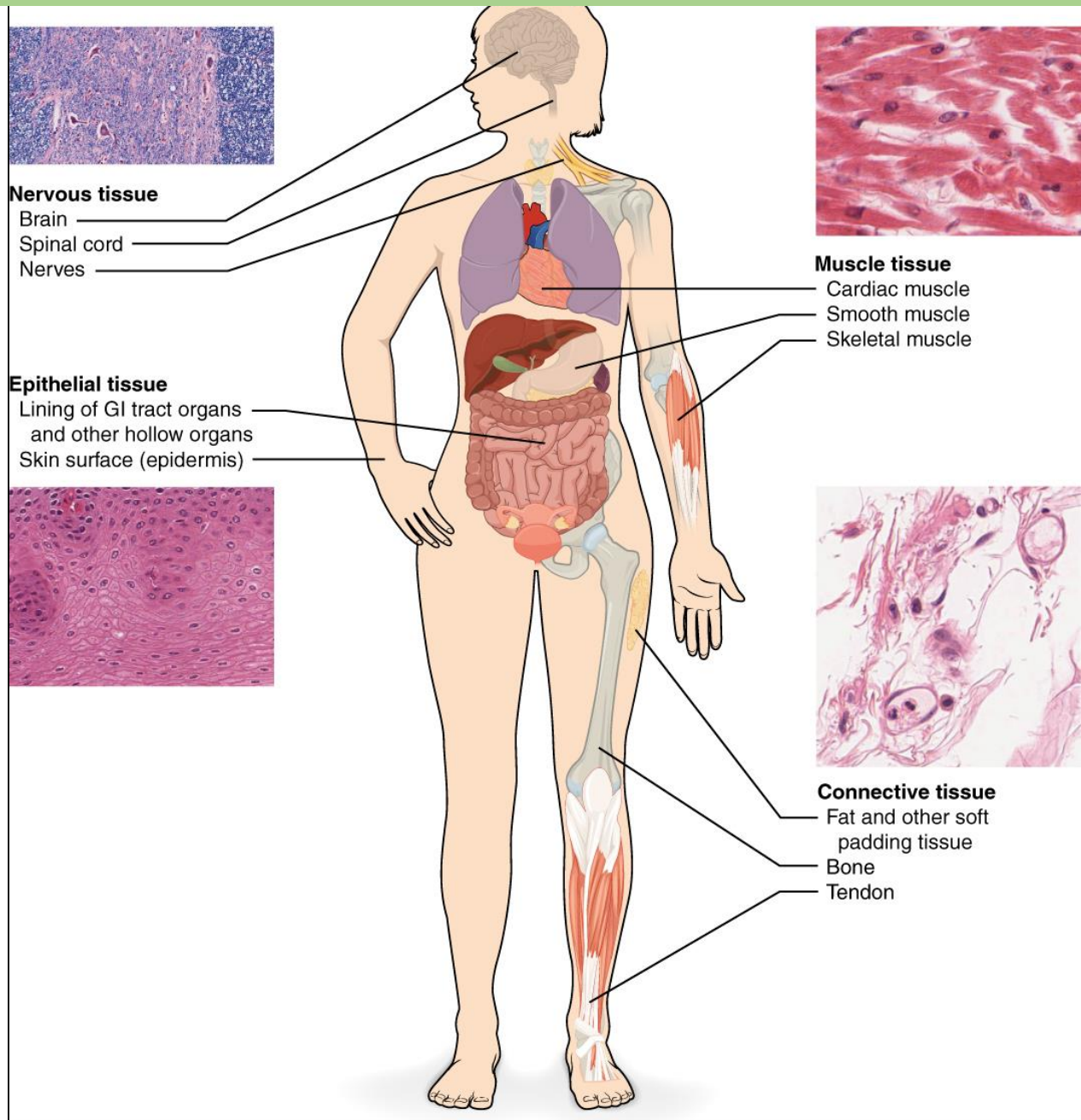
Human body tissue consists of groups of cells with a similar structure working together for a specific function. There are four main types of tissues in a body.

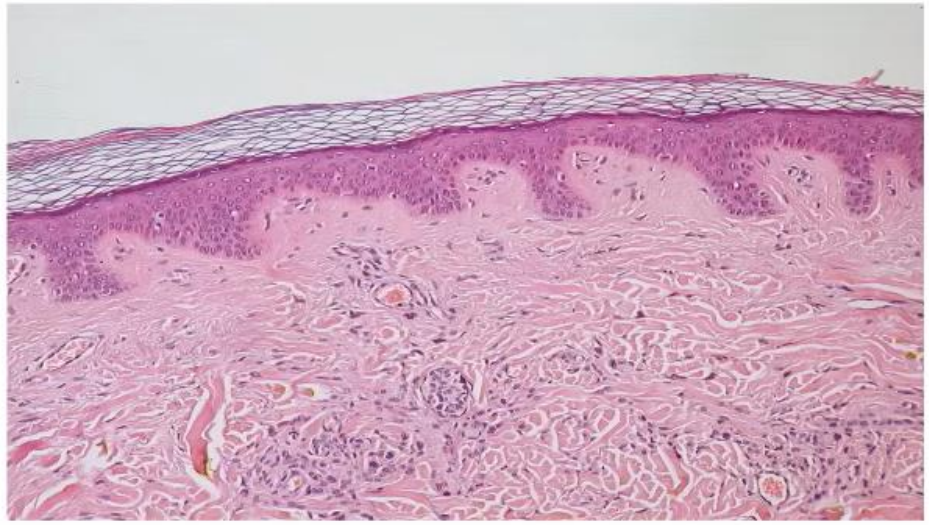
Epithelial tissue (epithelium)
- is made of layers (sheets) of cells that cover the surfaces of the body that come into contact with the exterior world, lines internal cavities and passageways, and form glands.

Connective tissue
- binds the cells and organs of the body together and performs many functions, especially in the protection, support, and integration of the body.

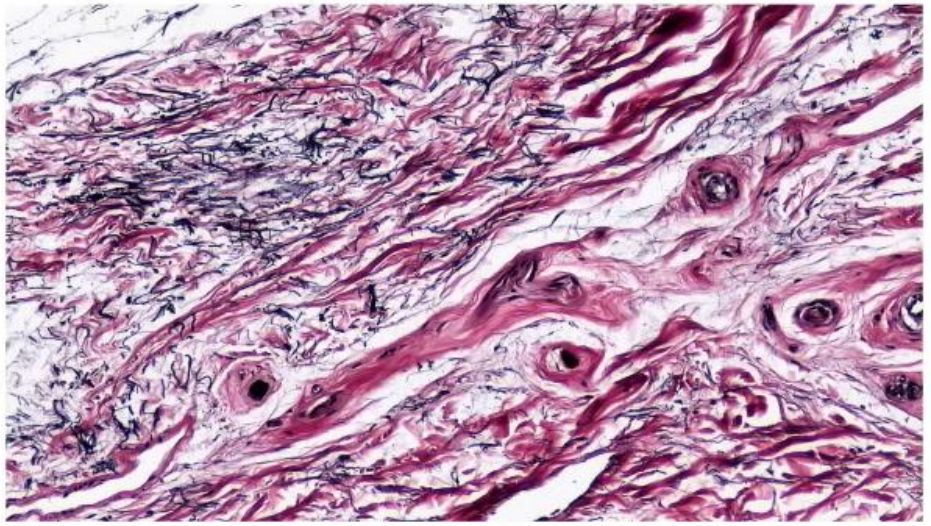
Muscle tissue
- is excitable, responds to stimulation and contracts to provide movement.
- occurs as three major types: skeletal (voluntary) muscles, smooth muscles, and the cardiac muscle in the heart.

Nervous tissue
- is also excitable, allows the body to receive signals and transmit information as electric impulses from one region of the body to another.



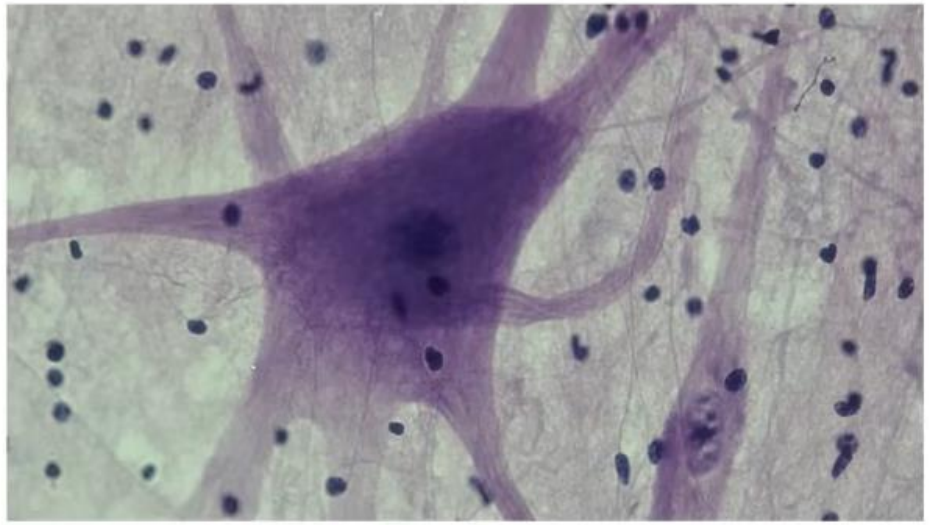


EPITHELIAL TISSUE

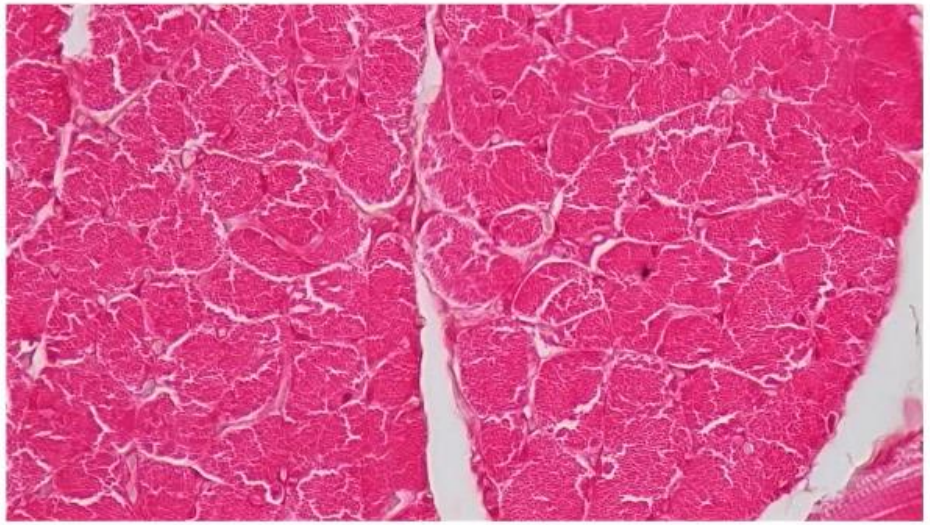


CONNECTIVE TISSUE

NERVOUS TISSUE



MUSCLE TISSUE



Tissue

- Although there are many types of cells in the human body, they are organized into four major categories of tissues: **epithelial, connective, muscle, and nervous**.

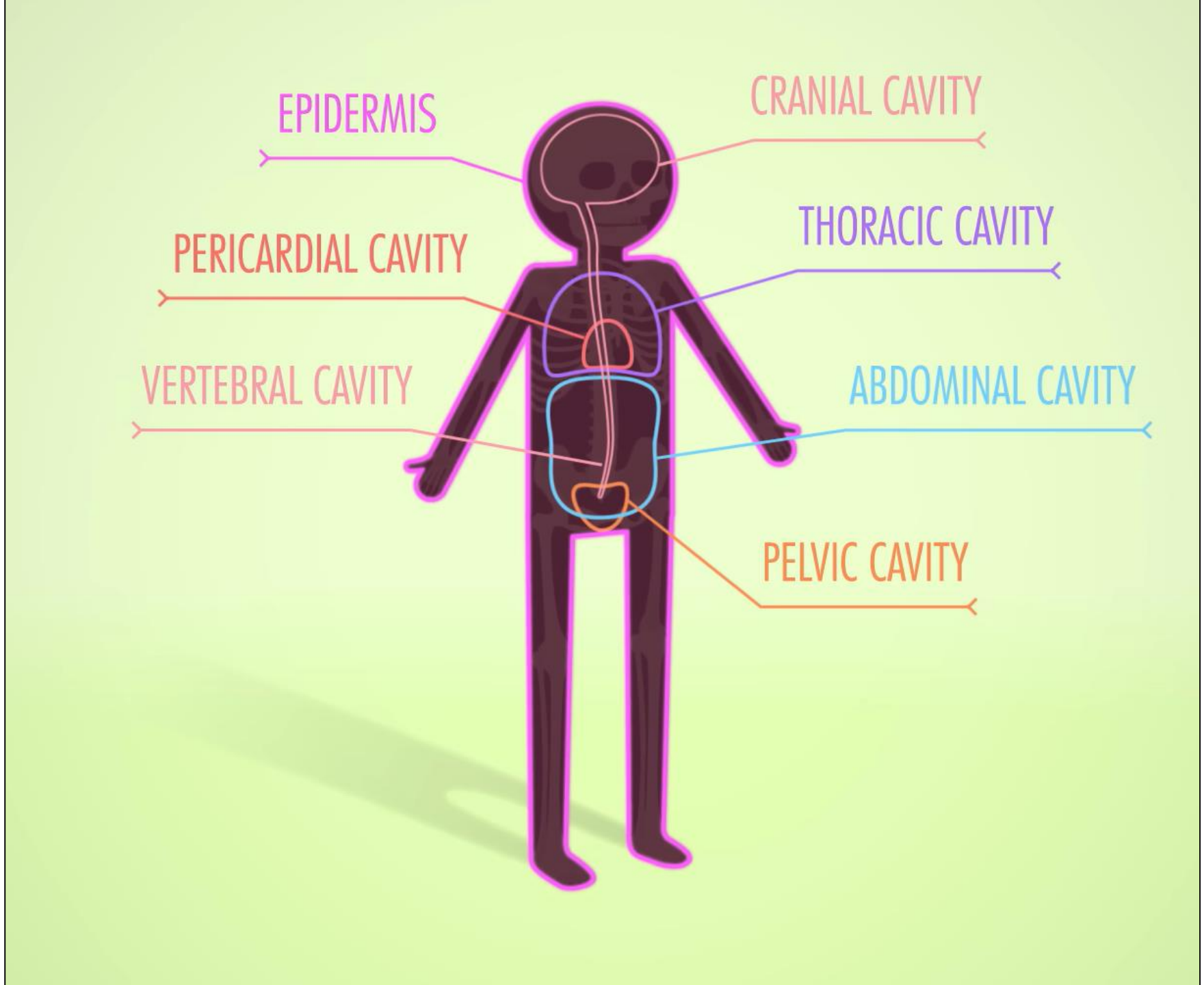
- Each of these categories is characterized by specific functions that contribute to the overall health and maintenance of the body.
- A disruption of the structure is a sign of injury or disease. Such changes can be detected through histology, the microscopic study of tissue appearance, organization, and function.

- **Epithelial tissue**, also referred to as epithelium, refers to the sheets of cells that cover exterior surfaces of the body, lines internal cavities and passageways, and forms certain glands.
- **Connective tissue**, as its name implies, binds the cells and organs of the body together and functions in the protection, support, and integration of all parts of the body.
- **Muscle tissue** is excitable, responding to stimulation and contracting to provide movement, and occurs as three major types: skeletal (voluntary) muscle, smooth muscle, and cardiac muscle in the heart.
- **Nervous tissue** is also excitable, allowing the propagation of electrochemical signals in the form of nerve impulses that communicate between different regions of the body.

- The next level of organization is the **organ**, where several types of tissues come together to form a working unit. Just as knowing the structure and function of cells helps you in your study of tissues, knowledge of tissues will help you understand how organs function.

Epithelial Tissue

- Lines every body surface and all body cavities.
- Forms both the external and internal lining of many organs.
- Composed of one or more layers of closely packed cells that form a barrier between two compartments having different components.
- Little to no extracellular matrix.
- No blood vessels penetrate an epithelium.
- Constitutes the majority of glands.


EPIDERMIS
CRANIAL CAVITY
PERICARDIAL CAVITY
THORACIC CAVITY
VERTEBRAL CAVITY
ABDOMINAL CAVITY
PELVIC CAVITY

Epithelial Tissue

- Epithelial tissue, or epithelium, covers the surfaces of organs including the skin, the trachea, the reproductive tract, and the digestive tract's inner lining.
- It creates a barrier that helps protect organs, and it also has roles in absorbing water and nutrients, getting rid of waste, and secreting enzymes or hormones.
- All of the body's glands are formed from ingrowths of epithelium.
- Some common epithelial tissue diseases are skin diseases like eczema and psoriasis, which both cause rashes.
- When cancer develops from epithelial tissue, it is called a carcinoma.
- Epithelial cells in the airways are also responsible for asthma, which is characterized by inflammation of the airways that leads to shortness of breath.

Epithelial Tissue

- Most epithelial tissues are essentially large sheets of cells covering all the surfaces of the body exposed to the outside world and lining the outside organs and the body cavities.

- The epithelium also forms much of the glandular tissue of the body.

- Skin is not the only area of the body exposed to the outside.
- Other areas include the airways, the digestive tract, as well as the urinary and reproductive systems, all of which are lined by an epithelium.

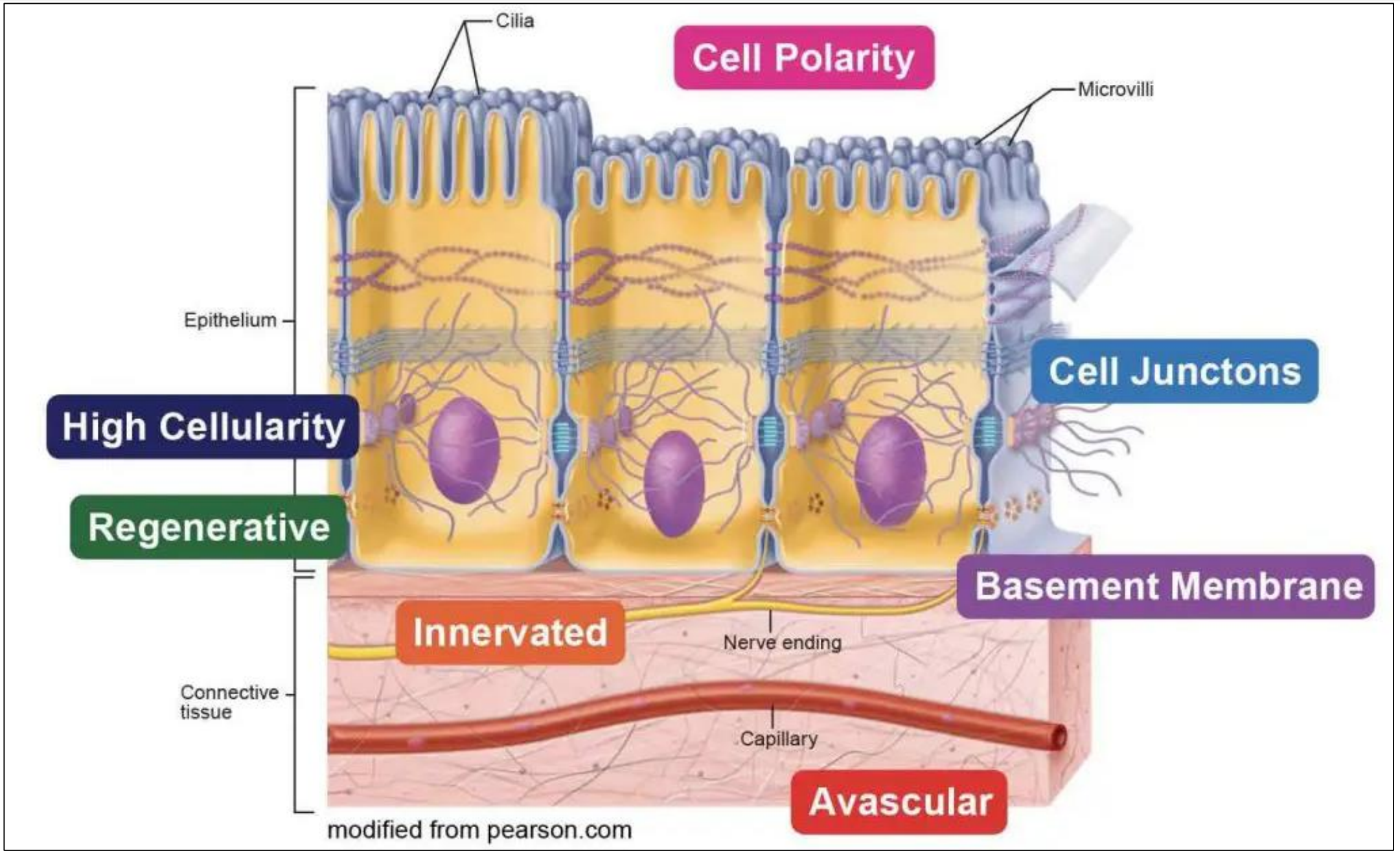
- One of the differences between skin epithelia and the epithelia covering the orifices of the body is whether or not it has a thick keratinized layer over it.

- Hollow organs and body cavities that do not connect to the exterior of the body, which includes blood vessels and serous membranes, are lined by endothelium (plural = endothelia), which is a type of epithelium.

Characteristics of Epithelial Tissue

- **Cellularity**
  - Composed almost entirely of cells bound closely together by different types of cell junctions
- **Polarity**
  - Apical surface (free, or top, surface)
  - Intercellular junctions
  - Basal surface (fixed, or bottom, surface)
- **Attachment**
  - The basal surface of an epithelium is bound to a thin basement membrane
- **Avascularity**
  - Lack blood vessels
  - Nutrients obtained either directly across the apical surface or by diffusion across the basal surface
- **Innervation**
  - Some epithelia are richly innervated to detect changes in the environment at that body or organ surface
  - Most nervous tissue is in the underlying connective tissue
- **Regeneration ability**
  - Frequently damaged or lost by abrasion and is replaced via high regeneration capacity
  - Continual replacement occurs through the divisions of the deepest epithelial cells (called stem cells) near its base

Characteristics of Epithelial Tissue



Distinguishing Characteristics of Epithelial Tissue Orifices

- All epithelia share some important structural and functional features. This tissue is highly cellular, with little or no extracellular material present between cells. The epithelial cells exhibit polarity with differences in structure and function between the exposed or apical-facing surface of the cell and the basal surface close to the underlying body structures. Particular structures found in some epithelial cells are an adaptation to specific functions. Certain organelles are segregated to the basal sides, whereas other organelles and extensions, such as cilia, when present, are on the apical surface. The basal lamina, a mixture of glycoproteins and collagen, provides an attachment site for the epithelium, separating it from underlying connective tissue. The basal lamina attaches to a reticular lamina, which is secreted by the underlying connective tissue, forming a basement membrane that helps hold it all together.

- Epithelial tissues are nearly completely avascular. For instance, no blood vessels cross the basement membrane to enter the tissue, and nutrients must come by diffusion or absorption from underlying tissues or the surface.

- Many epithelial tissues are capable of rapidly replacing damaged and dead cells. Sloughing off of damaged or dead cells is a characteristic of surface epithelium and allows our airways and digestive tracts to rapidly replace damaged cells with new cells.

Functions of Epithelial Tissue

- **Protection**
- **Regulation of materials into and out of the organ or tissue**
- **Produce secretions**
  - Endocrine glands
  - Exocrine glands
- **Nerve endings detect changes in the external environment at their surface**
- **Continuously supply information to the nervous system concerning touch, pressure, temperature, and pain.**

General Functions of Epithelial Tissue

- The general functions of the epithelial tissues can be summarized as **protection, absorption, filtration, secretion, excretion and sensation**.

- Epithelial tissues provide the body's first line of protection from physical, chemical, and biological wear and tear. The cells of an epithelium act as gatekeepers of the body controlling permeability and allowing selective transfer of materials across a physical barrier. All substances that enter the body must cross an epithelium. Some epithelia often include structural features that allow the selective transport of molecules and ions across their cell membranes.

- Many epithelial cells are capable of secretion and releasing mucous and specific chemical compounds onto their apical surfaces. The epithelium of the small intestine release digestive enzymes, for example. Cells lining the respiratory tract secrete mucous that traps incoming microorganisms and particles. A glandular epithelium contains many secretory cells.

Types of Epithelial Tissue

- Epithelial tissues are classified according to the shape of the cells and the number of cell layers formed. Cell shapes can be squamous (flattened and thin), cuboidal (boxy, as wide as it is tall), or columnar (rectangular, taller than it is wide). Similarly, the number of cell layers in the tissue can be one - where every cell rests on the basal lamina - which is a simple epithelium, or more than one, which is a stratified epithelium, and only the basal layer of cells rests on the basal lamina. Pseudostratified (pseudo- = “false”) describes tissue with a single layer of irregularly shaped cells that give the appearance of more than one layer. Transitional describes a form of specialized stratified epithelium in which the shape of the cells can vary.

- **Simple Epithelium:**
- The shape of the cells in the single-cell layer of simple epithelium reflects the functioning of those cells. The cells in **simple squamous epithelium** have the appearance of thin scales. Squamous cell nuclei tend to be flat, horizontal, and elliptical, mirroring the form of the cell. Simple squamous epithelium, because of the thinness of the cell, is present where the rapid passage of chemical compounds is observed. The alveoli of the lungs where gases diffuse, glomeruli and Bowman’s capsule of the kidney to filter the blood, and the lining of capillaries to allow rapid diffusion of the substances are also made of simple squamous epithelial tissue.

Types of Epithelial Tissue

- In **simple cuboidal epithelium**, the nucleus of the box-like cells appears round and is generally located near the center of the cell. These epithelia are active in the secretion and absorption of molecules. Simple cuboidal epithelia are observed in the lining of the kidney tubules and in the ducts of glands.

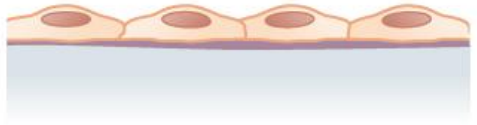
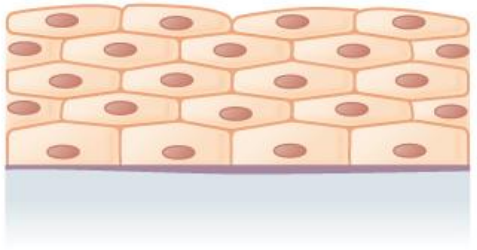
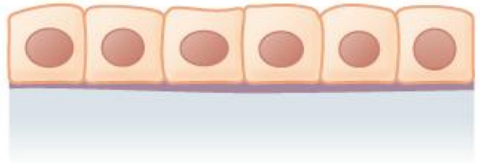
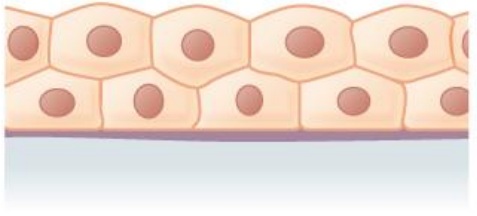
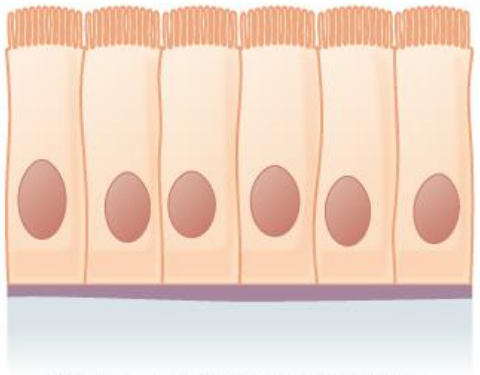
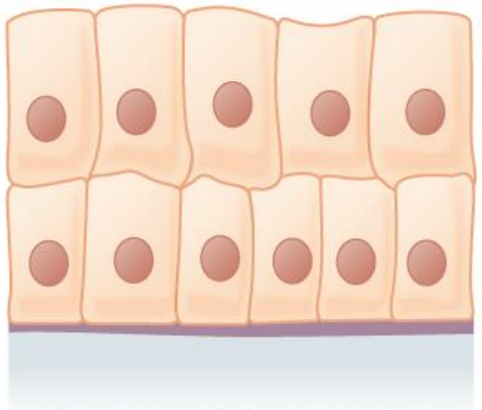
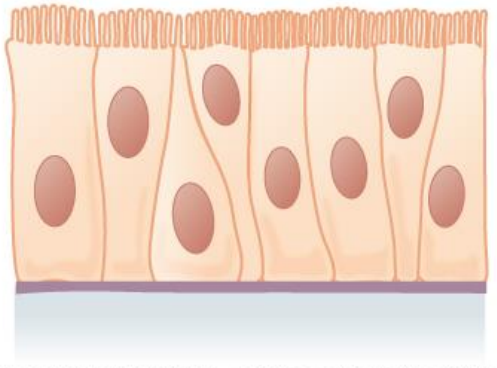
- In **simple columnar epithelium**, the nucleus of the tall column-like cells tends to be elongated and located in the basal end of the cells. Like the cuboidal epithelia, this epithelium is active in the absorption and secretion of molecules. Simple columnar epithelium forms the lining of some sections of the digestive system and parts of the female reproductive tract. The ciliated columnar epithelium is composed of simple columnar epithelial cells with cilia on their apical surfaces. These epithelial cells are found in the lining of the uterine tubes and parts of the respiratory system, where the beating of the cilia helps remove particulate matter.

- **Pseudostratified columnar epithelium** is a type of epithelium that appears to be stratified but instead consists of a single layer of irregularly shaped and differently sized columnar cells. In pseudostratified epithelium, nuclei of neighboring cells appear at different levels rather than clustered in the basal end. The arrangement gives the appearance of stratification; but in fact, all the cells are in contact with the basal lamina, although some do not reach the apical surface. The pseudostratified columnar epithelium is found in the respiratory tract, where some of these cells have cilia.

Types of Epithelial Tissue

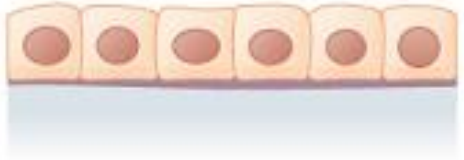
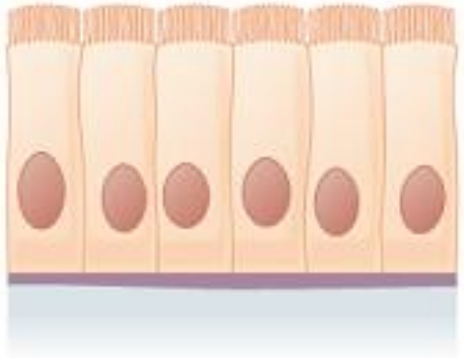
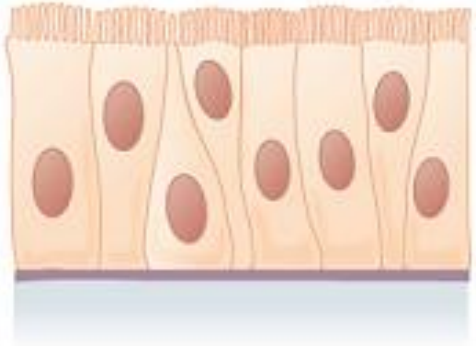
- **Stratified Epithelium**: A stratified epithelium consists of several stacked layers of cells. This epithelium protects against physical and chemical wear and tear. The stratified epithelium is named by the shape of the most apical layer of cells, closest to the free space.

- **Stratified squamous epithelium** is the most common type of stratified epithelium in the human body. The apical cells are squamous, whereas the basal layer contains either columnar or cuboidal cells. The top layer may be covered with dead cells filled with keratin. Mammalian skin is an example of this dry, keratinized, stratified squamous epithelium. The lining of the mouth cavity is an example of a nonkeratinized, stratified squamous epithelium. Stratified cuboidal epithelium and stratified columnar epithelium can also be found in certain glands and ducts but are uncommon in the human body

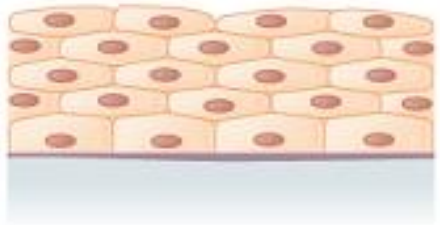
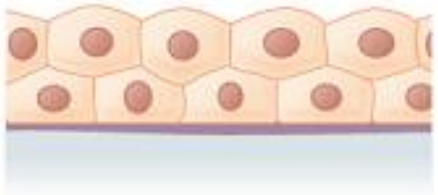
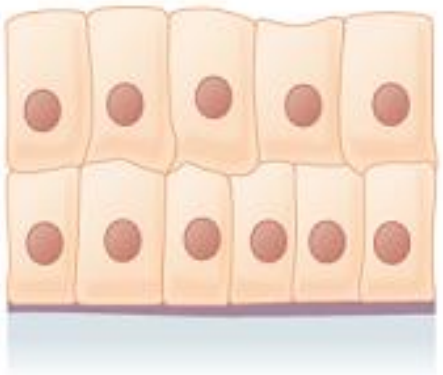
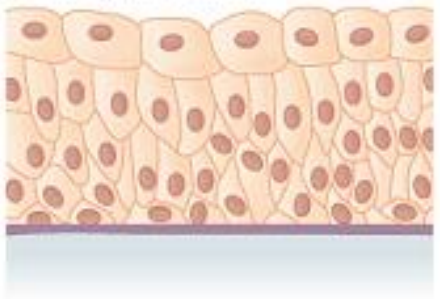
	Simple	Stratified	Pseudostratified
Squamous	 Simple squamous epithelium	 Stratified squamous epithelium	
Cuboidal	 Simple cuboidal epithelium	 Stratified cuboidal epithelium	
Columnar	 Simple columnar epithelium	 Stratified columnar epithelium	 Pseudostratified columnar epithelium

Types of Epithelial Tissue.

- **Simple epithelial tissue** is organized as a single layer of cells.
- **Stratified epithelial tissue** is formed by several layers of cells.
- **Pseudostratified epithelial tissue** is a single layer of cells that appears to be multiple layers because of the position of their nuclei.
- Epithelial tissue is further defined by the shape of the apical layer of cells in the tissue.

Cells	Location	Function
Simple squamous epithelium 	Air sacs of lungs and the lining of the heart, blood vessels, and lymphatic vessels	Allows materials to pass through by diffusion and filtration, and secretes lubricating substance
Simple cuboidal epithelium 	In ducts and secretory portions of small glands and in kidney tubules	Secretes and absorbs
Simple columnar epithelium 	Ciliated tissues are in bronchi, uterine tubes, and uterus; smooth (nonciliated tissues) are in the digestive tract, bladder	Absorbs; it also secretes mucous and enzymes
Pseudostratified columnar epithelium 	Ciliated tissue lines the trachea and much of the upper respiratory tract	Secretes mucus; ciliated tissue moves mucus

Summary of Epithelial Tissue Types.
Different types of epithelial tissue serve different functions and are found in different locations in the body.

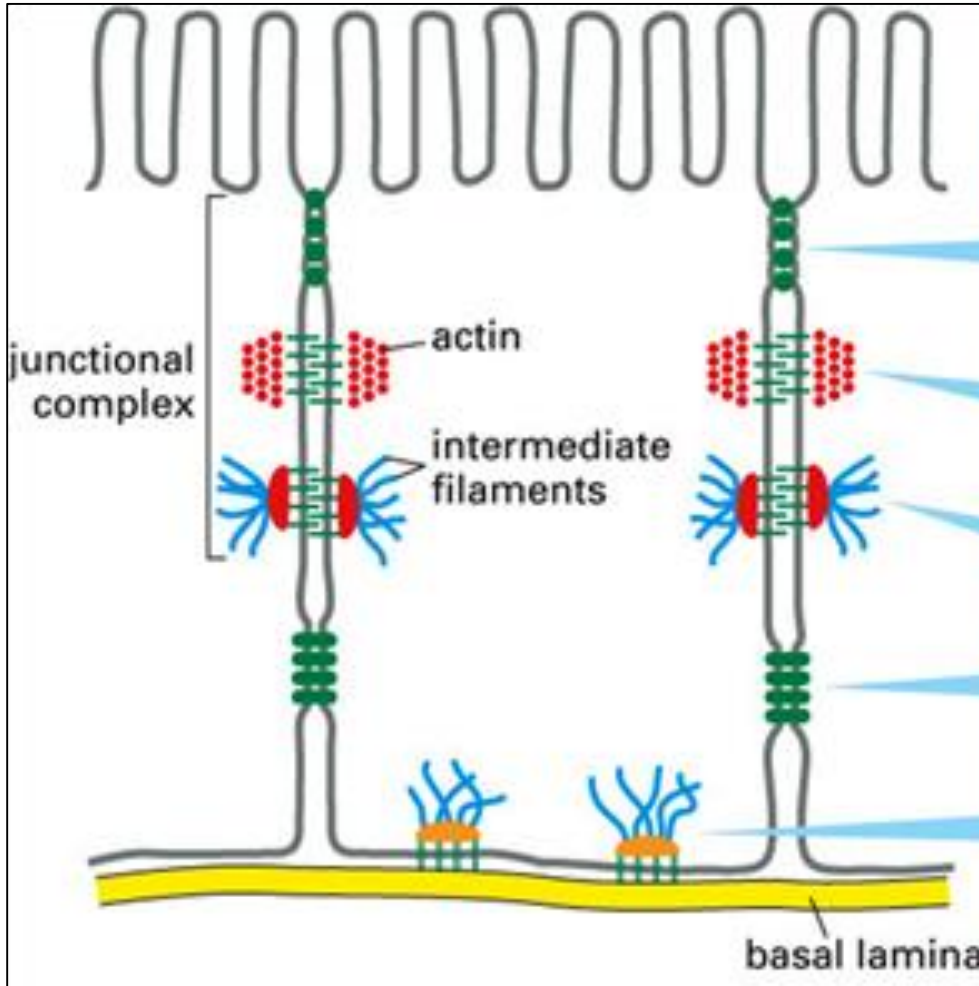
Cells	Location	Function
Stratified squamous epithelium 	Lines the esophagus, mouth, and vagina	Protects against abrasion
Stratified cuboidal epithelium 	Sweat glands, salivary glands, and the mammary glands	Protective tissue
Stratified columnar epithelium 	The male urethra and the ducts of some glands	Secretes and protects
Transitional epithelium 	Lines the bladder, uretha, and the ureters	Allows the urinary organs to expand and stretch

Summary of Epithelial Tissue Types.

Different types of epithelial tissue serve different functions and are found in different locations in the body.

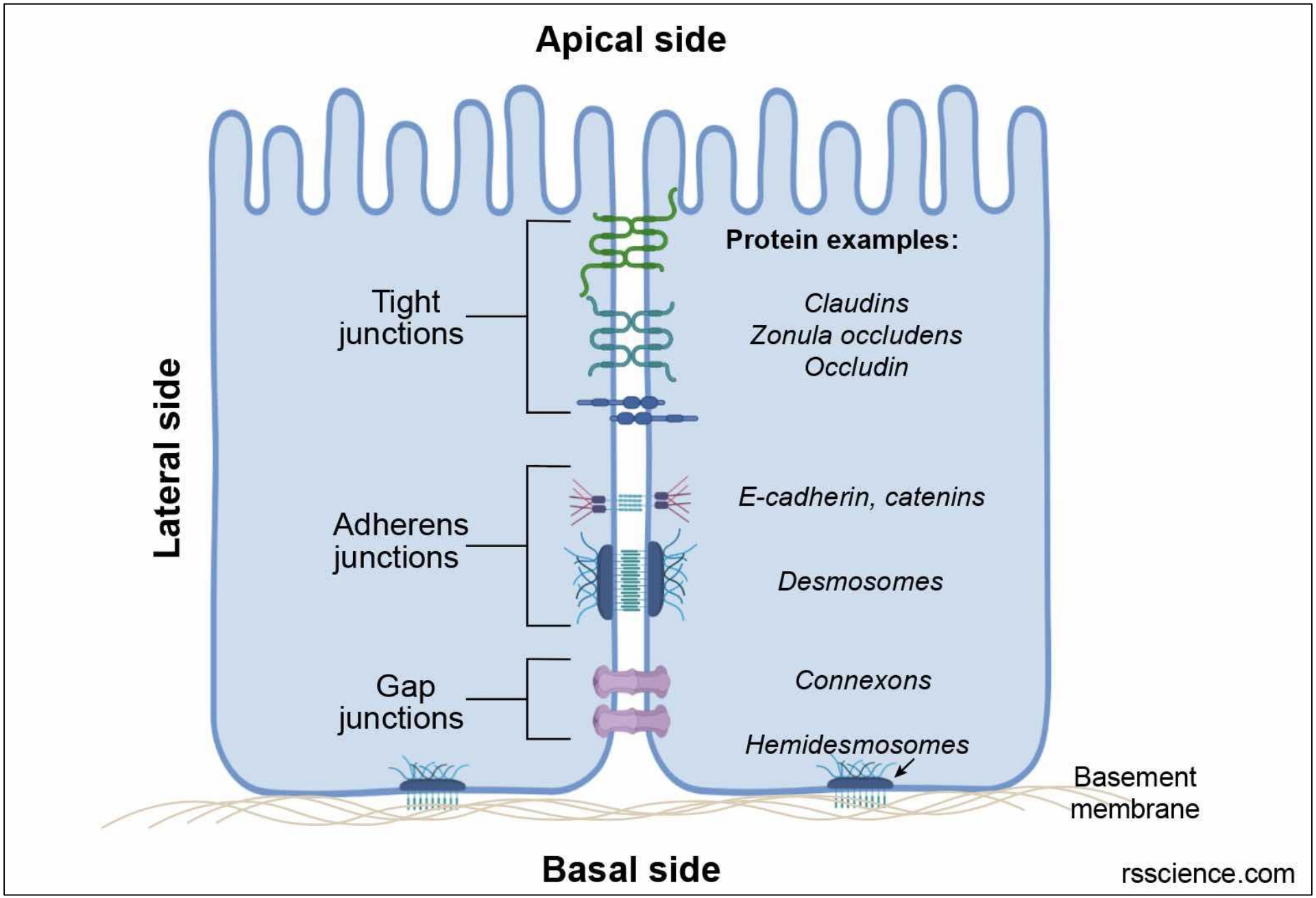
Junctions

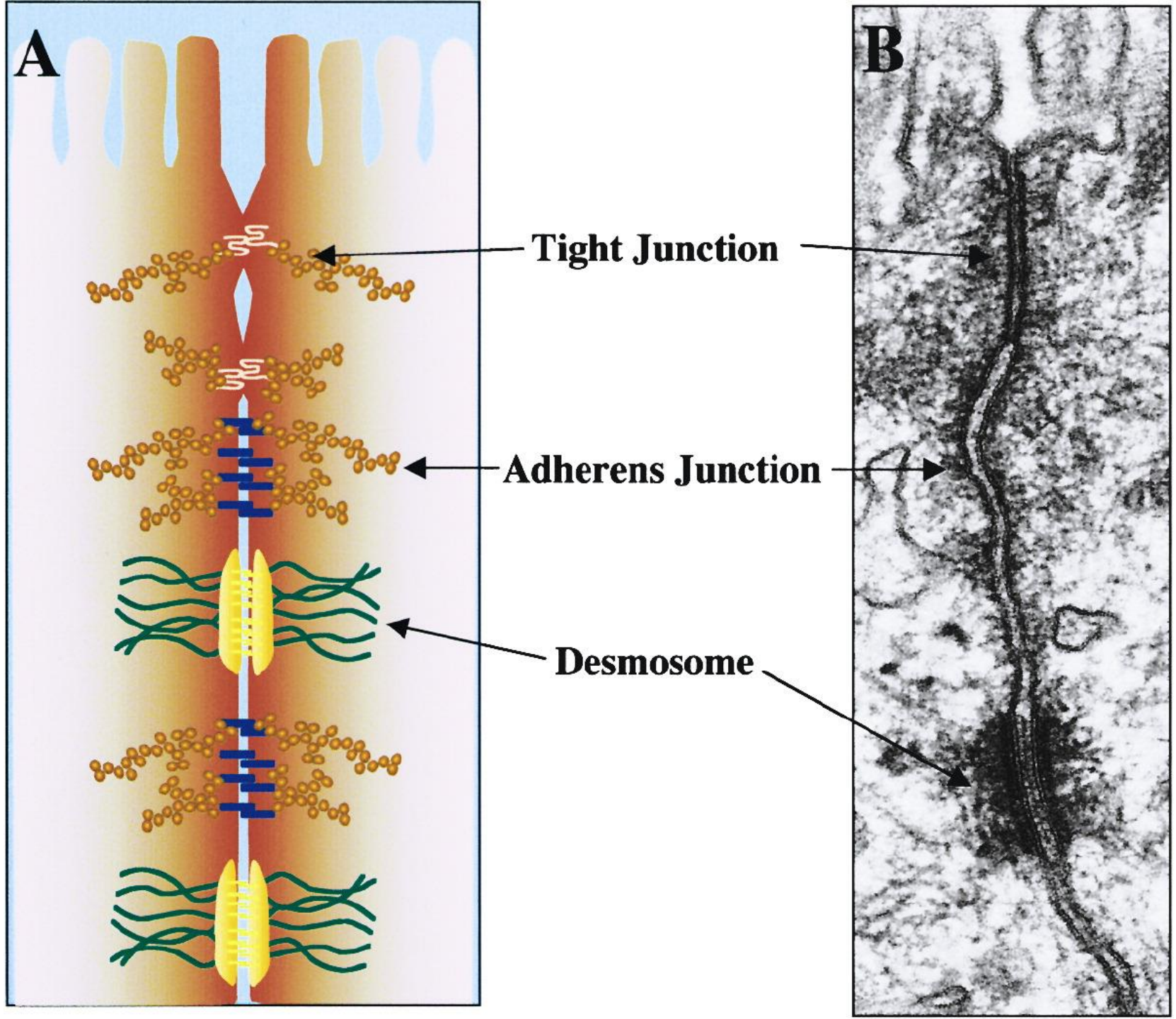
- There are four types of cell junctions:
  - tight junctions
  - adhering junctions
  - Desmosomes
  - gap junctions



name	function
tight junction	seals neighboring cells together in an epithelial sheet to prevent leakage of molecules between them
adherens junction	joins an actin bundle in one cell to a similar bundle in a neighboring cell
desmosome	joins the intermediate filaments in one cell to those in a neighbor
gap junction	allows the passage of small water-soluble ions and molecules
hemidesmosome	anchors intermediate filaments in a cell to the basal lamina

Junctions


Apical side
Lateral side
Tight junctions
Adherens junctions
Gap junctions
Protein examples:
Claudins
Zonula occludens
Occludin
E-cadherin, catenins
Desmosomes
Connexons
Hemidesmosomes
Basement membrane
Basal side
rsscience.com


A
B
Tight Junction
Adherens Junction
Desmosome

Glands

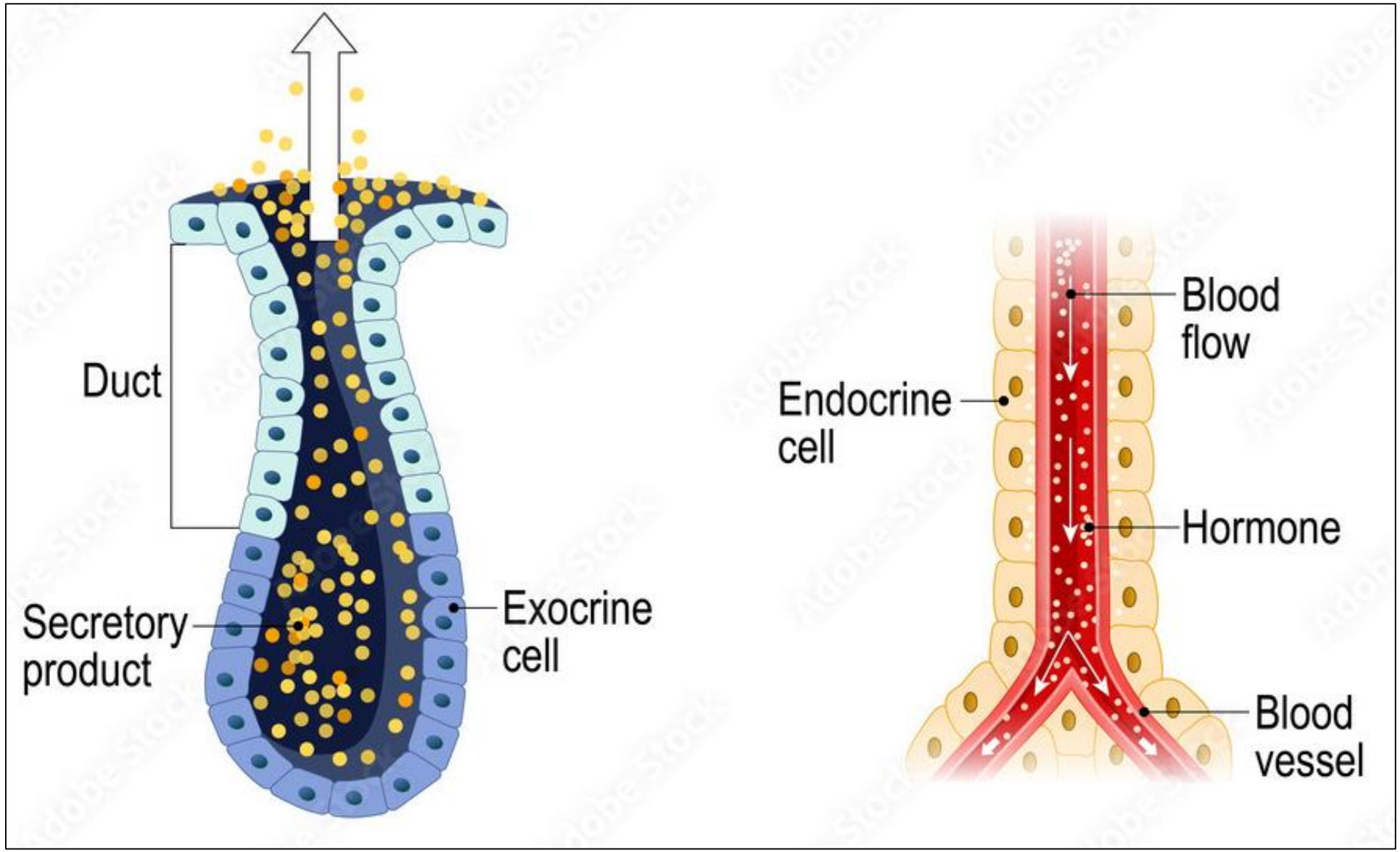
❑ Endocrine Glands

- ❖ Lack ducts (ductless glands) and secrete their products directly into the interstitial fluid and bloodstream.
- ❖ Secretion is generally hormones that act as chemical messengers to influence cell activities elsewhere in the body.
- ❖ Control long term activity of the target organs.
- ❖ Metabolism, growth and development are the main functions of endocrine glands.
- ❖ Examples: Pituitary gland, thyroid gland, pineal gland, etc.

❑ Exocrine Glands

- ❖ Usually maintain their contact with the epithelial surface by means of a duct to discharge their secretions (enzymatic, lubricant or excretory) on the body surface.
- ❖ Duct secretes materials onto the surface of the skin or onto an epithelial surface lining an internal passageway.
- ❖ Control short term activity.
- ❖ Regulation of body temperature is the main function of exocrine glands.
- ❖ Examples: Sebaceous glands (produces sebum; an oily and waxy matter) present in the skin; mucus glands (produces mucus) present in the nose, throat, cervix, lungs, gut, vagina, etc.; salivary glands (produces saliva) present in the buccal cavity; gastric glands (produces gastric juice and protective mucus) present in the walls of the stomach.

Glands



Exocrine Gland

Endocrine Gland

Thank you for your attention