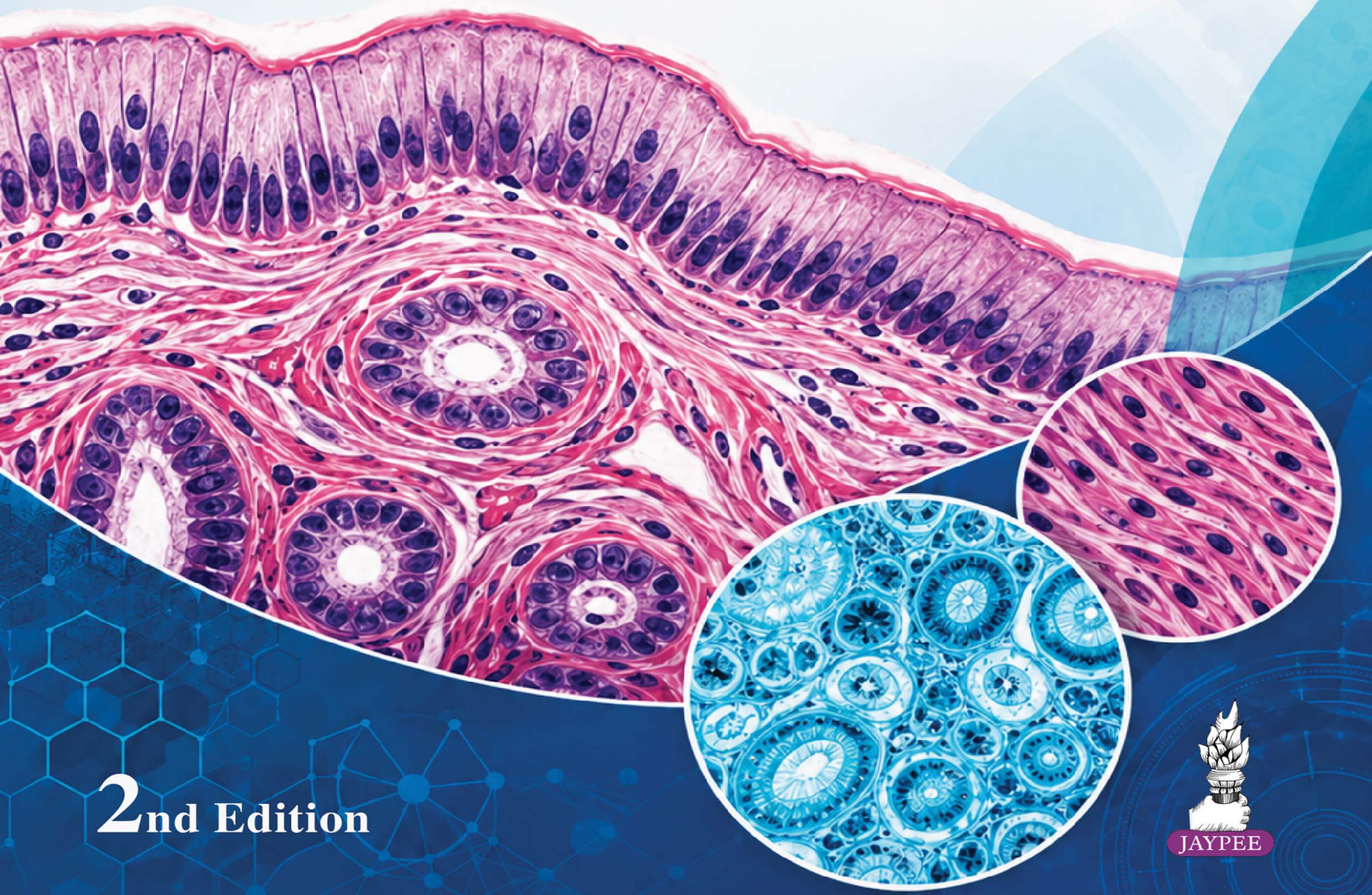
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HISTOLOGY

A Text & Practical Record Book

As per the Revised Competency-based Medical Education Curriculum 2024 (NMC)

Sangita Chauhan • Seema Gupta



2nd Edition

JAYPEE

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3 CHAPTER

Systemic Histology

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INTEGUMENTARY SYSTEM

It forms the largest organ and external covering of the body. It is 15–20% of the total mass and consists mainly of 3 layers.

1. Epidermis: It is comprising of keratinized squamous epithelium which grows continuously to maintain the thickness by desquamation and is derived from ectoderm. It has the regenerating power.
2. Dermis: It is derived from mesoderm. It consists of dense connective tissue which provides mechanical support, strength and nourishes the fibroelastic tissue. It is divided into the papillary and reticular layers. The papillary layer is made up of the thin fine interlacing collagen fibers blood vessels, lymphatics, capillary loops and sensory nerve endings whereas the reticular layer consist of irregular collagen and elastic fibers and fibroblasts which lay these fibers, lymphocytes and macrophages and blood vessels may be found in deeper levels of the dermis. Since the skin does not have a very high metabolic demand for nutrients and oxygen, this rich vascular network serves mainly for regulation of body temperature which depends on the amount of blood flowing through superficial capillaries that allows for either conservation or dissipation of body heat.

   Arteriovenous shunts, controlled by associated sphincters, allow blood to bypass capillaries and flow directly from arteries into veins. These shunts occur in both deep and superficial dermis. In the dermis of finger tips, nose, external ear which are prone to excessive cold, AV shunts are controlled by glomus bodies which are highly convoluted portions of AV shunts surrounded by condensed collagen tissue causing thickening of vessel wall and smooth muscle cells assume an epithelioid appearance.
3. Hypodermis contains fatty tissue arranged into lobules separated by connective tissue and is equivalent to subcutaneous fascia.

FUNCTIONS OF SKIN

- Protection against mechanical, chemical, thermal, UV rays and microorganisms.
- Checks dehydration by preventing water loss.
- Maintains homeostasis.
- Helps in the regulation of body temperature. In winters hair and subcutaneous fat act as insulators and prevent heat loss. In summers it facilitates the heat loss by evaporation and keeps the surface cool.
- Synthesis of vitamin D.
- Largest sensory organ as it has receptors for touch, pain and pressure **(Figs. 3.1 and 3.2)**.

SKIN APPENDAGES

- Hair
- Sweat gland
- Sebaceous gland
- Nails
- Mammary gland.

Glomus bodies which are the highly convoluted portions in the walls of arteries, veins or AV shunts which are thickened and smooth muscle cells acquire an epithelioid appearance, concerned with temperature regulation.

Color of the skin depends on:

- Melanin.
- Oxyhemoglobin present in the dermis.
- Carotene gives yellow hue taken from the food.
- Hemosiderin golden brown in color.
- Bilirubin yellowish brown so yellow discoloration in jaundice.

CELLS OF EPIDERMIS

Four types of cells are there.

KERATINOCYTES

They are the predominant cells which arise in the basal layer.

Function is to produce keratin which is the major structural protein of epidermis and forms epidermal water barrier.

MELANOCYTES

- Present in the basal layer.
- They synthesize and release a brown pigment called melanin responsible for the color of the skin.
- Melanoblasts are derived from neural crest which give rise to melanocytes.
- Melanocytes synthesize melanin which is a brown pigment.
- Cytoplasm contains special membrane bound oval granules called premelanosome and melanosomes.
- Tyrosine is converted to DOPA which polymerizes into melanin bound to the protein.
- This melanin is transferred to basal and stratum spinosum along the cytoplasmic processes.
- Melanin secretion increases when exposed to UV rays.
- Melanin increases in the presence of UV light and this has a protective role.
- In old age melanin decreases so more chances of cancer. In albinos there is lack of tyrosinase enzyme which converts tyrosine to melanin so there is no pigment in the skin and hair.
- Melanin pigment increases in cases of hormonal imbalance in Addison's disease.

LANGERHAN'S CELLS

Langerhan's cells present in all the layers of epidermis.

- Also occur around blood vessels in papillary dermis.
- Nucleus is oval, reniform or irregular surrounded by pale cytoplasm extending as processes between keratinocytes.
- They contain rod like Berbeck granules, the ends of which distends in a vesicle resembling a tennis racket.
- They are antigen presenting cells.

MERKEL CELLS

Merkel cells are specialized touch receptors

- Scattered among the cells of the basal layers.
- At their bases are neuroendocrinal vesicles and have a synaptic junction with a fine nerve ending in the papillary dermis.

The layers of epidermis are best seen in thick skin. Epidermis is lined by stratified squamous keratinized epithelium and shows the following layers:

Stratum basale is the germinal layer and it shows mitotic activity (also takes place in stratum spinosum). Cells are columnar, forms a single layer which is separated from the dermis by basement membrane bounded by hemidesmosomes and provides a constant supply of keratin to replace the cells lost by normal wear and tear from 25 to 50 days.

Key Histologic Features: Thin skin

- Thickness depends on the thickness of stratum corneum which is thin.
- Absence of stratum lucidum.
- Contains hair follicles and the epidermal ridges are less prominent.
- Numerous arteriovenous anastomoses are there which help in thermoregulation by controlling the blood flow to dermis.
- Thin skin is seen in the eyelids and anterior abdominal wall.

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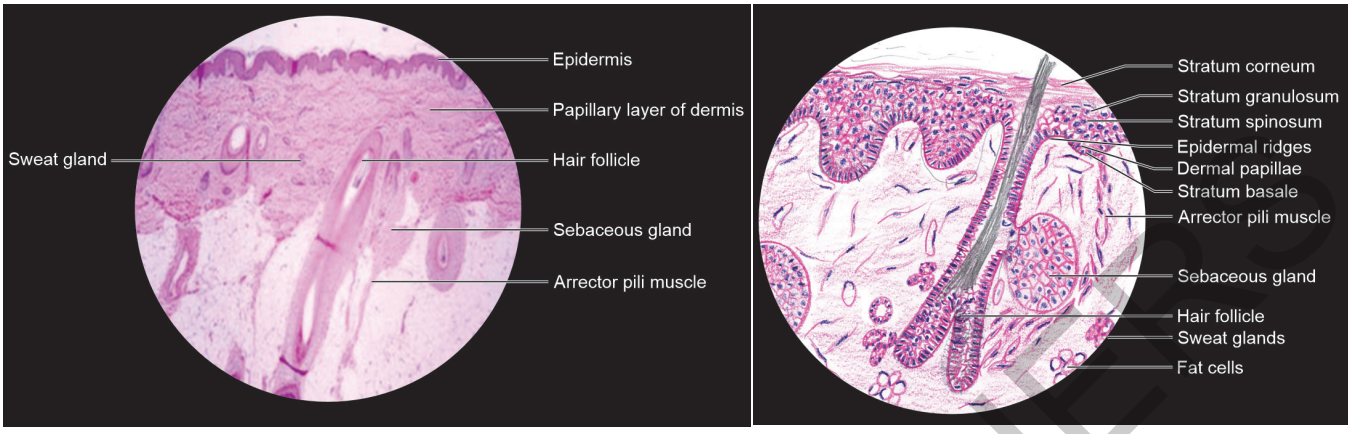


Fig. 3.1: Thin skin

Stratum spinosum also called **prickle cell** layer. The cells are large polyhedral and have numerous cytoplasmic processes (prickles) which show cytoplasmic basophilia and prominent nucleoli which is indicative of active protein synthesis.

Stratum granulosum cells have numerous basophilic keratohyalin granules.

Stratum lucidum is the subdivision of stratum corneum, found only in thick skin, highly refractile, nucleus and cytoplasmic organelle become disrupted and disappear as cells fill with keratin.

Stratum corneum consists of dead or dying cells. Cells are flattened, no nuclei and other organelles. Cells are filled with mature keratin.

Key Histologic Features: Thick skin

- Present in the palms and soles or at places which are subjected to wear and tear.
- Thick keratinized surface layer.
- Epidermal ridges, dermal papilla and stratum lucidum more prominent.
- No hair follicles.

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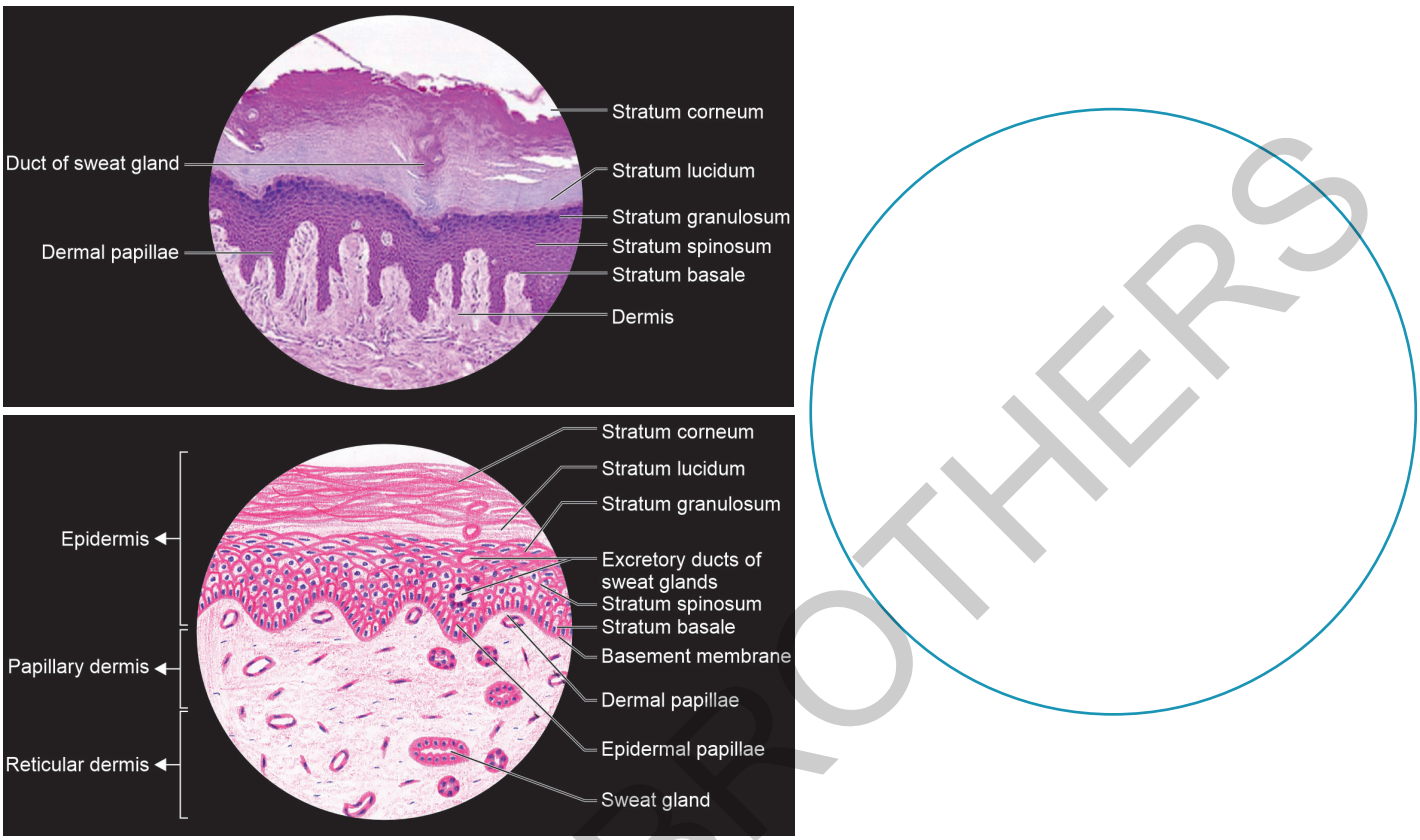


Fig. 3.2: Thick skin

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QUESTIONS

1. **What is the lining epithelium of epidermis?**
2. **What are the different layers of skin and its functions?**
3. **Name the cells in the epithelium and give their embryonic origin.**
4. **What is pilosebaceous unit?**
5. **What are the differences between thick and thin skin?**

DIFFERENCES BETWEEN THICK AND THIN SKIN

Features	*Thin skin (scalp)*	*Thick skin (sole)*
Epidermis	Nonkeratinized stratified squamous epithelium Only four layers are present stratum lucidum is absent	Keratinized stratified squamous epithelium All five layers are present so more thick Stratum lucidum is prominent
Dermis Papillary Reticular	 Less prominent dermal papillae More thicker	 More prominent dermal papillae and epidermal ridges Less thick
Sweat glands	More in number	Less and located deep in dermis (max. in soles)
Hair follicles	Present	Absent
Sebaceous glands	Present with arrector pili muscle	Absent
Location	All other places except palm and sole	Present in palm and sole

SKIN CIRCULATION

There are two plexuses:

1. At the junction of dermis and hypodermis called **cutaneous plexus**.
2. Below the dermal papilla called **subpapillary plexus**.

There are no blood vessels in epidermis, it receives its nutrition by diffusion from the dermis.

SWEAT GLANDS

There are two types of sweat glands:

1. Merocrine (eccrine).
2. Apocrine.

Merocrine

They are simple coiled tubular glands:

- The secretory portion of the gland lies deep in the dermis and duct communicates outwards through the dermis and the epidermis.
- Found all over the body except lips and glans penis.
- They secrete a watery fluid hypotonic to plasma. The evaporation of sweat plays an important role in the thermoregulation. Sweat contains sodium, chloride ions urea and other metabolites. So sweating is considered as a minor form of excretion.
- The secretory part is lined by simple cuboidal epithelium comprised of larger cells than the duct, along with interspersed myoepithelial cells (which can expel sweat by contraction).
- The duct is lined by stratified cuboidal epithelium (two-layered).
- Cells of duct are stained more intensely than those of the secretory portion of the gland. As fluid flows through the duct, its composition is modified by reabsorption of certain elements from the fluid. This is a means of conserving salt.
- Sweat glands are vital for thermoregulation. They also influence water and ion balance.
- The primary function for sweating is cooling of the body by evaporation. Thus, the amount of sweat is regulated as a function of body temperature. However, sweat also contains salt. Normally, sweat which comes out on the surface of the skin has a lower salt concentration than the precursor fluid produced by the secretory cells of the sweat gland. Salt is reabsorbed by the duct of the sweat gland. The effectiveness of this salt reabsorption is regulated by aldosterone the hormone responsible for maintaining electrolyte homeostasis in response to salt balance of body.

Apocrine

- Glands are present in the axillary, pubic, and perianal regions.
- Large glands that produce a viscid milky secretion.
- They do not become functional until puberty and they always secrete via a duct into the hair follicle.
- They are coiled tubular glands with a wide dilated lumen.
- Both types of sweat glands have the same basic shape, but apocrine glands have taller cells and much larger diameter.

SEBACEOUS GLAND

- Found in dermis of skin.
- Keeps skin smooth to prevent it from drying.
- Simple acinar gland whose duct usually open into hair follicle and in lips, glans penis and clitoris it directly opens on the epidermal surface with holocrine mode of secretion.
- Acini consist of a layer of flat epithelial cells resting on a basement membrane.
- These are rounded cells with central nucleus and filled with fat droplets.
- Secretes sebum which is an oily secretion with antifungal and antibacterial properties.
- Secretion is controlled by testosterone in males and by androgens (ovarian and adrenal) in females.

IMMUNE SYSTEM

THE TONSILS (FIG. 3.3)

It is a special variety of lymphoid tissue which is neither primary nor secondary.

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Key Histologic Features: Palatine tonsil

- Surface is covered by nonkeratinized stratified epithelium.
- Deep to the epithelium numerous lymphoid nodules are seen.
- Crypts are seen.

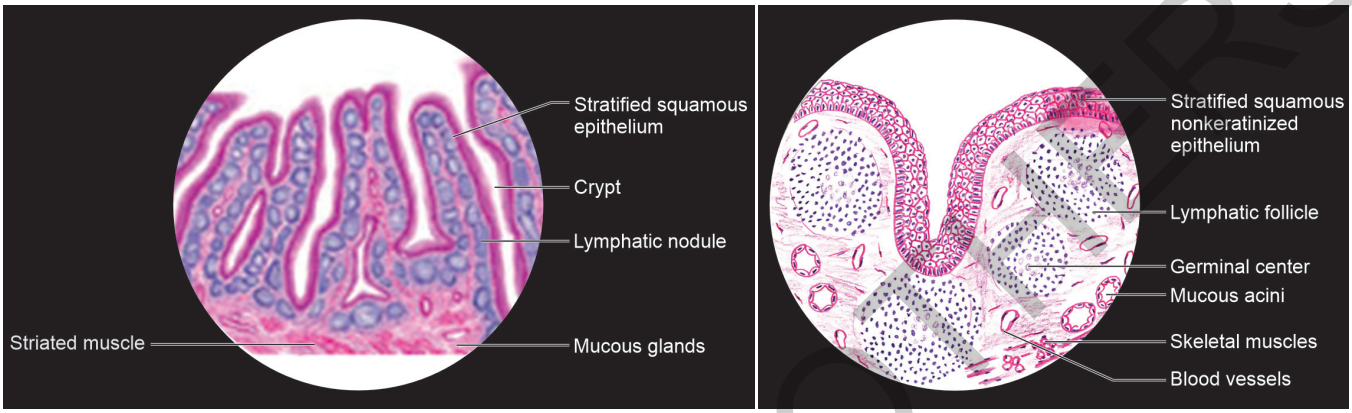


Fig. 3.3: Palatine tonsil

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Microanatomy

It shows the presence of a **hemi capsule** on the basal side separating it from underlying muscles. The surface of the tonsils is covered by stratified squamous epithelium (nonkeratinized) which dips into the surface **forming tonsillar crypts**.

Numerous **lymphatic nodules** (B lymphocytes) are present in the lamina propria which may be primary or secondary. T lymphocytes are present in the interfollicular region.

If secondary, that is exposed to an antigen shows lighter staining germinal center with large lymphoblasts and plasma cells. At the periphery the lymphocytes are small with condensed nuclei.

The lymphocytes invade or penetrate the epithelium and come in the lumen of the crypts.

Serous and mucous acini with ducts opening on the side of crypt are seen.

Salivary corpuscles formed of desquamated epithelial cells with lymphocytes migrating through the epithelium and few bacteria.

QUESTIONS

1. **What is the lining epithelium?**
2. **What are tonsillar crypts?**
3. **What is salivary corpuscle?**
4. **Where are B and T lymphocytes present?**
5. **What is a hemi capsule and where it is present?**

THYMUS (FIG. 3.4)

Its function is to produce immunologically competent T lymphocytes. From here they migrate to other tissues to populate T dependent portions of lymph node, spleen and loose connective tissue. It has no afferent lymphatics.

It is a primary **lymphoreticular organ** and produces a lymphocyte stimulating hormone called **thymosin** which increases the response to antigens and is responsible for maturation and proliferation of T lymphocytes. It involutes at puberty.

Key Histologic Features: Thymus

- Capsule sends trabeculae in the cortex only forming leaf like lobule.
- Cortex is composed of small darkly stained lymphocytes, epitheliocytes and macrophages.
- In the medulla Hassall's corpuscles are seen.

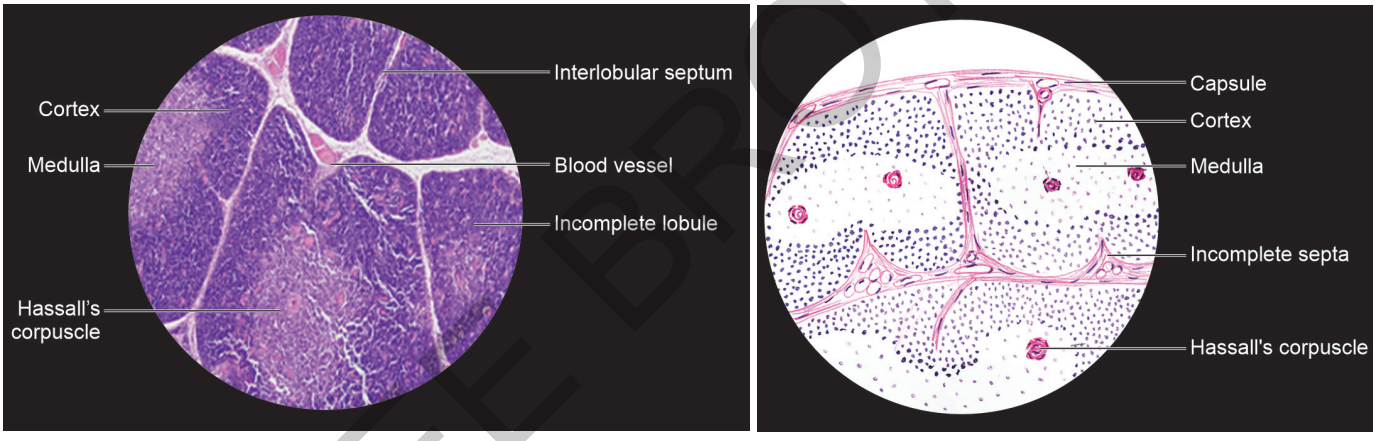


Fig. 3.4: Thymus

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It has a thin outer fibrous covering called capsule made of elastic and collagen fibers. Thymus is of endodermal origin, the tissue framework is formed by **epithelia reticular cells**.

From the capsule extend thin connective tissue septae (only up to corticomedullary junction) which divide it into incomplete lobules, it is only the cortex, as the medulla is a continuous branching mass surrounded by cortex. **Incomplete lobulation** is the feature of thymus. Numerous small arteries enter via septae and branch at the corticomedullary junction where the **postcapillary venules** have a special cuboidal endothelium to supply cortex and medulla.

The cortex contains an increased population of lymphocytes which are small rounded and darkly stained called **thymocytes**. Outer cortex contains large lymphocytes which divide by mitosis into small lymphocyte which are pushed deeper into the medulla. Only few lymphocytes leave the thymus via post capillary venules in the medulla as immunocompetent T lymphocytes and majority die in the thymus because they act against self antigens of the body. The process of maturation includes proliferation rearrangement of T-cell receptor (TCR) genes to produce a large variety of specific antigens and acquiring surface markers (phenotypes) of T-cells, i.e., mature helper and cytotoxic T-cells. At this stage, T-cells which react against self antigens (normal body components) are removed by apoptosis and establish self tolerance. The dead cells are taken up by pale stained macrophages at the corticomedullary junction giving a starry sky appearance.

Epithelio reticular cells are flattened, pale staining, supporting cells called **epitheliocytes**. It gives out cellular processes which are branched and are bounded together by desmosomes and lie in close contact with adjoining cells forming a membrane or a barrier called haemothymic barrier which is made up of endothelial lining of capillaries, little perivascular space and epithelial lining formed by epithelia reticular cells. The barrier prevents exposure of the immature lymphocytes to blood borne antigens. These epitheliocytes also form a framework for the lymphocytes. Cortical epithelial cells called nurse cell surround many lymphocytes promoting T-cell differentiation and proliferation. They also secrete at least four peptide hormones named as thymulin, thymopoietin, alpha and beta thymosin that regulate and promote T-cell maturation and proliferation.

Medulla is similar to the germinal center of lymphatic organ which is lightly stained. It contains several **Hassall's corpuscles** which are oval or spherical whorl like aggregation of flattened **Type VI cells** arranged concentrically and contain pink eosinophilic degenerating material in the center. The center of the corpuscle shows keratinization. The young thymus is more cellular with less adipose tissue in between the lobules.

There are no afferent lymphatic vessels so it cannot react to circulating antigens, it has only efferent lymphatics.

QUESTIONS

1. **What types of cells are present in thymus?**
2. **What are epithelio reticular cells and what is their embryonic origin?**
3. **Describe Hassal's Corpuscle.**
4. **What is the role of macrophages in thymus?**
5. **What is blood thymic barrier. Name the cells forming it and its clinical significance?**

LYMPH NODE (FIG. 3.5)

The Lymph Node is a collection of lymphatic tissue organized to form an organ.

It consists of a capsule formed by dense collagen and elastic fibers.

The **capsule** sends processes known as **trabeculae** into the substance of the node which form incomplete septa.

Between the capsule and the substance of the node is present a space called **subcapsular sinus** into which the afferent lymphatics open. The substance of the node has a coarse framework formed by the reticular fibers which are more closely set in the cortex than in the medulla.

On the reticular mesh is present the cellular stroma which exists as rounded or pear shaped zones in the cortex called **cortical nodules**. The cortical nodules may be primary or secondary. A primary nodule has no germinal center which exists only in secondary nodule which is a reaction center in response to an antigen.

The germinal center is lightly stained area containing large lymphocytes and plasma cells. It is considered as zone 3, dark

Key Histologic Features: Lymph node

- Presence of capsule and subcapsular sinus.
- In the cortex are present lymphatic nodules.
- Medulla shows medullary cords and sinuses.

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rims of the follicle as zone 2. The term zone 1 is applied to the region immediately around the follicle containing loosely packed lymphocytes, plasma cells and macrophages. Zone 1 becomes continuous with the medullary cords.

In between the cortex (has B lymphocytes) and the medulla is the **paracortex** which contains (T lymphocytes). Paracortex lies between the cortical nodules and the medulla. It is densely cellular, homogenous but few nodules may be seen in the deeper paracortex. The venules in the paracortex comprise important entry points for the lymphocytes from the blood into the lymph node (90%). A few (10%) lymphocytes also enter from lymph vessels.

The **medulla** consists of:

- Medullary cords which are the extensions of the lymphatic tissue arising from the cortex and paracortex containing both B lymphocytes, T lymphocytes, plasma cells and macrophages.
- Medullary sinuses which are continuous with cortical sinuses join together at the hilus to deliver lymph to efferent lymphatic vessel.

Flow of lymph afferent vessels cross the capsule and pour lymph into the subcapsular sinus, cortical sinuses, medullary sinuses and efferent vessels. Due to valves in both afferent and efferent vessels there is unidirectional flow of blood. During this passage lymph infiltrates the cortex and medullary cords where it is filtered and modified by immune cells.

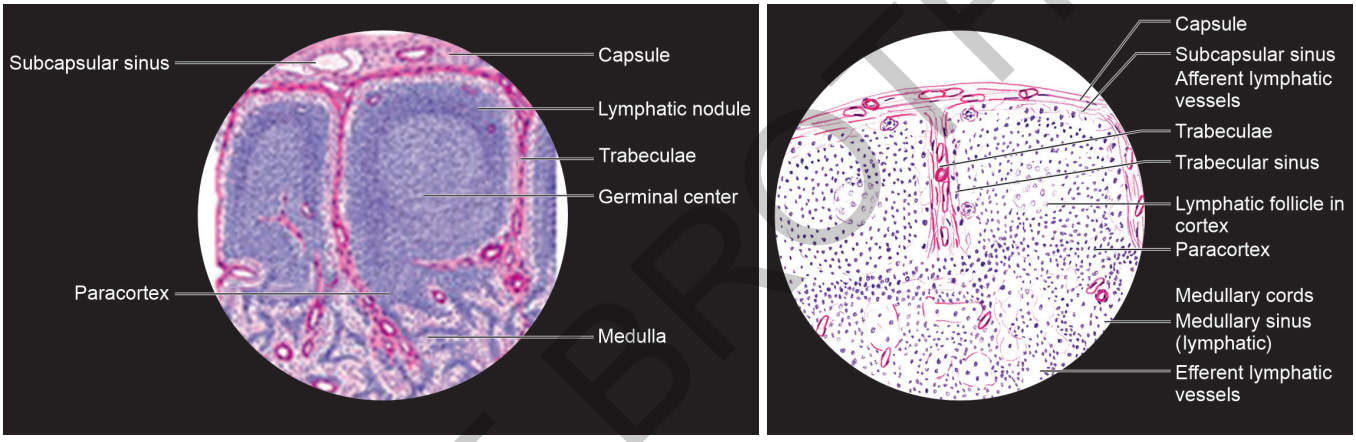


Fig. 3.5: Lymph node

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QUESTIONS

1. **What is the importance of capsular, trabecular and medullary sinuses?**
2. **Type of lymphocytes present in cortex.**
3. **Type of lymphocytes seen in paracortex.**
4. **What are the components of medulla?**
5. **What are high endothelial venules and what is their function?**

SPLEEN (FIG. 3.6)

Spleen is a lymphoid organ associated with the blood vascular system. Its function is to screen the blood and thus helps in immune response.

B lymphocytes in the spleen are exposed to antigens present in circulating blood.

The blood (especially the RBCs) in the spleen can be returned to the circulation rapidly in an emergency, so acts as a reservoir of blood.

Key Histologic Features: Spleen

- Capsule sends trabeculae in the parenchyma (not differentiated into cortex and medulla).
- White pulp shows lymphoid follicles with eccentric arteriole (Malpighian corpuscle).
- Highly vascular red pulp surrounds the white pulp.

The spleen is covered by a capsule consisting of dense fibroelastic connective tissue, some smooth muscle, and an outer covering of mesothelium. Trabecular extensions of the capsule (which contain blood vessels) partially subdivide the spleen. The parenchymal tissue is supported on a framework of reticular connective tissue and **is not differentiated into cortex and medulla**.

Two types of parenchymal tissue can be identified in the spleen.

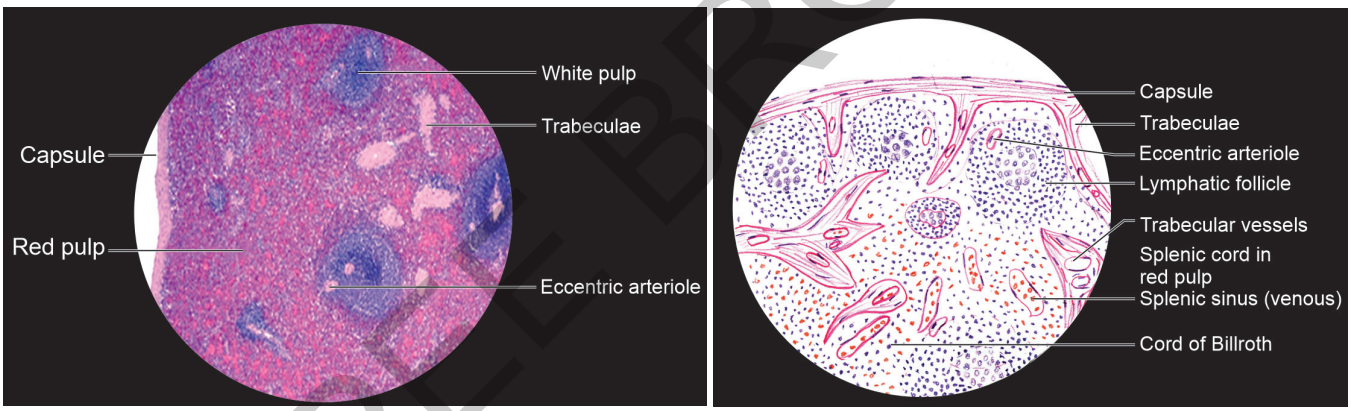


Fig. 3.6: Spleen

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White Pulp

White pulp consists of typical dense lymphoid tissue organized around arterial vessels as periarterial lymphoid sheaths (PALS). The central "artery" in a PALS is really an arteriole. Most of the inner cells of PALS are recirculating T-cells, but nodules containing B lymphocytes also occur. White pulp is composed of splenic nodule which is traversed by the central arteriole but is eccentric in position because they avoid the germinal center where the B lymphocytes are produced.

Red Pulp

Red pulp is located between white pulp and trabeculae. It contains small arteries called penicilli, capillaries, venous sinuses, and diffuse lymphoid tissue in the form of cords (cords of Billroth). Other cells seen are reticular cells, lymphocytes, macrophages, monocytes, plasma cells and granular leukocytes and erythrocytes. The central artery gives a number of branches called penicillar arteries at right angles and terminate as sheathed capillaries which form first part of filtering mechanism of spleen. These are unique vessels which have no endothelial lining and surrounded by a thickening of macrophages, forming the ellipsoid arteriole whose distal part is dilated to form the ampulla which open in the reticular framework of splenic cords (open circulation) or directly into the venous sinusoids from where the blood is drained into the venules and then into the veins which come out of the hilum (closed circulation). Passage of blood through the spleen is complex.

Trabecular arteries → arterioles of white pulp smaller arterioles → capillaries of red pulp → venous sinuses in red pulp → trabecular veins.

Venous sinusoids are lined by large cells which bulge into the lumen called **stave cells**. These cells are wrapped by reticular fibers set in transverse direction. These sinusoids are surrounded by an incomplete basal lamina. **Stave cells** have a unique property that allows only healthy red blood cells to enter but the aged red blood cells (senescent antigen) undergoes changes in the membrane which gets swollen and is less flexible so they do not enter in the sinusoids.

Perilymphoid zone of red pulp just outside white pulp differs from red pulp by absence of sinuses, very few reticulin fibers and a large number of RBCs and WBCs (10%) of blood in spleen which passes very slowly in the sinuses of red pulp. This sluggish blood flow increases the interaction of blood cells antigens and antibodies.

Macrophages in the spleen remove old, abnormal, and damaged blood cells from the blood by phagocytosis.

FEATURES OF IMPORTANT TISSUES/ORGANS

Tissue/Organ	*Capsule*	*Cortex-Medulla*	*Germinal Centers*	*Lobulation*
Tonsils	Yes on one side, Covered on other side by stratified squamous epithelium (SSE)	No	Yes	Infoldings of SSE and underlying CT form tonsillar crypts
Lymph node	Yes	Yes	Yes	No. Framework contains trabeculae which are elongated dense CT spicules extending from capsule
Thymus	Yes	Yes	No (Hassall's corpuscle represents germinal center)	Yes. Cortex is partially lobulated by septae (dense CT walls), where as medulla is continuous
Spleen	Yes may have smooth muscle fibers no subcapsular sinus	No Nodules spread throughout organ	Yes	No. Framework contains trabeculae, elongated dense CT spicules extending from capsule

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QUESTIONS

1. **What is the importance of capsule?**
2. **Name the structures present in red and white pulp.**
3. **What is PALS? Where are Tand B lymphocytes present?**
4. **What is the characteristic feature of arteriole present in spleen?**
5. **Splenic sinuses are lined by which cells and what is their function?**

THE BLOOD VASCULAR SYSTEM

The cardiovascular system is concerned with the transport of blood and lymph through out the body. It is divided into three major components; the heart, blood vessels and the lymph vessels. Blood vessels are further classified into arteries, veins, arterioles and capillaries.

The vessel wall consists of a basic plan that is having three layers except in capillaries.

Tunica intima is towards the lumen and is comprised of an endothelial lining of simple squamous epithelium, subendothelial connective tissue. Beneath this is internal elastic lamina which separates tunica intima from tunica media.

Tunica media is formed by a layer of circumferential smooth muscle and elastic fibers. A second layer of elastic fibers, the external elastic lamina separates T. media from T. adventitia.

Tunica adventitia consists of a layer of collagen, few elastic fibers, arterioles and vasa vasorum.

The arteries carry the blood from the heart to the tissues. Vessels close to the heart (aorta, pulmonary trunk and the larger arteries that originate from them) are elastic arteries.

The elastic arteries include the aorta which converts the intermittent flow of blood into a constant flow **(Fig. 3.7)**.

The **tunica intima** of elastic arteries is innermost and thicker than in other arteries and includes:

- Flat endothelial cells resting on a basement membrane.
- Subendothelial connective tissue is well developed consisting of collagen and elastic fibers with few fibroblasts and macrophages. A few flat smooth muscle cells accumulate lipids with age leading to atherosclerosis causing narrowing of the lumen. These cells are called **myointimal cells**.
- **Internal elastic lamina** is made up of elastic fibers and limits the T. intima and T. media. This layer is not prominent as it merges with the elastic fibers in T. media.

Tunica media is made up of elastic and smooth muscle fibers.

- It is thickest and forms 2/3 of the thickness of vessel wall. Distension of the walls is facilitated by 40–70 concentric lamellae of elastic fibers in the tunica media of the aorta. The energy stored in the elastic fibers of the tunica media allows them to function as a "pressure reservoir" which forwards blood during ventricular relaxation (diastole).
- Smooth muscle cells and collagen fibers are present between the layers of elastic fibers. The external elastic lamina is difficult to identify separately from other layers of elastic fibers in the tunica media.
  Tunica adventitia is outermost layer consisting of dense irregular connective tissue, collagen fibers, few elastic fibers, arterioles and vasa vasorum.
- It prevents undue stretching and rupture of the vessel wall.
- It is thinner than the tunica media and forms 1/3 of the vessel wall.
- The walls of these large arteries are so thick that their peripheral parts cannot derive enough oxygen and nutrients from the blood of the vessel that they form. Larger vessels are therefore accompanied by smaller blood vessels which supply the tunica adventitia and, in the largest vessels, the outer part of the tunica media of the vessel wall. The vessels are called vasa vasorum.

Key Histologic Features: Elastic artery

- The lumen is circular.
- Internal elastic lamina is not sharply defined.
- Tunica media is broad, forming 2/3 thickness of the wall and predominantly of elastic fibers.

Muscular arteries are the distributing vessels and control the amount of blood flowing through them **(Fig. 3.8)**.

- All the named arteries in the body, except for the large elastic arteries, are muscular arteries.
  The thickness of the wall is usually more than the diameter of lumen.

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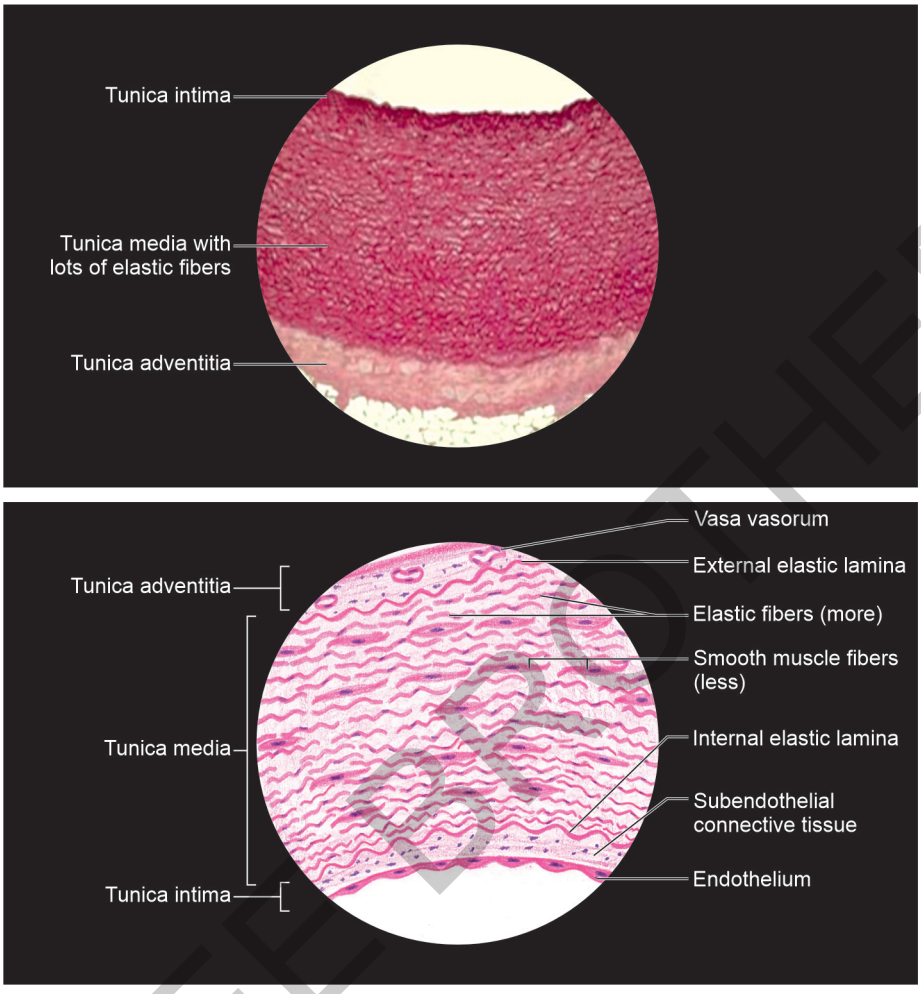


Fig. 3.7: Elastic artery

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T. intima consists of endothelium, a flattened subendothelial layer of collagenous fibers and internal elastic lamina is very prominent and wavy.

- The media is the major identifying features. It consists of a thick smooth muscle layer with as many as 40 layers of smooth muscle encircling the lumen.
- Larger muscular arteries may have a prominent external elastic lamina at the border of the media with the adventitia.
- Adventitia is well developed and usually thinner than media.
- Spasmodic contraction of the media smooth muscle helps prevent bleeding.
- Lumen is circular.
- Prominent internal elastic lamina is thrown into wavy folds.
- Tunica media is thick and muscular (circularly arranged smooth muscles)
- Well developed external elastic lamina.

Key Histologic Features: Muscular artery

- Internal elastic lamina well defined and thrown into folds.
- Smooth muscle fibers in T. media are more than elastic fibers.
- External elastic lamina diffuse and well developed.

Arterioles are resistant vessels and maintain the peripheral blood pressure

- Arterioles are small arteries, less than 0.5 mm in diameter.
- Tunica intima is lined by a single layer of flat endothelial cells with large nuclei projecting into the lumen of the vessel and has a very thin subendothelial layer of loose connective tissue so internal elastic lamina is closely applied to endothelial layer.

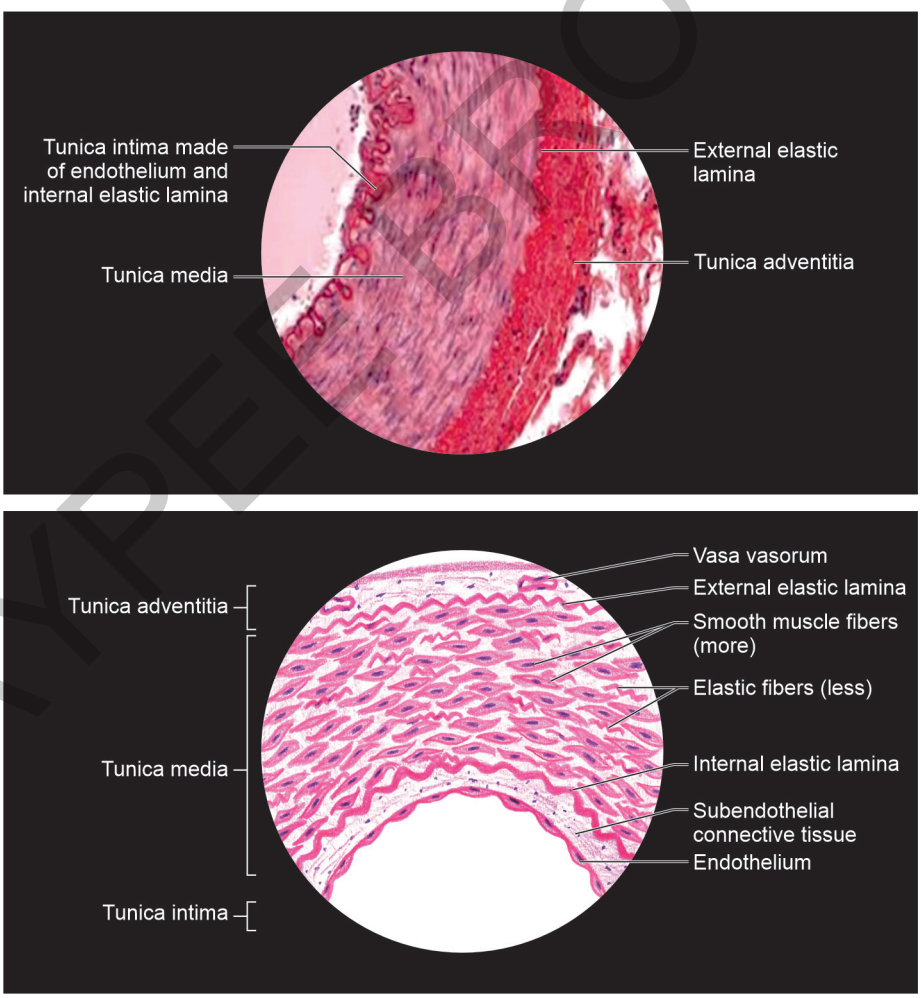
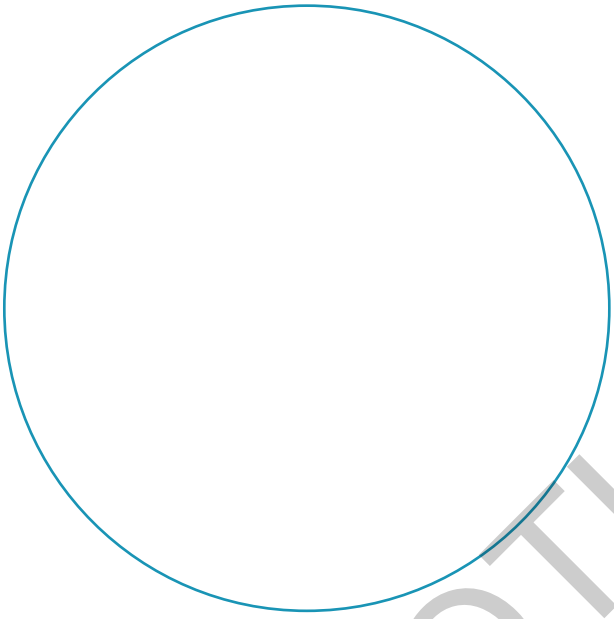


Fig. 3.8: Muscular artery

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- Tunica media is muscular and composed of 1–3 layers of smooth muscle with minimum elastic fibers. External elastic lamina is seen.
- Tunica adventitia is fairly prominent and densely innervated by sympathetic fibers.

CAPILLARIES

They act as exchange vessels. They allow the movement of fluids, metabolites and gases through their walls to the tissue.

- Usually 7–9 μ in diameter, but varies between 5 and 15 μ in diameter
- Wall consists of a simple squamous epithelium called endothelium resting on a basal lamina.
- Cells called pericytes may be found between the basal lamina and the endothelial cells. The cells are able to contract and thus constrict capillaries. Pericytes have their own basal lamina which may fuse with the basal lamina of the endothelial cells that form the capillary wall.
- Wall of a capillary is generally formed by 2–3 squamous cells held together by occluding or gap junctions. Nuclei of the cells bulge into the capillary lumen.
- There is no subendothelial connective tissue, no internal elastic lamina, no T. media and no T. adventitia.
- Capillaries are narrow regular spaces, lined by few continuous endothelial cells, found in all tissues of body and basal lamina is continuous. There are three types of capillaries.

Continuous Capillaries

- Most capillaries are of this type formed by "continuous" endothelial cells and basal lamina. The endothelial cell and the basal lamina do not form pores or spaces which would allow substances to pass through the capillary wall.
- The edges of endothelial cells fuse with the adjacent cells and exchange occurs through the cytoplasm by the formation of pinocytic vesicles. In continuous capillaries, macromolecules can also be passed into or out of the circulatory system by transcellular pinocytosis. Cells can move into and out of continuous capillaries by diapedesis.

Fenestrated Capillaries

- The walls may have pores (fenestrae) in the squamous endothelial cells, or there may be spaces between adjacent endothelial cells.
- The walls may have pores (fenestrae) in the squamous endothelial cells, or there may be spaces between adjacent endothelial cells.
- Pores of 20–100 microns are present in the walls of endothelial cells.
- Found in tissues where rapid exchange of substances occur (e.g., villi of the intestinal wall and glomeruli of the kidney).
- The pores are closed by the basement membrane or by cytoplasm of the adjoining cells.

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Sinusoids

- Lumen is large, 30–40 microns in diameter, highly convoluted, lined by both endothelial and phagocytic reticuloendothelial cells which bulge into the lumen (Kupffer cells in liver)
- Sinusoidal capillaries called discontinuous capillaries are large irregularly shaped vessels formed by fenestrated endothelial cells.
- Open spaces are present between endothelial cells.
- The endothelium also lacks a continuous basal lamina.
- Found mainly in liver and hematopoietic organs such as bone marrow and spleen. Sinu- soidal capillaries are constructed to allow for the passage of materials (macromolecules) and sometimes cells (e.g., monocytes, eosinophils) into and out of the circulatory system. This can occur through pores in cells or spaces between cells. They connect arterioles with venules (bone marrow, spleen, adrenal cortex) or venules with venules (liver, adenohypophysis).

DIFFERENCES BETWEEN CAPILLARIES AND SINUSOIDS

Capillaries	*Sinusoids*
Narrow and regular lumen	Wide and regular lumen
Endothelium continuous	Endothelium fenestrated
Basal lamina continuous	Basal lamina discontinuous
Only lined by endothelial cells	Lined by endothelial and reticular cells

Veins are called capacitance vessels. They have few muscles, so allow easy expansion and are easily compressible. Valves facilitate the flow of blood in one direction only and are present in veins where blood flow is against gravity.

LARGE VEINS (FIGS. 3.9 AND 3.10)

- T. intima is well developed, but thin. It is antithrombotic and nutritive in function.
- T. media is muscular, but thin relative to that of similar sized muscular arteries. A few circular layers of smooth muscle are present amongst abundant connective tissue. Forms 1/3rd of the vessel wall and helps in the contraction of the vein.
- T. adventitia is thickest, forms 2/3rd of the vessel wall and contains longitudinal bundles of smooth muscles and dense irregular connective issue which is protective and supportive in function.

This arrangement of longitudinal muscle in adventitia and circular in media helps to strengthen wall and help prevent settling of blood in limb veins due to gravity and to push the deoxygenated blood towards the heart. In addition to this muscular arrangement, valves are also present in large veins. They help to prevent back flow of blood. Skeletal muscle in conjunction with valves is helpful in preventing back flow by propelling blood through veins in the correct direction as the muscles contract.

Key Histologic Features: Veins

- Thin walled as related to diameter large, irregular and collapsed lumen.
- Blood seen in lumen.
- Internal and external elastic lamina poorly defined.
- T. media forms 1/3 of the wall.
- T. adventitia forms 2/3 of the vessel wall.
- All veins carry deoxygenated blood except pulmonary and umbilical veins.
- Vasa vasorum supply up to intima.
- Valves present in veins where blood flow is against gravity.

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