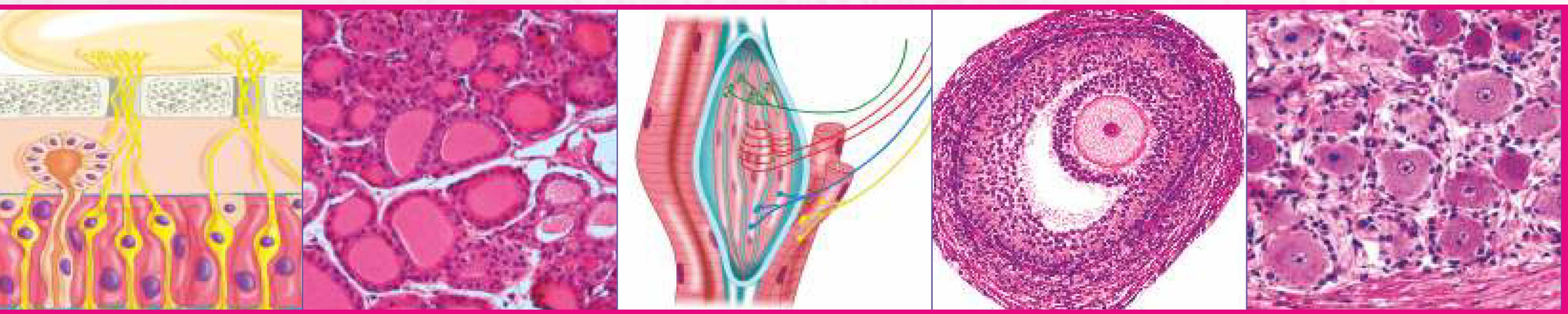
Textbook of Human Histology

with Color Atlas, 3D Illustrations and Flowcharts



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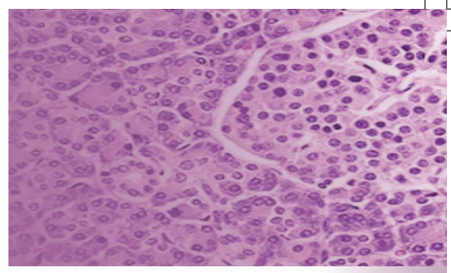


CHAPTER 2

Orientation to Histological Techniques

Chapter Outline

- Tissue processing
- Special stains
  - Hematoxylin and eosin staining
  - Decalcification
- Orientation of sectional plane
  - Interpretation of Sections in Histology
    - *Sections of solid structure*
    - *Sections of tubular structure*

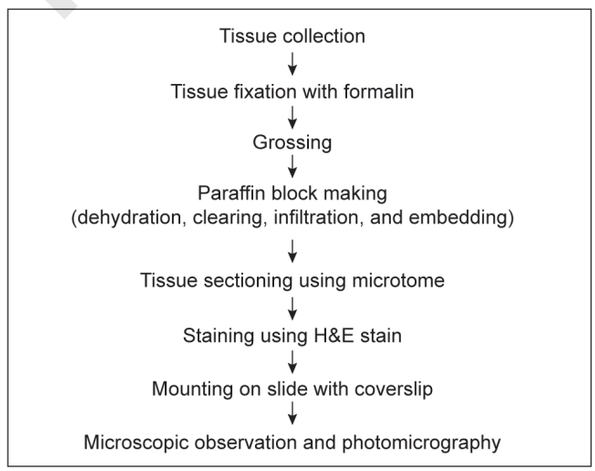
- Microscopic examination is based on thin sectioning of the tissue. AFJK Mayer (1819) coined the term *histology* (*histos* = tissue, *-logy* = science).
- This chapter provides brief overview of the histological techniques that are required for the section/slide preparation of tissue and orientation of sections (relationship of gross structure and microscopic section).

TISSUE PROCESSING

- In routine histology and histopathology, a specimen is sliced into 0.5 cm or so. These slices are processed and finally further sectioned into 5–7 µm thin sections. These sections are mounted and stained on glass slides to make them suitable for microscopic observation. This entire procedure is called *tissue processing.*
- Histological tissue processing involves the following major steps (Flowchart 2.1):

Tissue collection, grossing, tissue fixation, dehydration, cleaning, embedding, section cutting, staining, and mounting.

Flowchart 2.1: Steps in tissue processing



1. Tissue collection

- For histological studies, suitable tissue is collected from cadavers, forensic autopsies, surgical procedures, animals (goat, rat, dog, and so on) with permission from authorities (ethics and research committees).

2. Tissue fixation

- Collected specimen is preserved for retaining their biological structure without any significant distortion or decomposition.
- 10% formalin is the most commonly used fixative.[Viva]
- It cross-links proteins (enzymes and others) in the tissue. Other fixatives include glutaraldehyde, mercuric chloride, osmium tetroxide (highly toxic), and so on.

3. Grossing

- Grossing involves observing tissue for gross pathological changes and selecting a suitable part of the tissue for microscopic examination.
- The selected area is cut into ~5 mm thick slices.

4. Paraffin block making

- It is difficult to make thin sections of the tissue (5–7 µm) as most of the cells contain water (50–60%). Hence, the tissue is processed to replace water with firm material (paraffin wax) and to make the tissue suitable for cutting.
- It involves the following steps:
  - ***Dehydration:*** Tissue slice is treated with ascending grades of alcohols (50%, 70%, 90%, and absolute/100% alcohol) to gradually remove water from the tissue.
  - ***Removal of alcohol/clearing:*** Tissue slice is treated with xylene (clearing agent). Clearing agent makes the tissue clear by changing the refractive index of the tissue.
  - ***Infiltration/removal of clearing agent:*** Tissue slice is kept in melted paraffin that replaces xylene by infiltration in the tissue.
  - ***Embedding/block making:*** Tissue slice is kept fixed in the melted paraffin and allowed to form a solid block on cooling. This solid block makes the tissue suitable for sectioning.

5. Tissue sectioning

- Microtome is an instrument used for thin sectioning of tissue.
- Paraffin block is fitted on microtome and cut into thin sections (5–7 µm). These sections are transferred to glass slides.

6. Staining

- A section on a glass slide is stained with suitable staining.
- Hematoxylin and eosin (*H&E*) are commonly used stains.

7. Mounting

- Stained section is mounted with the help of a coverslip and DPX (glue) to make ready for observation under microscope and preserve.

SPECIAL STAINS

- Many structures or substances cannot be differentiated from each other with the help of routine hematoxylin and eosin staining.
- For the visualization and differentiation of specific structure, special stains are required.
- Some commonly used special stains and their uses are listed in Table 2.1.

Box 2.1: Hematoxylin and eosin staining

- Hematoxylin and eosin stain is most commonly used in routine histology and histopathology.
- Hematoxylin is a basic dye that is obtained from wood of *Hematoxylon campechianum* tree.
- Hematoxylin stains nuclei, calcium deposits, fibrin, muscle cross striations, matrix in cartilages, and so on. *Practical guide*
- Eosin is an acidic type that is derived from fluorescein.
- Eosin stains basic or eosinophilic compounds such as cytoplasm, connective tissue (collagen fibers), muscle fibers, red blood cells, and so on. *Practical guide*
- Steps involved in *H&E* staining.
  Deparaffinize the section using xylene, rehydrate the section with descending grades of alcohol (100% or absolute alcohol, 90% alcohol, 70% alcohol, and water), staining with hematoxylin, removal of excess hematoxylin (using acid-alcohol and water wash/bath), staining with eosin and dehydration. Dehydrated slide is preserved by fixing coverslip using DPX (transparent glue).

Box 2.2: Decalcification

- Calcified tissue (bones) cannot be sectioned properly using routine microtome.
- Decalcification is the technique useful for removing deposited minerals from the matrix of the tissue (bone) to facilitate microtome sectioning.
- The following agents are useful for decalcification strong mineral acids (nitric acid, hydrochloric acid), weak organic acids (formic acids), and calcium chelating agents (EDTA).

ORIENTATION OF SECTIONAL PLANE

- In histology, a two-dimensional view of a tissue section is observed under the microscope.
- The observer has to imagine a three-dimensional structure from a two-dimensional image.
  For example: If a circular structure is seen, the observer has to decide whether it is a sectional part of a tube or a sphere.
- *Microtome* is an instrument used for section cutting in histology. The knife/blade fitted to the microtome makes thin slices of the tissue.
- Tissue has various structures that have different size, shape, and orientations.
- Some structures are spherical, some are tubular, or solid. Some structures run parallel to the long axis of tissue, some run perpendicularly or obliquely. The resultant section of the tissue gives a two-dimensional image of these structures.

Table 2.1: Special stains and their uses

Structure	Stain	Color
Collagen fibers	Van Gieson technique	Red
	Masson's trichrome stain	Blue/green
Elastic fibers	Verhoeff–van Gieson method	
Bluish black	Weight's Resorcin–Fuchsin method	Blue-black
	Orcein stain	Dark-brown
Reticular Fibers	Gordon–Sweet's method	Black
	Gomori's silver impregnation method	Black
Basement membrane	Periodic acid–Schiff (PAS) method	Magenta
Carbohydrates (glycogen, amyloid, fungi, pancreatic zymogen granules, corpora amylacea in prostate, thyroid colloid)	PAS method	Magenta
Lipids/fat	Oil red-O	Brilliant red
Iron	Perl's Prussian blue reaction	Blue
Hemoglobin	Leuco patent blue V method	Dark blue-green
Bile pigment	Hall's method	Olive green
Melanin	Masson–Fontana method	Black
Lipofuscin	Pearse's staining method	Magenta
Calcium	Von Kossa method	Dark green-black
Uric acid	Hexamine–silver method	Black
Nissl substance in neuron	Cresyl Fast violet stain	Purple-dark blue
Myelin	Luxol fast blue method	Blue
	Osmium tetroxide method	Black
Astrocytes	Cajal's gold chloride method	Reddish-black

Interpretation of Sections in Histology

- To understand the histological section, the following examples are given:
  - Sections of solid structure
  - Sections of tubular structure

Sections of Solid Structure

- A boiled egg has an outer egg white and inner yellow/orange egg yolk.
- The nature of the section depends on orientation of the egg-like solid structure in the tissue (Fig. 2.1).
- For example: If an egg is oriented vertically, it will cut in longitudinal plane (*longitudinal section/LS*). If an egg is oriented horizontally, it will cut in transverse plane (*transverse section/TS*). If an egg is oriented obliquely, it will cut in oblique plane.
- In each plane, the egg is sectioned into various oval shapes depending on the depth of the section (from superficial to deep planes). In superficial or tangential planes egg yolk (similar to cell nucleus) may not be observed. *Practical guide*

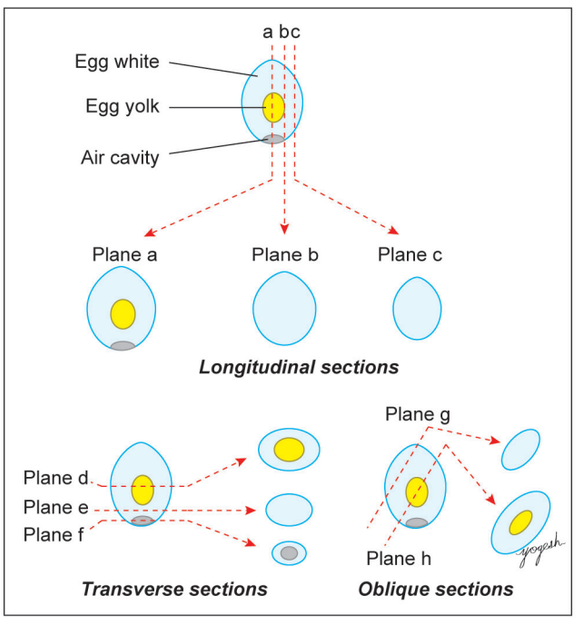
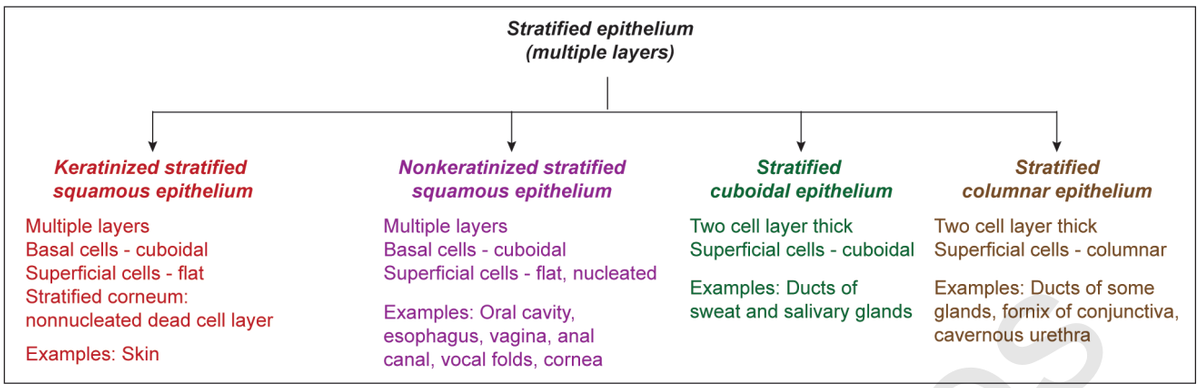


Fig. 2.1: Planes of sections of solid object.

Flowchart 4.3: Stratified epithelium



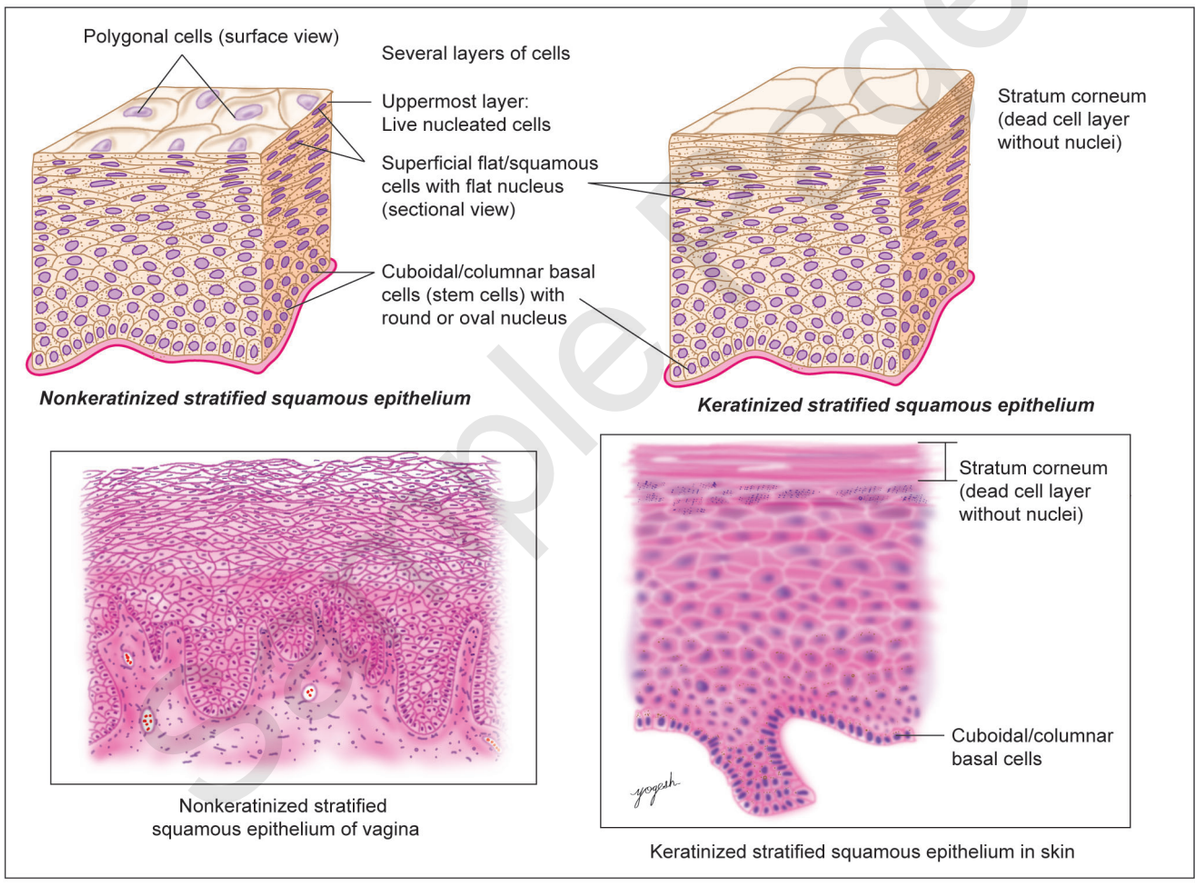
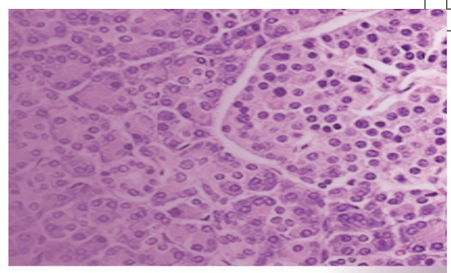


Fig. 4.10: Keratinized and nonkeratinized stratified squamous epithelium (with practice figures).

- *Functions*
  - It protects the deeper structures from mechanical injuries.
  - It acts as a barrier against infection.
  - It prevents water loss.

Nonkeratinized stratified squamous epithelium

- There is no stratum corneum. *Identification feature*
- Cells in the uppermost layer are live and nucleated (Figs 4.10 and 4.11). *Identification feature*
- Cells become increasing flattened as one move toward the superficial layer. *Identification feature*
- This epithelium remains always moist.
- Such moist epithelium with underlying thin connective tissue layer (lamina propria) is called mucosa.



CHAPTER 6

Glands

Chapter Outline

- Classification of glands
- Exocrine glands
- Classification based on branching pattern of duct
- Classification based on nature of secretions
  - Serous glands
  - Mucous glands
  - Mixed gland
- Classification based on mode of secretion
  - Merocrine glands
  - Apocrine glands
  - Holocrine glands
  - Paracrine and autocrine glands
- Goblet cell

Competency achievement: The student should be able to:

AN70.1 Identify exocrine gland under the microscope and distinguish between serous, mucous and mixed acini

INTRODUCTION

- Gland is a specialized group of cells that synthesizes and secretes substances/hormones.
- Glands are derived from epithelium (Figs 6.1 and 6.2).
- Note: Mucus is a noun and mucous is an adjective. For example, mucous cells secrete mucus.

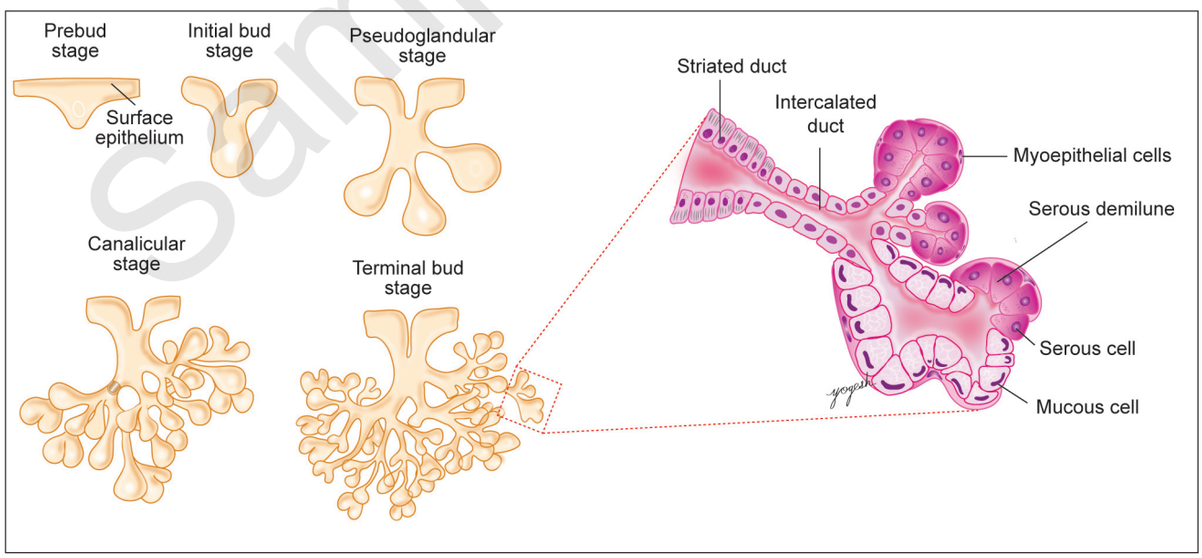


Fig. 6.1: Development of exocrine gland (salivary gland) (*Source:* Textbook of Human Embryology, Yogesh Sontakke, 1st edn., CBS Publishers).

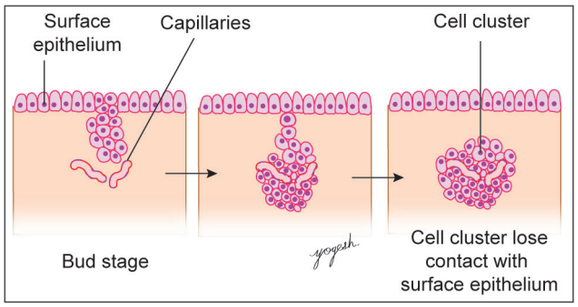
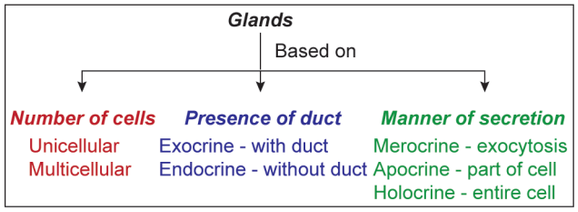


Fig. 6.2: Development of endocrine gland.

CLASSIFICATION OF GLANDS

- Glands are classified in various ways as follows (Flowchart 6.1):*Viva*
  1. Based on number of cells
     - *Unicellular glands:* They have single cell that performs secretory function.
     - *Multicellular glands:* They have group of cells.
  2. Based on presence of duct
     - *Exocrine glands:* They use duct to convey their secretions

Flowchart 6.1: Classification of glands

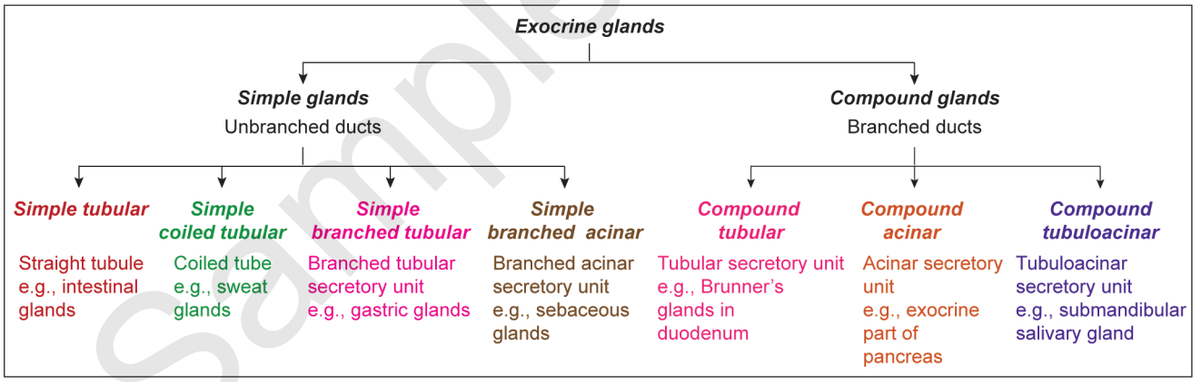


     - *Endocrine glands:* They do not have ducts and secrete secretions directly into the blood. For details on endocrine glands, *refer* Chapter 23.
  3. Based on the manner of secretion:
     - *Merocrine glands:* They secrete by exocytosis.
     - *Apocrine glands:* They secrete by shedding of apical portion of glands.
     - *Holocrine glands:* They secrete by disintegration of entire cell.

EXOCRINE GLANDS

- Exocrine glands convey their secretions with the help of duct.
- Exocrine glands are further classified as follows (Figs 6.3 to 6.12 and Flowchart 6.2):

Flowchart 6.2: Classification of exocrine glands based on duct branching and shape of secretory unit



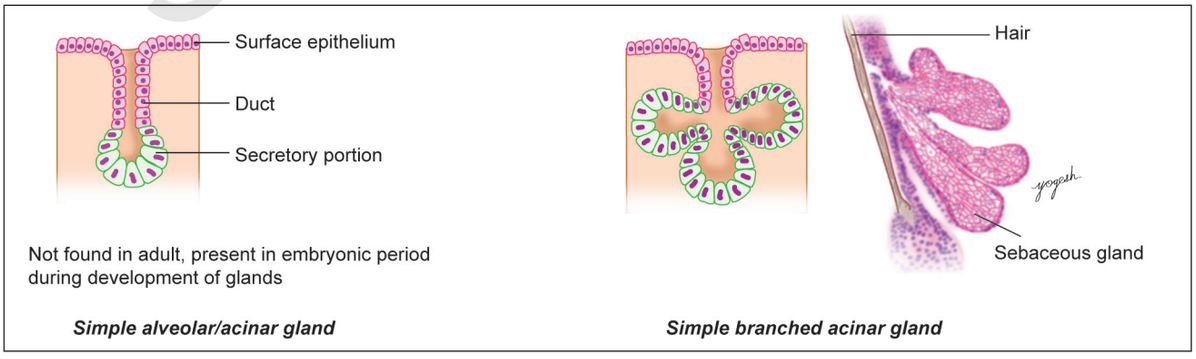
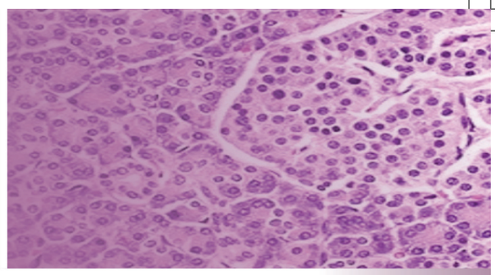


Fig. 6.3: Types of simple acinar glands.



CHAPTER 11

Lymphoid Tissue

Chapter Outline

- Lymphatic tissue
- Cells of lymphoid system
  - Lymphocytes
  - Antigen-presenting cells
  - Reticular cells
- Lymph
- Lymphatic vessels
- Lymphatic nodule
- Lymph node
- Thymus
- Epithelioreticular cells
- Blood-thymic barrier
- Spleen
- Palatine tonsil

Competency achievement: The student should be able to:

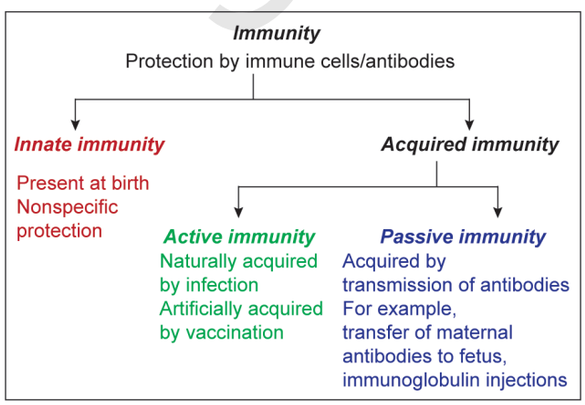
AN43.2 Identify, describe and draw the microanatomy of tonsil.

AN70.2 Identify the lymphoid tissue under the microscope and describe microanatomy of lymph node, spleen, thymus, tonsil and correlate the structure with function

INTRODUCTION

- Lymphatic system provides protection to individuals by imparting immunity.
- *Immunity* is ability of organism to resist a particular infection or toxic substance with the help of antibodies or activated white blood cells.
- There are two types of immunity: Innate and acquired immunity (Flowchart 11.1).
  1. *Innate/native immunity* is present at birth. Innate immunity provides nonspecific protection against all type of infections.
  2. *Acquired or adaptive immunity* is acquired by an individual throughout the life.
- Acquired immunity is of two types:[Viva]
  A. *Active immunity:* It is acquired by an individual on exposure of antigenic agents, toxins or micro-organisms. During exposure, immune cells get activated and impart acquired immunity.
  B. *Passive immunity:* It is acquired by an individual by the transfer of readymade antibodies (immunoglobulin injections).

Flowchart 11.1: Immunity



LYMPHATIC TISSUE

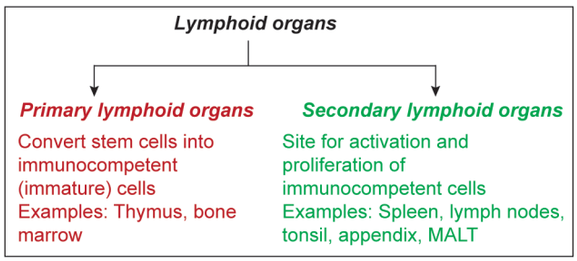
Q. List the primary and secondary lymphoid organs.

- Lymphatic tissue is a specialized form of connective tissue that consists of immune cells (lymphocytes and plasma cells), meshwork of reticular fibers and cells.
- Lymphoid tissue identifies foreign antigens and dead/old cells of body and removes them by phagocytosis or by producing antibodies.
- Lymphoid organs are classified as primary and secondary lymphoid organs (Flowchart 11.2).

Primary Lymphoid Organs

- These are also called *central lymphoid organs.*
- These organs produce immature lymphocytes from stem cells or immature cells.
- For example, thymus, and bone marrow[Neet]

Flowchart 11.2: Lymphoid organs[Neet]



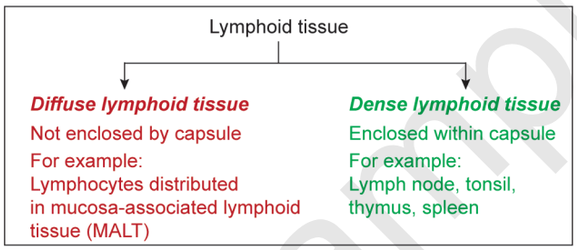
Secondary Lymphoid Organs

- These organs provide exposure to foreign antigen and convert immature lymphocytes into active lymphocytes.
- For example, spleen, lymph nodes, tonsils, appendix, and payer's patches
- Histologically lymphoid tissues are grouped as follows (Flowchart 11.3).
  A. Diffuse lymphoid tissue
  B. Dense lymphoid tissue

Diffuse Lymphoid Tissue

- Lymphocytes are distributed throughout mucosa of gastrointestinal tract, respiratory, urinary, and reproductive tracts. This type of lymphoid tissue is called *diffuse lymphoid tissue.*
- As this lymphoid tissue is associated with mucosa, it is also called *mucosa-associated lymphoid tissue* (MALT). Ileum is the most common site of MALT.[Neet]
- It protects and provides immunity against micro-organisms coming in contact with mucosa.
- Diffuse lymphoid tissue is not enclosed within capsule.[Identification feature]
- Some authors consider MALT as a dense lymphoid tissue.

Flowchart 11.3: Lymphoid tissue



Dense Lymphoid Tissue

- Dense lymphoid tissue is enclosed by a well-defined capsule.[Identification feature]
- It includes discrete lymphoid organs such as lymph nodes, spleen, thymus, and tonsils.

CELLS OF LYMPHOID SYSTEM

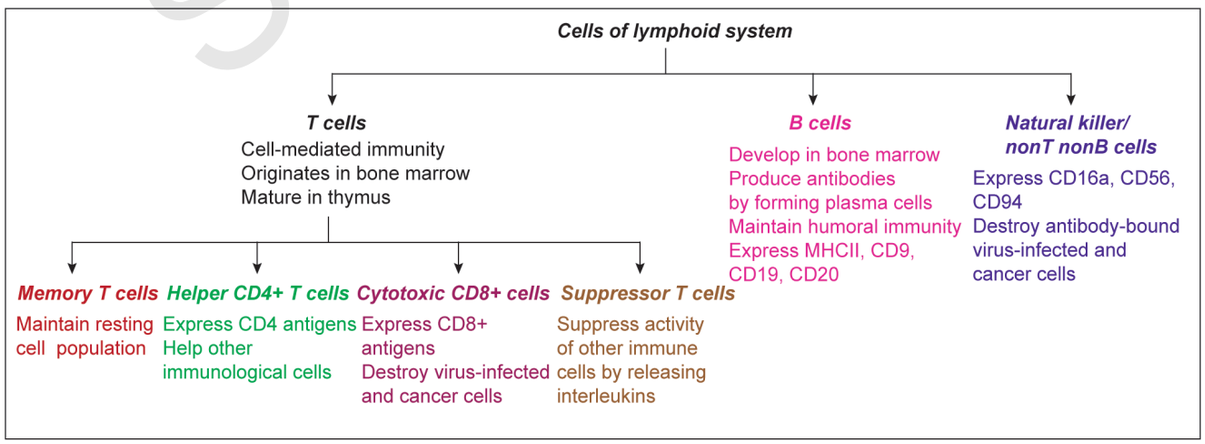
Q. List the cells of lymphoid tissue.

- Lymphoid tissue consists of lymphocytes and other supporting cells such as reticular cells, epithelio-reticular cells.
- Some cells of immune system also form part of lymphoid system. They include monocytes, macrophages, neutrophils, basophils, dendritic cells, and so on (Flowchart 11.4).
- Differentiation of cells of lymphoid tissue depends on presence of specific molecules on their surface. These molecules are called *cluster of differentiation (CD)* molecules or markers.

Lymphocytes

- Lymphocyte is a subtype of white blood cells that forms a major component of lymphoid tissue.

Flowchart 11.4: Cells of lymphoid system



Q. List the differences between dorsal root ganglion and sympathetic ganglion.

Table 12.2: Differences between sensory and autonomic ganglia

	Sensory (Dorsal root) ganglion	Autonomic (sympathetic) ganglion
Neuron	Pseudounipolar Neet	Multipolar Neet
Neuron–body shape	Large spherical	Small irregular
Types of neuron	Sensory	Postganglionic autonomic/sympathetic neuron
Nucleus	Large, vesicular, centrally placed Neet	Large, vesicular, eccentrically placed Neet
Satellite cells	Complete ring around neuronal body	Few satellite cells, do not form complete ring around neuronal body
Neuronal groups	Neurons present in groups (clusters) Neet	Neurons are scattered Neet
Nerve fibers	Nerve fibers are present in bundles that separate clusters of neurons	Nerve fibers are present between scattered neurons

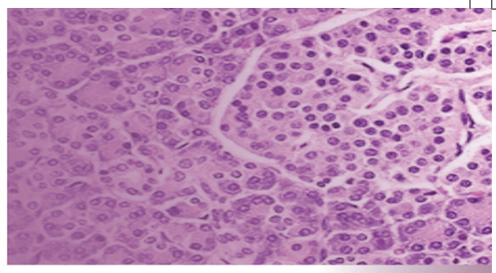
- *Satellite/capsular cells:* Few satellite cells are seen to surround each nerve cell body, but these cells *do not form a complete capsule*. Reason: Automimic neurons are multipolar, their numerous processes break the continuity of capsule, and autonomic neurons have synapse in the ganglia. In sensory ganglia, satellite cell capsule is nearly complete as sensory neurons do not synapse in ganglia. *Identification feature*
- The ganglion is surrounded by connective tissue capsule.
- As postganglionic autonomic neurons synthesize catecholamines, Nissl granules are prominently seen in their cytoplasm.
- Silver staining is useful for better visualization of processes of neurons.

The difference between sensory and autonomic ganglia are listed in Table 12.2.

Note: For histology of cerebrum, cerebellum, spinal cord and brain stem, refer Chapter 26.

Summary (Examination Guide) of Ganglion

- Ganglion is surrounded by connective tissue capsule.
- ***Dorsal root ganglion***
  - Pseudounipolar neuronal bodies: They are arranged in clusters (groups). They are large, spherical in shape with large, vesicular, and centrally placed nuclei. Neurons are present on one side of ganglion. *Identification feature*
  - Nerve fibers (myelinated) are arranged in bundles that separate groups of neurons.
  - Satellite cells: Flattened satellite cells form a *complete* ring around body of each neuron. *Identification feature*
- ***Autonomic/sympathetic ganglion***
  - Multipolar neuronal bodies: They are scattered among nerve fibers. They are large, irregular shaped. Nuclei of neurons are large, vesicular, and eccentrically placed. *Identification feature*
  - Nerve fibers are arranged in bundles that run between scattered neurons.
  - Satellite cells: Few flat satellite cells surround each nerve cell body but do not form a complete ring. *Identification feature*
  - Nerve fibers are both myelinated (preganglionic) and unmyelinated (postganglionic).



CHAPTER 13

Cardiovascular Tissue

Chapter Outline

Competency achievement: The student should be able to:

AN69.1 Identify elastic and muscular blood vessels, capillaries under the microscope

AN69.2 Describe the various types and structure-function correlation of blood vessel

AN69.3 Describe the ultrastructure of blood vessels

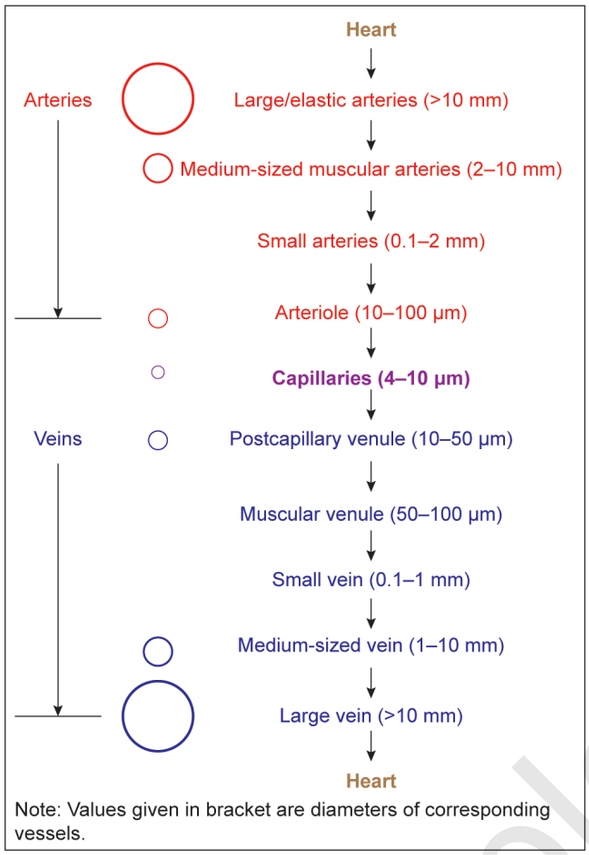
INTRODUCTION

- Cardiovascular system transports blood to and from various tissues of the body.
- Cardiovascular system consists of heart and blood vessels. Blood vessels include arteries, capillaries, and veins. Some authors consider lymphatic vessels as part of cardiovascular system.
- Heart is a muscular organ that pumps the blood into the arterial system. Heart receives blood from veins.
- Blood vessels form a network of pipe system that transport blood from heart to tissues and back to heart.
- Blood vessels can be grouped as follows (Flowchart 13.1):
  - *Arteries* carry blood away from the heart.
  - *Arterioles* are the smallest arteries that deliver blood to capillaries.
  - *Capillaries* are the smallest vessels that exchange nutrients between blood and tissue.
  - *Venules* are the smallest veins that receive blood from capillaries.
  - *Veins* carry blood toward heart.
- There are several types of circuits in body that distributes blood. For example, systemic circulation, pulmonary circulation, portal circulation, and so on.
- Pulmonary and systemic circulation has only single plexus of capillaries.
- In portal circulation, portal vein forms another (second) set of capillary plexus. Examples of portal circulations: Hepatic portal system, hypothalamo-hypophyseal portal system.
- All blood vessels, irrespective of their size and type, are lined by endothelium.

ENDOTHELIUM

- Vascular endothelium is a lining epithelium of internal surface of cardiovascular system (Fig. 13.1).
- Vascular endothelium is a *simple squamous epithelium.*
- Endothelium consists of *endothelial cells.*
- Endothelial cells are flattened, elongated and polygonal cells.
- The long axis of endothelial cell is parallel to the axis of blood flow.
- *H&E staining:* In transverse section, endothelial cell shows small quantity of cytoplasm and elongated, flat, densely stained nucleus.
- *Electron microscopy:* Cytoplasm contains endoplasmic reticulum, mitochondria, and microfilaments. Adjacent endothelial cells are connected with each other by *tight junctions*. Endothelial cells rest on basal lamina that can be visualized by periodic acid-Schiff staining method.

Flowchart 13.1: Blood circulation through vessels



Note: Values given in bracket are diameters of corresponding vessels.

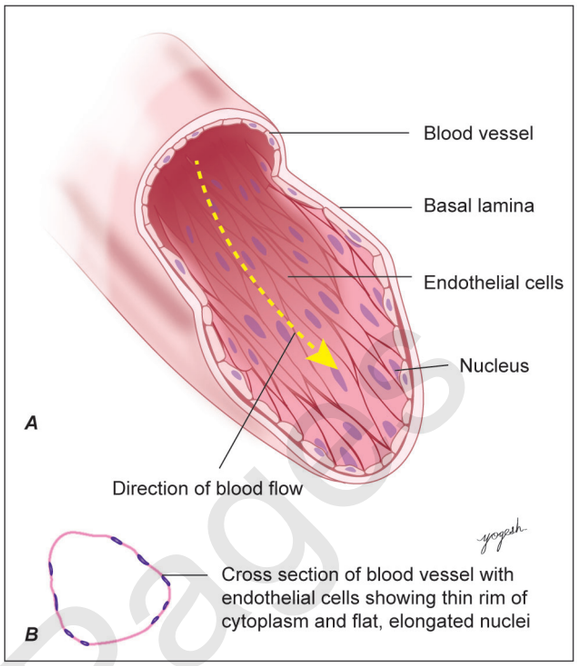


Fig. 13.1: (A) Endothelial cells. Note: Long axis of endothelial cells lies parallel to the direction of blood flow. (B) Practice figure for endothelial cells.

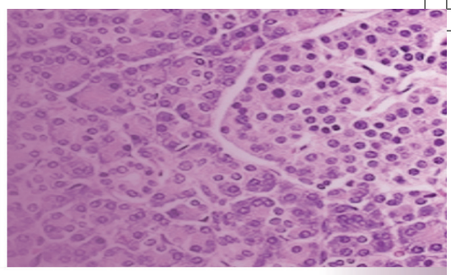
Functions of Endothelium (Table 13.1)

Q. List the functions of endothelium.

- *Smooth surface:* Endothelium provides a smooth nonadherent surface for flowing blood columns.
- *Selective permeability barrier:* Endothelium allows movement of selected substances across it through simple diffusion, pinocytosis, and receptor-mediated endocytosis. Transport of substance mainly depends on its size and charge.
- *Release of von Willebrand Factor* (plasminogen-activator inhibitor): Damaged endothelium release von Willebrand factor that induces platelet aggregation and clot formation [Erik Adolf von Willebrand, 1870–1949, Finnish physician].
- *Release of nitric oxide* (NO) and prostacyclin: These are vasodilator agents.
- *Release of endothelin, angiotensin-converting enzyme* (ACE): These are vasoconstrictor agents. With the help of vasodilator and vasoconstrictor agents, endothelium controls blood flow through the vessels.
- *Hormone synthesis:* Endothelium synthesizes and secretes many growth factors such as colony-stimulating factors, fibroblast growth factors, platelet-derived growth factors.
- *Release of endothelial-derived relaxing factor* (EDRF): EDRF produces vasodilatation with the help of nitric oxide (NO).
- *Synthesis of type IV collagen fibers* that are responsible for the formation of basal lamina.

Table 13.1: Function of endothelium[Viva]

1. Prevention of clotting
2. Selective permeability barrier
3. Release of von Willebrand Factor
4. Release of nitric oxide (NO) and prostacyclin
5. Release of endothelin, angiotensin-converting enzyme (ACE)
6. Hormone synthesis: colony-stimulating factors, fibroblast growth factors, platelet derived growth factors
7. Release of endothelial-derived relaxing factor (EDRF)
8. Synthesis of type IV collagen fibers



CHAPTER 14

Skin and its Appendages

Chapter Outline

- Introduction
- Structure of skin
  - Epidermis
  - Dermis
- Cells of epidermis
- Blood supply and nerve supply of skin
- Panniculus carnosus
- Sensory receptors of skin
- Appendage of skin
  - Hairs
  - Sebaceous glands
  - Sweat glands
  - Nails
- Arrector pili muscle
- Nail clubbing

Competency achievement: The student should be able to:

AN72.1 Identify the skin and its appendages under the microscope and correlate the structure with function

INTRODUCTION

- Integumentary system consists of skin and its appendages as follows:
  - Skin consists of two layers epidermis and dermis
  - Hair follicles and hairs
  - Sweat glands
  - Sebaceous glands
  - Nails
  - Mammary glands
- Hypodermis consists of adipose tissue that lies deep in to the dermis (*hypodermis* = subcutaneous fascia).
- Skin forms the outer covering of body.
- Skin-covering is supported by appendages or derivatives of skin such as hairs, nails, sebaceous glands, and sweat glands.
- Skin is the largest organ of body constituting about 16% (15–20%) of total body weight. *Viva*
- Skin has two layers: Superficial epidermis and deep dermis.

Types of Skin

- There are two types of skin depending on thickness of epidermis:
  1. *Thick skin:* Thick skin has very thick layer of epidermis. Its epidermis shows thick stratum corneum. Thick skin is also called *glabrous skin*. Thick skin does not have hairs. Locations: Skin of palm of hand and sole of feet. *Viva*
  2. *Thin (hairy) skin:* In thin skin, epidermis is thin. Thin skin shows hairs. Locations: Skin covering all parts of body except palm and soles. *Viva*
- For detailed differences between thick and thin skin, refer Table 14.1.

Structure of Skin

- Histologically, skin consists of two layers:
  1. *Epidermis:* It is a superficial layer that consists of keratinized stratified squamous epithelium.
  2. *Dermis:* It is deep layer that is made up of connective tissue.

Epidermis

- Epidermis consists of keratinized stratified squamous epithelium. *MCQ, Viva*
- Epidermis shows five layers of cells as follows (Figs 14.1 to 14.5): *Neet, Viva*
  1. Stratum basale
  2. Stratum spinosum
  3. Stratum granulosum
  4. Stratum lucidum (only in thick skin)
  5. Stratum corneum

Q. List the differences between thick and thin skin.

Table 14.1: Differences between thin and thick skin[Viva]

	Thick skin	Thin skin
Stratum lucidum	Present	Absent
Thickness of epidermis	0.6–4.5 mm	0.01–0.15 mm
Epidermal ridges	Present	Absent
Hair follicles	Absent	Present
Arrector pili muscle	Absent	Present
Sebaceous glands	Absent	Present
Sweat glands	Many	Few
Sensory receptors/Merkel's cells	More	Less
Location	Skin of palm and sole	Skin except of palm and sole

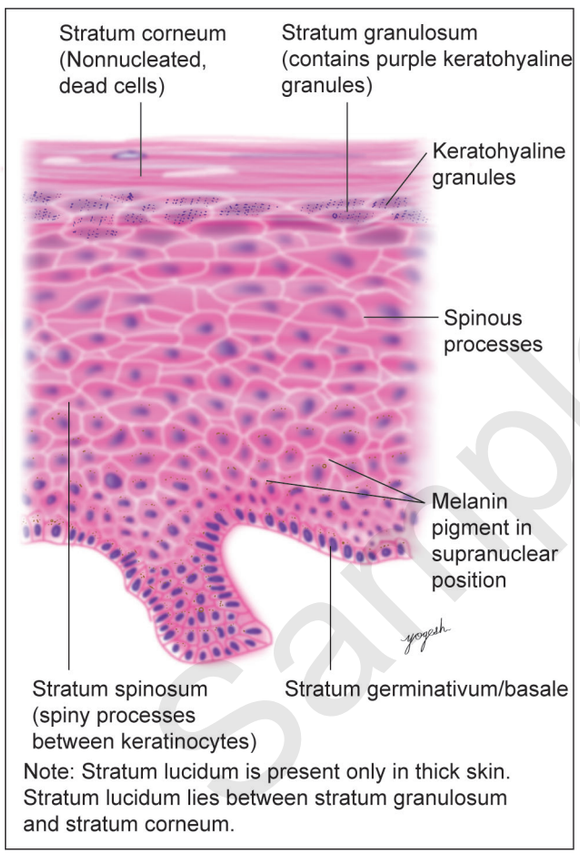


Fig. 14.1: Layers of epidermis.

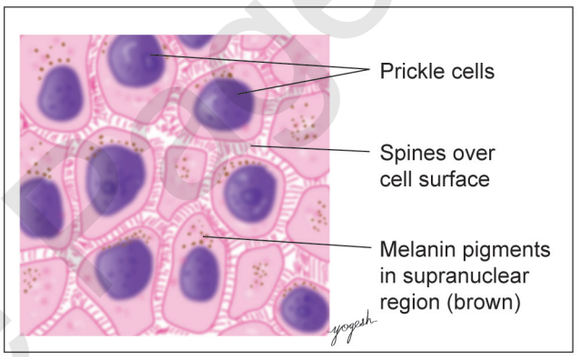


Fig. 14.2: Stratum spinosum of epidermis.

Some Interesting Facts

- *Thickest skin of body* is present in upper part of the back. Here, thin skin covers extremely thick dermis.
- Skin of eyelid is the *thinnest skin of body.* It is devoid of fat.
- *Cutaneous root for drug delivery:* Lipid-soluble drugs can be absorbed by skin when applied as ointment, spray, or patches.
- Cells of skin undergo specialized form of apoptosis. Stratum basale cells divide and migrate toward superficial layers. During migration, these cells show nuclear apoptotic changes and accumulation of intracellular keratin protein.

1. Stratum Basale (Stratum Germinativum)

- Stratum basale is the deepest layer of epidermis.
- Cells: It consists of a *single layer of cuboidal (low columnar) cells* that rest on basal lamina.
- *H&E staining:* Cells show basophilic cytoplasm and *melanin pigments.*
- *Functions:* These cells divide mitotically to give rise to keratinocytes (cells of skin) that form superficial layers of skin. Hence, stratum basale is also called stratum germinativum.[Viva]

2. *Stratum Spinosum* (Malpighian Layer, Prickle Cell Layer) (Figs 14.2, 14.5 and 14.6)

- Above the stratum basale, several layers of thick *stratum spinosum* are present.

Box 18.1: Peyer's patches

Q. Write a short note on Peyer's patches.

- Peyer's patches are organized lymphatic nodules in lamina propria of terminal part of ileum.
- These are elongated thickening of intestinal mucosa (few centimeters in length).
- Number: About 100 Peyer's patches are present in ileum.
- Peyer's patches are aggregation of lymphatic follicles.
- At many places, Peyer's patches cross muscularis mucosa and extend into submucosa.
- Peyer's patches form a part of gut-associated lymphatic tissue (GALT).
- Peyer's patches are found in antimesenteric border of ileum.
- *M-cell:* These are columnar epithelial cells that overlie Peyer's patches. These cells have recesses to accommodate lymphocytes and macrophages. M-cell presents bacterial antigens to immune cells.
- *Function:* Peyer's patches help to maintain normal bacterial intestinal flora and prevent infections.

LARGE INTESTINE

- Large intestine consists of cecum, vermiform appendix, colon (ascending, transverse, descending, and sigmoid), rectum and anal canal.
- Gross anatomically, large intestine shows three cardinal features (Fig. 18.10):[Viva]
  1. *Taenia coli:* These are three narrow thickened bands longitudinal smooth muscle fibers of muscularis externa. Taenia are absent in appendix, rectum, and anal canal.[Viva]
  2. *Haustrations:* These are dilatations (sacculations) of colon.
  3. *Appendices epiploicae* (omental appendices): These are small pockets of fat on outer surface of large intestine.

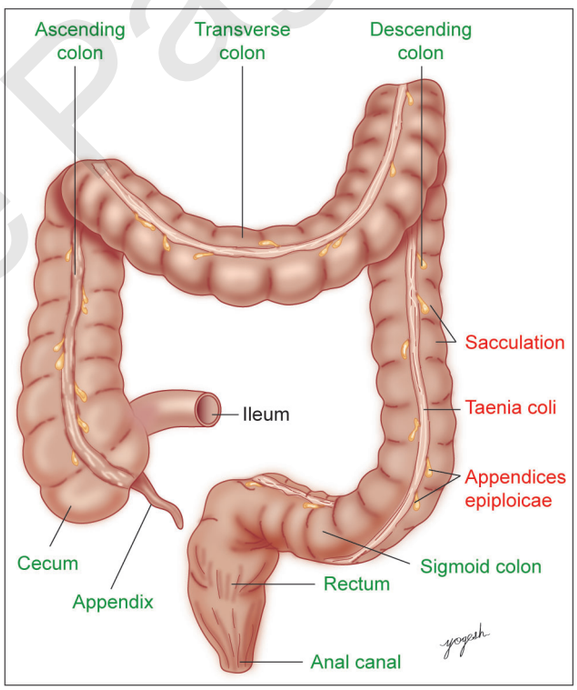


Fig. 18.10: Parts of large intestine and its features.

COLON

- A section of colon shows four layers: Mucosa, submucosa, muscularis externa, and serosa (Figs 18.11 to 18.13 and Flowchart 18.3).

Mucosa

- Mucosa consists of lining epithelium, lamina propria, and muscularis mucosa.
- *Epithelium:* Colon is lined by *simple columnar epithelium* and number of *goblet cells*. Epithelial cells show microvilli (striated border) on absorptive cells.[Identification feature]
- In large intestine (colon), plicae circularis (mucosal folds) and villi are absent.[Identification feature] Hence, mucosa of large intestine has smooth surface.
- *Glands:* Lamina propria is occupied by short *simple tubular intestinal glands* or crypts of Lieberkühn.[Identification feature] These glands are lined with simple columnar cells and may goblet cells.
- Note: Paneth cells are absent in large intestine.[Neet]
- Some *caveolated tuft cells* are present in colon.
- *Stem cells* are located at the bottom of gland.
- Surface epithelial cells and goblet cells have a lifespan of 5–6 days.[MCQ]
- Lifespan of enteroendocrine cells is 4 weeks.[MCQ]
- Large intestine performs absorption of water and electrolytes and production of mucin that lubricates its contents.

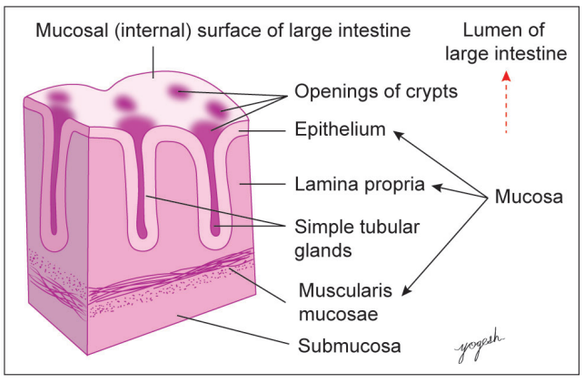


Fig. 18.11: Location of simple tubular glands in lamina propria of large intestine.

- Lamina propria shows collagen table (thick collagen fibers) between basal lamina and epithelium. Collagen table regulates transport of water and electrolytes.
- *New concept:* There is pericryptal fibroblast sheath in lamina propria of colon. These fibroblasts replicate and migrate toward luminal surface and may differentiate to form macrophages.
- Lamina propria shows discrete lymphatic nodules that are regularly spaced.

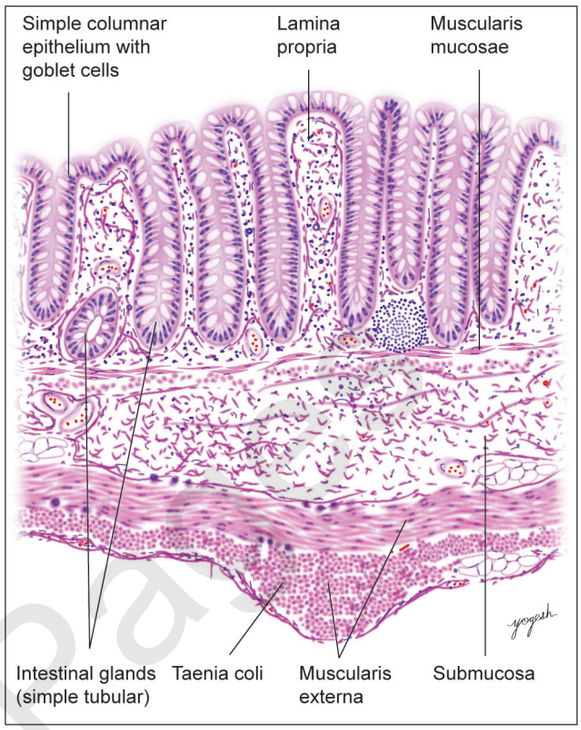


Fig. 18.12: Histology of large intestine (practice figure).

Flowchart 18.3: Histology of colon

Colon

Mucosa
- Simple columnar epithelium with numerous goblet cells
- Simple tubular glands
- Lamina propria shows discrete lymphatic follicles
- Muscularis mucosae

Submucosa
- Connective tissue
- No Brunner's glands and Peyer's patches

Muscularis externa
Smooth muscle layer
- Inner circular
- Outer longitudinal

3 bands of taenia coli

Serosa/Adventitia
- Connective tissue layer
- Partly covered by mesothelium (serosa)

Note: Colon do not have plicae circularis, villi, and Paneth cells.

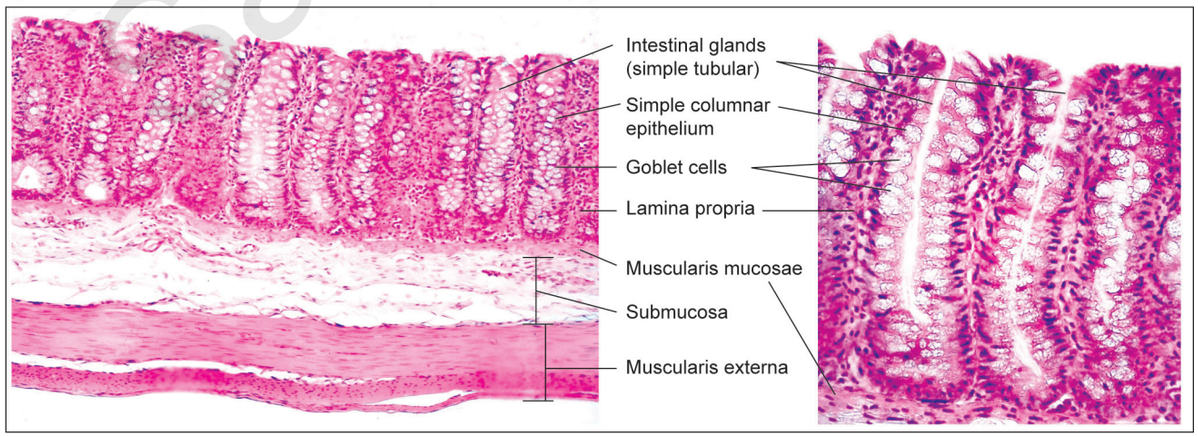
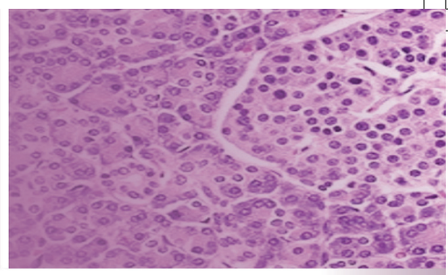


Fig. 18.13: Photomicrograph. Histology of colon/large intestine (low magnification on left, mucosa at high magnification on right, *H&E* staining).



CHAPTER 28

Special Senses II: Ear

Chapter Outline

- Internal ear
  - Bony labyrinth
  - Membranous labyrinth
- Organ of Corti
- Macula
- Ampullary crests

INTRODUCTION

- Ear is the sensory organ of hearing and equilibrium.
- Ear consists of three parts: External ear, middle ear, and internal ear (Fig. 28.1).
- External ear consists of auricle and external acoustic meatus.
- *Auricle* is shaped irregular because of presence of irregularly shaped *elastic cartilage*.

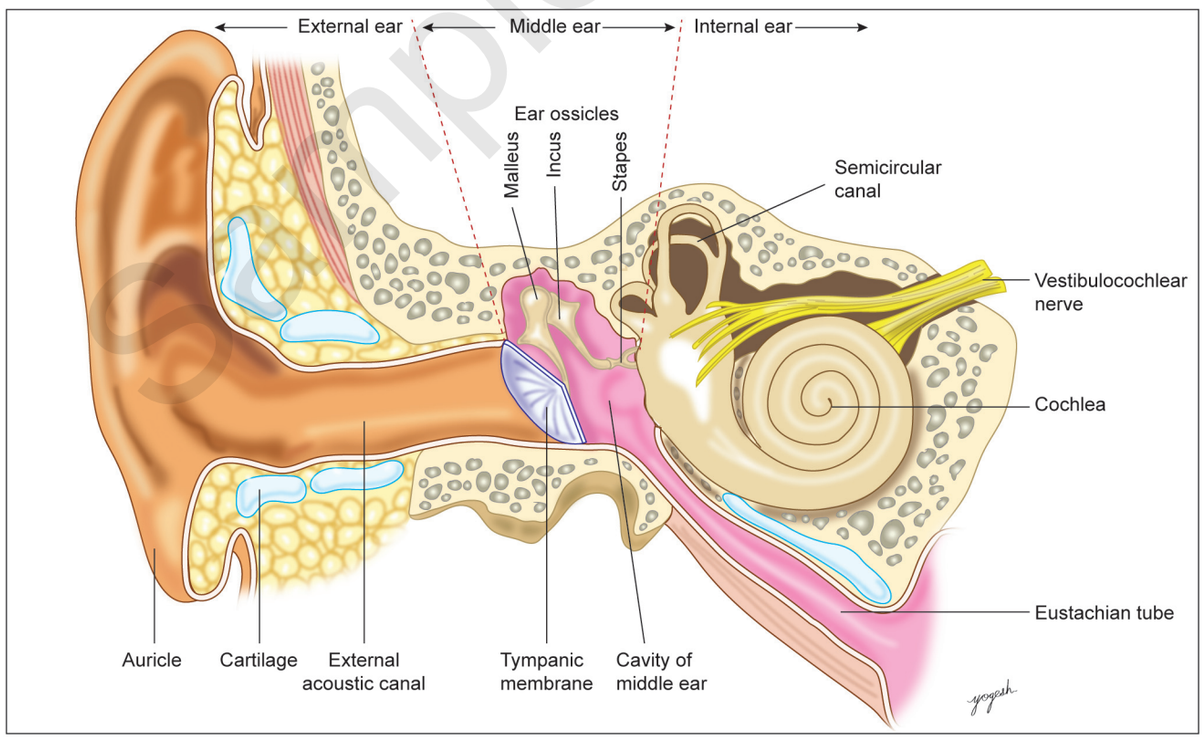


Fig. 28.1: Parts of ear.

- Auricle consists of an elastic cartilage that is covered on both side by tightly adherent layers of thin skin.
- Skin of auricle shows presence of hair follicles, sweat glands, and sebaceous glands.
- Auricle helps to gather sound waves.
- *External auditory meatus*
  - It is a tubular canal that extends from concha to the tympanic membrane.
  - It has two parts: Outer one-third (8 mm) is cartilaginous and inner two-thirds (16 mm) is bony part.
  - It is covered by thin skin.
  - It has *ceruminous glands* (modified apocrine sweat glands) that secrete cerumen or *earwax.*
  - The external ear is separated from middle ear by tympanic membrane

Middle Ear

- Middle ear is a small space in the petrous part of temporal bone
- Middle ear is lined by ciliated columnar or cuboidal epithelium.
- Middle ear contains three ossicles (incus, malleus and stapes) that are composed of compact bone.
- Middle ear contains two skeletal muscles (tensor tympani and stapedius muscles) that control movement of ear ossicles.
- Auditory tube/Eustachian tube connects middle ear cavity with nasopharynx.

Internal Ear

- Internal ear lies within the petrous part of temporal bone.
- It has *bony labyrinth* and *membranous labyrinth.*
- Bony labyrinth consists of three parts: Cochlea, vestibule, and semicircular canals.
- Within the bony labyrinth, there is a system of ducts that constitutes membranous labyrinth

Box 28.1: Tympanic membrane

- Tympanic membrane is a thin partition between external acoustic meatus and middle ear.
- Shape and size: Oval and 9 mm × 10 mm.
- It has two surfaces: Outer and inner.
- Histologically, tympanic membrane consists of the following three layers:
- 1. Outer cuticular layer of skin
  2. Middle fibrous layer
  3. Innermost mucous layer
- Fibrous layer has superficial radiating fibers and deep circular collagen fibers.
- Inner mucous layer is lined by ciliated simple columnar epithelium.

INTERNAL EAR

- Internal ear lies in the petrous part of temporal bone.
- It consists of two parts as follows:
  1. *Bony labyrinth:* It has three parts: Cochlea, vestibule, and semicircular canals.
  2. *Membranous labyrinth:* It consists of duct of cochlea, semicircular ducts, ductus reuniens, utricle, saccule, and endolymphatic duct and sac.
- Membranous labyrinth is filled with a fluid called *endolymph.*
- Membranous labyrinth is separated from the bony labyrinth by *perilymph* (fluid).

Bony Labyrinth

- Bony labyrinth consists of three parts: Cochlea anteriorly, vestibule in the middle, and semicircular canals posteriorly (Fig. 28.2).

Cochlea

- Bony cochlea resembles the shell of a common snail.
- It is cone shaped, spirally arranged bony canal.
- It has a conical central axis/*modiolus* around which cochlea makes two and three-quarter (2¾) turns.
- A spiral ridge of bone (*spiral lamina*) projects from modiolus and divide the bony cochlear canal into *scala vestibuli* above and *scala tympani* below.
- Scala vestibuli and scala tympani are filled with perilymph.
- *Basilar membrane* completes the division of bony cochlear canal.
- Scala vestibule communicates with the scala tympani at the apex of cochlea by a small opening called *helicotrema.*
- Cochlear nerve emerges from the base of cochlea.

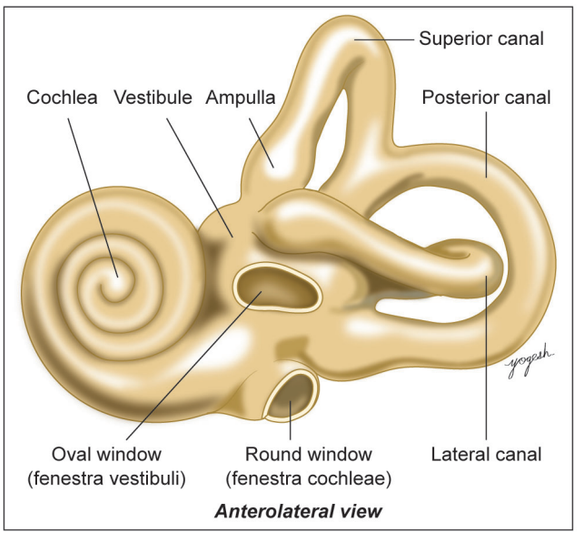


Fig. 28.2: Left bony labyrinth.

Textbook of
Human Histology
with Color Atlas, 3D Illustrations and Flowcharts

Highlights of the book

- A complete textbook on the subject for undergraduate medical students
- Text and graphics conform to the requirements of the **Competency based Undergraduate Curriculum** 2018 prescribed by the Medical Council of India.[1]
  - Help to develop knowledge (K) and skill (S) learning domains.
  - Train for knows (K) and knows how (KH) as per Miller's pyramid.[2]
- **Concise text** with functional correlation for quick recapitulation during examination (horizontal integration).
- **117 Photomicrographs** help to identify the microscopic structures.
- **122 Flowcharts** help to revise and memorize the microanatomy.
- **106 Practice figures (H&E pencil drawings)** are easy to draw for theory examination.
- **175 3D illustrations** provide a visual grasp and easier retention of difficult concepts.
- **Summary (examination guide)** to overcome the difficulty of summarizing the facts in written assessments.
- **Identification feature** markings focus readers on specific points.
- **NEET, MCQs, viva voce, and clinical facts** markings for preparation (for knows, knows how levels of competencies) of various upcoming academic entrance examinations.
- **Tables** to summarize essential facts.
- **Boxes** to focus on important topics.
- **Interesting facts** to isolate them from main text, so that these facts should not be missed by the reader.
- **Clinical correlation** for orientation towards pathogenesis of diseases (vertical integration).

[1] Medical Council of India, *Competency based Undergraduate Curriculum for the Indian Medical Graduate*. 2018;1: 41–80.
[2] Miller GE. The assessment of clinical skills/competence/performance. *Acad Med.* 1990;65(9 Suppl):S63–7.

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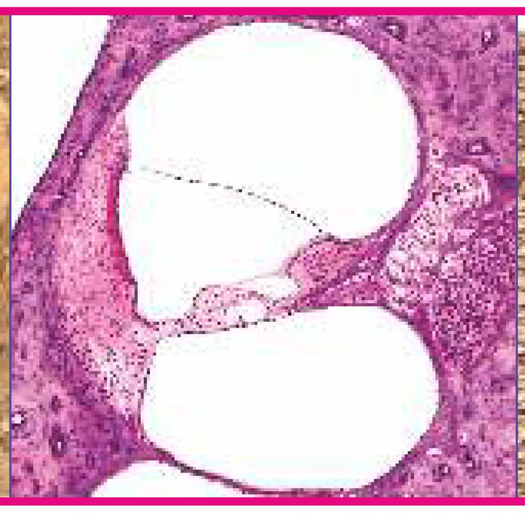

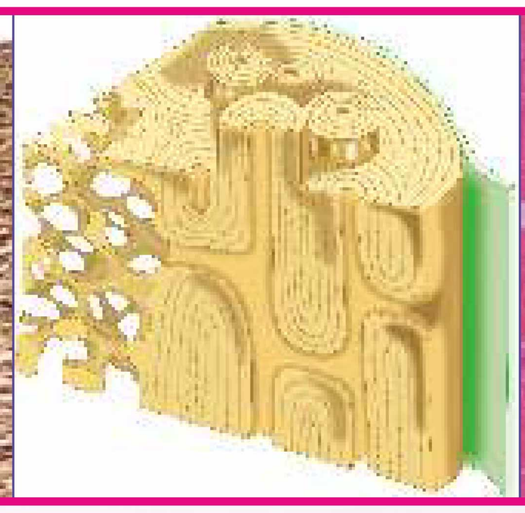
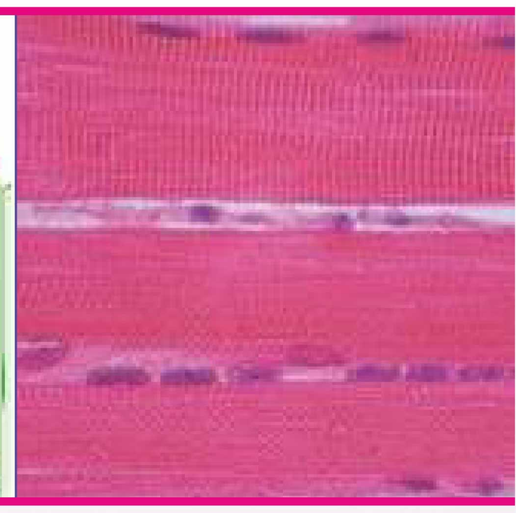

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