DRMATS'
Essential Histology
Last-Minute Exam Booster"

"A concise, exam-oriented study aid specially curated by Dr. Mats to support slow learners and all MBBS students during final revision. Simplified for clarity. Structured for success."

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1. Microscope

A microscope is an optical instrument used to magnify small objects. In **simple microscope** a single convex lens is used and in **compound microscope** more lenses are used. In light microscope natural or artificial light is used while an electron microscope uses an electron beam. Depending upon number of eyepieces microscopes are called as monocular, binocular/ trinocular etc.

Fluorescence, polarizing, phase contrast or dark ground illumination facilities may be added to compound microscopes.

a) Parts of monocular compound microscope: A monocular compound microscope has a **base**, which is 'U' or 'V' shaped and a **limb** or an arm attached to base. A **body tube** is fitted to upper end of arm and **stage** is fitted to lower end of arm. Body tube holds **eye piece** in upper part and a **nose piece** in lower part. Four different types of **objectives** (scanning,low power, high power & oil immersion lenses) are fixed to nose piece while draw tube holds eye piece. Below stage **diaphragm, filter** and **condenser** lenses are fixed. There are **fine** and **course** adjustment and **condenser** adjustment knobs.

b) Magnification: Extent to which size of object appears increased in image is magnification by light microscope is product of magnification of eyepiece and magnification of objective.

	Low power	**High power**	**Oil immersion**
Eyepiece (x times)	10	10	10
Objective (x times)	10	40	100
Magnification (x times)	100	400	1000
Diameter of areas under view	1500µ	375µ	150µ

c) Resolution: It is ability of an optical instrument to distinguish between **two adjacent points** clearly. Smaller clearly seen distance between two points, better is resolution and better are image details. Resolution by an **unaided eye is 0.2mm or more** and with that of **light microscope is 0.25µ or more**. Resolution depends upon wavelength of energy (light) employed for illumination: In electron microscope resolution is increased because energy of shorter wavelength (electrons) is used.

d) Numerical aperture: Aperture size of objective lens is product of refractive index & angle between optical axis of lens and most. Inclined rays of light it can accept. If angle is more proportion of light rays put to good use in forming image are more thus greater is proportion of potential details reproduced in image. Resolution is inversely proportional to numerical aperture. Brightness of field is directly proportional to square of numerical aperture.

2. Epithelium

Epithelium is a group of cells, with comparatively little intercellular material. It covers external and internal surfaces of body and cavities. It may be simple or stratified.

Simple epithelium: Made up of ***single layer*** of cells. It may be of several types according to cell's shape and size.

1. **Simple squamous**: Cells of epithelium are flat, having length and breadth but negligible thickness, with a small round and centrally placed nucleus.
2. **Simple Cuboidal**: Cells are cubical *length, width & height* are almost equal, with a centrally placed spherical nucleus.
3. **Simple Columnar**: Cells are tall in appearance *length is greater than width*, cytoplasm looks vacuolated due to mucinogen and nucleus is oval in shape.
4. **Pseudostratified Columnar Ciliated**: All cells of epithelium touch base line but all of them do not reach surface. So nuclei are placed at different levels, giving a stratified or layered appearance.

Stratified epithelium: Made up of ***several layers*** of cells and name of epithelium is given <u>according to shape of cells present in the most superficial layer.</u>

1. **Stratified squamous**: Basal cell layer consists of cuboidal or low columnar cells with mitotic activity. Intermediate layers are polygonal in shape and superficial cells are flattened.
2. **Stratified cuboidal**: Superficial cell layer is cuboidal and rest are polyhedral in shape.
3. **Stratified columnar**: Superficial layers of cells are columnar and deeper cells are polyhedral or cuboidal in shape.
4. **Transitional**: All cells are similar, being able to adjust themselves according to surface area. The outermost layer, with dome-shaped or umbrella cells. These surface cells can flatten and stretch, which is important for accommodating changes in volumeBasement membrane is not indented by connective tissue.

3. Connective Tissue

Tissue that fills inter-cellular space between more specialized elements, supports and holds them together is called connective tissue. Cells are relatively few and widely separated by inter-cellular substance. Connective tissue can assume various forms depending upon nature of ground substance, type of fibers and cells present in the tissue. Different types of cells are present in connective tissue like mesenchymal cells, fibroblast, fibrocytes, adipose cells, reticular cells, pigment cells, macrophages, mast cell and plasma cells.

Fibers in connective tissue: There are three main types of fibres.

1. **Collagen fibres**: Most numerous, run in bundles, bundles branc and anastomose. Individual fibers do not branch. They are acidophilic in staining.
2. **Reticular fibres**: Are of small length, branching and anastomosing. They are specially stained by silver stain.
3. **Elastic fibres**: Less frequent than collagen, fine, run singly, branch and anastomose freely.

4. Cartilage

Cartilage is considered to be a modified connective tissue having cells and matrix (extracellular component), where matrix is solid. It has cells like chondrocytes and chondroblasts that synthesize connective tissue fibres and ground substance. Cartilage is classified according to amount and type of fibres. There are three types of cartilage:

Hyaline cartilage:

1. Has encapsulated cartilage cells, forming **cell nests** and **ground substance appears homogenous**.
2. Refractive index of collagen is same as that of matrix, so they are not seen separately.
3. **Perichondrium** covers hyaline cartilage **except** at articular surfaces.
4. It is **avascular.** examples are trachea, bronchial tree, larynx.

Elastic cartilage:

1. Encapsulated cartilage cells are present **singly.**
2. Ground substance contain **elastic fibres**, and matrix **non-homogeneous**.
3. Elastic fibres are better seen with orcein stain.
4. Example Epiglottis, Cartilage of external ear, corniculate and apices of arytenoid.

Fibrocartilage:

1 Encapsulated chondrocytes are **ovoid**, surrounded by concentrically striated matrix.

2 Chondrocytes lie in **rows or layers**, between rows there are bundles of **collagen fibres**.

3 Perichondrium is absent.

4 Example intervertebral disc, symphysis pubis, intra articular disc.

5. Bone

Bone is hard specialized connective tissue.

Compact bone:

1. It consists of **Haversian canal system** which consists of concentric tubular layers known as **lamellae**.
2. Haversian canal **communicates with** each or, medullary cavity and outer surface of bone through oblique channel called **Volkmann's canal**.
3. Haversian and Volkmann's canals in living contain blood vessels, nerves and lymphatics.
4. Bone is covered by periosteum except articular (cartilage) surfaces.

Spongy bone:

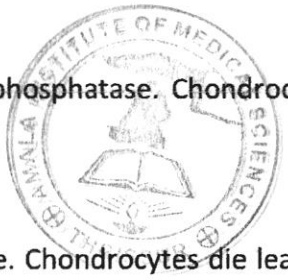
1. Lamellae are **irregularly** arranged and Haversian system is **absent.**
2. Bone marrow is present in large marrow spaces defined by shelves and spicules of bones.
3. Osteocytes can be seen in layers in adult spongy bone.

Developing bone L.S.- process of bone formation is ossification. In endochondral ossification a cartilage model is replaced by bone. The epiphyseal plate of long bone is best example of growing bone. Slide of developing bone shows following zones.

1. **Zone of resting cartilage** - Chondrocytes are small and flat. This is a reserve zone of normal hyaline cartilage in which chondrocytes are distributed in lacunae singly or in groups.

2. Zone of proliferation- This is a zone of cartilage growth. Cells are larger and show mitotic activity. y multiply and arrange in parallel columns separated by bars of matrix.

3. Zone of maturation - Cells increase in the size and secrete alkaline phosphatase. Chondrocytes hypertrophy by swelling of nucleus and cytoplasm and lacunae enlarge.



4. Zone of calcification - Calcium salts are deposited in matrix of cartilage. Chondrocytes die leaving lacunae or empty spaces, with dead and dying cells. This is chondrolysis.

5. Zone of ossification - Blood vessels from periosteum grow inside and calcified matrix is replaced by bone matrix. Chondrogenic layer of periosteum is stimulated to differentiate into osteogenic layer from which osteoblast are formed.

7. Muscle Tissue

Muscle tissue is made up of cells called myocytes. Myocytes are elongated and often referred to as muscle fibres. Muscle tissue is contractile in nature due to presence of contractile protein element. There are three types of muscle tissue according to function and anatomical classification:

1. **Skeletal muscle**: muscle fibres are present in bundles. They are elongated, cylindrical, multinucleated cells where nuclei are peripheral in position lying just beneath the sarcolemma (Cell membrane of muscle cell). Muscle fibres have longitudinal and transverse striations.
   T.S.- entire muscle is covered by a tough sheath of relatively dense connective tissue called as epimysium. The fibrous partition which extends into muscle to surround fascicles (bundles of muscle fibres) is called as perimysium. Delicate sheets of connective tissue that arise from it provide a network extending between each and every muscle fibre and constitutes endomysium.

2. **Smooth muscle**: Spindle shaped cells having single, centrally placed oval nucleus. Faint longitudinal striations are present.

3. **Cardiac muscle**: Each muscle fibre shows branching, has a single centrally placed oval nucleus. Transverse striations are present. The junctions between adjacent muscle cells are seen as dark staining transverse lines running across the fibres called **intercalated discs**. Gap junctions allow electrical continuity thus cardiac muscle is a physiological syncytium but not an anatomical one.

8. Nerve Tissue

Nervous tissue consists of neurons and nerve fibres.

Neuron: Is structural and functional unit of nervous system. It has a cell body called perikaryon and processes namely axon and dendrites. Neurons receive and conduct impulses. They may be of unipolar, bipolar, pseudo unipolar and multipolar type.

Nerve fibres: may be myelinated or unmyelinated.

Neuroglial cells : Astrocytes (Fibrous, protoplasmic), oligodendroglial cells & microglial cells.

Peripheral nerve: Peripheral nervous system consists of ganglia and nerves. Ganglion is a collection of neurons in PNS while nerves are mostly bundles of axons (motor) or/and peripheral processes of sensory ganglia.

T.S.- A tube like arrangement of fairly dense extensive connective tissue that encases the whole nerve is epineurium. Perineurium is inner thick and strong connective tissue enclosing a fascicle of nerve fibres. Each nerve fibre (axon) is enclosed in a tube of connective tissue called as endoneurium.

L.S.- Myelin dissolved away by dehydration and clearing agents, slips to one side of the space. Myelin can be seen by Osmic acid staining method. Longitudinal section of peripheral nerve shows streaky appearance and streaks run in a wavy snake like manner. Many nuclei are seen in bundle of fibres.

9. Blood Vessels

Cardiovascular system consists of heart and blood vessels.

Heart: It has three layers from inside out: **1. Endocardium, 2. Myocardium & 3. Epicardium.**

Arteries: histological structure of an artery varies considerably with its diameter. However, all arteries have some features in common. The wall of an artery is made up of three layers:

1. Tunica intima: *innermost layer*
2. Tunica media: *middle layer*
3. Tunica adventitia: *outermost layer.*

In artery, media is thicker than or two coats, while in vein adventitia is thicker than or two coats. Depending upon amount of elastic fibres or smooth muscles, arteries are their elastic or muscular type.

A). Elastic artery- Compared with intima in or vessels elastic artery shows very thick intima, one fifth of total thickness of the wall. Internal elastic lamina is not easy to distinguish as media consists of mostly elastic fibres with few smooth muscle fibres. E.g. ascending aorta, arch of aorta, thoracic aorta, pulmonary artery etc.

B). Muscular artery- The size of lumen of this type of artery is regulated by the muscles, so it is also called as a distributing artery. Internal elastic lamina is seen at junction of intima and media. It is usually in a contracted condition giving a wavy appearance to intima and is easily seen as bright pink line. Media consists of mainly smooth muscle fibres with few elastic fibres.

10. Lymphoid Tissue

The fluid passing through lymphatic vessels is called lymph. As a rule, lymph from any part of body passes through one or more lymph nodes before entering in the blood stream. Lymph nodes act as filters removing bacteria and or particulate matter from lymph. Each group of lymph node has a specific area of drainage.

A) **Lymph node**: covered by connective tissue capsule containing adipose tissue. Afferents penetrate capsule around the convex surface while efferents come out from concave hilum. Internal structure shows cortex and medulla. Cortex is packed with lymphocytes. Cortex consists of lymphatic follicles (nodules) with germinal centre. Medulla consists of medullary cords.

B) **Spleen:** does not show cortex and medulla. Consists of white pulp and red pulp. White pulp consists of lymphatic nodules, which may show the germinal centre. In the red pulp there are sinusoids lined by long narrow endothelial cells showing slits. Red pulp between two sinusoids is like a cord so called Billroth cords.

C) **Thymus**: This is a lymphoid organ showing cortex and medulla but no germinal centre. Each lobe has a capsule, which divides the lobe into lobules, but division is incomplete. Presence of Hassal's corpuscles is the main feature of slide.

D) **Palatine tonsil:** This lymphoid tissue is covered by a mucous membrane. tonsil is covered from oral side by stratified squamous nonkeratinised epithelium, which dips into the underlying lymphatic tissue to form 10 to 20 little pits or primary crypts.

11. Integumentary System

Skin is the outer most covering of body. It is composed of two main layers: epidermis and dermis.

Epidermis: composed of stratified squamous keratinized epithelium and divided into two zones.

1. Keratinized zone: here cells are dead or dying.
2. Germinating zone: Proliferations of cells are taking place to replace dead cell in this zone.

Dermis: it is composed of papillary and reticular layers.

Skin- basal layer of columnar cells rest on a basement membrane and is called the stratum basale. Nuclei are distinct and show mitosis. Next layer is stratum spinosum of polyhedral cells. Cells show many spine like processes. Third layer is stratum granulosum, which is 2 to 4 cell thick. y show kerato hyaline granules in the cytoplasm, which is basophilic in nature. Fourth layer is stratum lucidum. Outermost layer is stratum corneum or layer of keratin. Here nuclei and cytoplasmic organelles disappear.

12. Gastrointestinal Tract

In ordinary English word 'alimentary' means 'pertaining to nourishment'. The abdominal part of alimentary canal referred to as gastrointestinal tract. In general arrangement of GIT has four histological layers:

1. **Mucosa:** three layers collectively called mucosa (from in to outside): epithelium, lamina propria, muscularis mucosae.
2. **Submucosa:** help in independent movement of mucosal layers.
3. **Muscularis externa:** mainly it consists of inner circular and outer longitudinal muscle fibres.
4. **Adventitia/ serosa**: depending on location of organ.

Tongue-

Slide of the tongue shows stratified squamous epithelium on both the surfaces with a core of striated muscle in the centre cut in all directions. Epithelium of one surface is continuous with that of other at tip and sides of the tongue. Dorsal surface shows various types of papillae. The epithelium on ventral surface is nonkeratinised. Each papilla consists of lining stratified squamous epithelium and a core of connective tissue of lamina propria. Depending upon the shape, papillae are of various types, filiform, fungiform and circumvallate. Taste buds are seen on the fungiform and circumvallate papillae.

Salivary glands (Exocrine)- There are 3 pairs of large salivary glands and many small scattered salivary glands. Saliva is a mixed secretion of salivary glands. Depending upon the type of secretory unit, salivary glands are either serous, mucous or mixed type.

1. Serous salivary gland-

Large triangular columnar cells rest on a basement membrane. Small lumen is present in the centre of each acinus but lumen is difficult to see under light microscope. The cytoplasm of the basal aspect of cell is basophilic as it is rich in RER. apical cytoplasm contains eosinophilic zymogen granules which are membrane bound vesicles containing secretion. Nucleus of myoepilial cell is seen around the alveolus.

2. Mucous salivary gland-

Mucous secretory units are packed within a lobule. They are larger as compared to serous alveoli and are lined by simple columnar cells resting on a basement membrane. Mucous cells are pale staining because mucous is washed during staining. Lumen is larger and easily seen while the nuclei are flat near basement membrane.

Demilune is half-moon shaped cluster of serous secreting cells around a mucous secretory unit.

Esophagus-

It shows four basic layers of GIT but the specific features are ***stratified squamous epithelium*** and presence of submucosal glands.

Stomach- wall of the stomach also shows four basic layers of GIT. Histological structure and features of the first layer i.e. mucous membrane differs at fundic / body part and at pyloric part of stomach.

Stomach Fundus or Body T.S.- Lining of the stomach is simple columnar (nonciliated) epithelium and mucous secreting columnar cells. Lining epithelium dips at places into lamina propria to form gastric pits. At bottom of the pits, gastric glands open. Each pit receives opening of many glands. *Villi are absent.*

(i) *Mucous cells-* these are columnar cells with basal nucleus and apical eosinophilic vacuolated cytoplasm, they *secrete mucous.*

(ii) *Chief cells:* cytoplasm is basophilic in the basal part because of which these cells can be identified, apical part is eosinophilic and contains secretory zymogen granules. They *secrete enzymes.*

(iii) *Oxyntic or Parietal cells:* - They have darkly stained pink cytoplasm and are scattered in the gland between other cells. Shape of cells vary, may be rounded or triangular with spherical nuclei. These cells *secrete acid.*

Stomach pylorus T.S.- Pylorus has same four basic layer of GIT as those in fundic/body part of stomach. Only difference is in the mucous membrane or in glands proper. *Depth of gastric pit and that of the glands is approximately same*. This is the first feature by which pylorus can be distinguished from fundic / body part. Second important feature is *absence of prominent parietal cells* which appear *dark pink to red* within gastric glands.

Intestine (Duodenum, Small intestine, Large intestine and Appendix)- There are three parts of small intestine out of which ileum and jejunum are histologically similar except for the number and size of villi while ***duodenum*** *is characterized by* ***submucous glands.***

Duodenum:

Duodenum slide should be identified as slide showing features of small intestine on the basis of ***presence of villi.*** For confirmation of duodenum see for ***presence of glands (Brunner's glands), in submucosa.*** Mucous membrane shows many circular folds core of which is formed by submucosa. There are numerous finger like processes called villi that project from surface into the lumen. Core of villus is formed by the lamina propria. Lining epithelium is *simple columnar* containing columnar with goblet cells.

Ileum, Jejunum:

Histologically ileum and jejunum cannot be differentiated except for the relatively greater number of mucosal folds, thicker and larger villi, greater vascularity and fewer solitary submucosal lymphatic follicles in jejunum compared to ileum.

Large intestine T.S.- slide of large intestine shows four basic layers of GIT. *Absence of villi, absence of submucosal glands and presence of more goblet cells* are the features by which it can be differentiated from or parts of GIT. It is lined by *simple columnar epithelium* containing many scattered goblet cells.

Muscularis externa shows inner circular muscles along whole wall of large intestine which is approximately uniform in thickness. However outer longitudinal muscle coat is condensed at three places to form *taenia coli.* Between the two taenia coli thin layer of longitudinal muscle may be seen.

Appendix:

It shows all four basic layers of GIT. Mucous membrane and all or layers are like those in slide of large intestine. Due to large sized lymphatic nodules muscularis mucosa is not seen properly or is interrupted so that nodules arc seen in lamina propria or in submucosa or in both. Germinal centers are often seen in se nodules.

Liver:

It shows hepatic lobules, polyhedral or hexagonal in shape. Hepatocytes show radial arrangement in a lobule. At the centre of hepatic lobule is a thin walled central vein. At periphery of lobule re is portal triad consisting of branches of hepatic artery, portal vein and hepatic duct.

Hepatic artery (branch) shows thick wall and regular lumen while *portal vein* (branch) shows thin wall and large lumen. *Bile duct* (tributary) can be identified very easily as it is lined by simple cuboidal epithelium with prominent nuclei and eosinophilic cytoplasm.

Gall Bladder:

Shows four layers but different from GIT layers.

1. Mucosa consists of simple tall columnar epithelium with microvilli (*brush border*). Lamina propria is present but muscularis mucosa is absent.
2. Second layer consists of muscularis externa coat of smooth muscle.
3. Third layer of organ is submuscular coat.
4. Fourth layer is serosa on one side and adventitia on hepatic side.

Pancreas : It is both exocrine and endocrine in function. Exocrine part is mostly like parotid or serous salivary glands. Endocrine part is in form of small islands between the exocrine acini.

capsule sends septa inside gland and divides gland into lobules. Secretory cells are pyramidal and cell boundaries are not always distinct while lumen is hardly seen. Endocrine part of pancreas is seen as pale areas larger than an acinus called islets of Langerhans. y are non-capsulated cords and irregular clumps of cells and capillaries.

Intercalated ducts are lined by simple squamous to simple cuboidal epithelium, intralobular ducts are lined by simple cuboidal to low columnar epithelium, while interlobular ducts are line by simple columnar epithelium.

13. Respiratory System

Respiratory system consists of lung and passage through which air reaches them. The passage has some features in common. Their walls have a skeletal basis made up of variably of bone, cartilage and connective tissue. Skeletal basis keeps passage always patent. Smooth muscle present in the wall of trachea and bronchi make alteration in size of lumen. Interior of passage is lined in most of its extent by pseudostratified ciliated columnar epithelium. This epithelium is kept moistened by secretion of glands. Numerous goblet cells and mucous glands cover the epithelium with a protective mucoid secretion that serves to trap dust particles present in inhaled air. Deep to mucosa, presence of numerous blood vessels serve to warm inspired air.

A) **Epiglottis-** A slide showing elastic cartilage lined on either side by a mucous membrane is slide of epiglotis. Lip, tongue, eyelid are other slides lined by mucous membrane on either side but none of them shows elastic cartilage inside. Perichondrium of the elastic cartilage is continuous with lamina propria on both sides. Anterior surface shows stratified squamous nonkeratinised epithelium.

B) **Trachea** - is lined by pseudostratified ciliated columnar epithelium with goblet cells. Hyaline cartilage is deep to submucosa covered by perichondrium. Trachealis is a smooth muscle bundle transversely arranged extending between ends of 'U' shaped cartilage on posterior side. Tracheal glands are also present deep to Trachealis muscle. Outside cartilage there is adventitia containing collagen fibres, adipose tissue and bloodvessels.

C) **Lung** - Lung is divided into lobules which are separated by fibrous septa. Lung is covered by pleura which show surface simple squamous epithelium with small amount of sub epithelial connective tissue. slide shows many empty spaces some communicating with each or and wall of se spaces is thin and pink in staining. Bronchioles are seen cut in various planes in section. Respiratory bronchioles open into alveolar duct which further continues into alveolar sacs and alveoli. se are spaces of various orders and shapes that exist in a huge elastic sponge like arrangement of capillary beds. alveolar ducts are long branching hallways along which re are many open doors.

14. Urinary System

Urinary organs are kidneys, ureter, urinary bladder and urethra. These organs are responsible for production, storage and passing of urine. Urine production and control of its composition, is function of kidneys. Urinary bladder is responsible for storage of urine until it is voided. The ureter and urethra are simple passage for transport of urine.

So all organs have different modification according to their function. But urinary epithelium is transitional epithelium. Uriniferous tubule is structural and functional unit of kidney, which consist of nephron and a collecting duct system.

A). Kidney-Nephron is a structural and functional unit of a kidney. Kidney is covered by fibrous capsule from all sides and coronal section shows outer cortex and inner medulla.

Nephron shows Bowman's capsule, proximal and distalconvoluted tubules and loop of Henle. Apart from nephron there are glomeruli and collecting ducts. A glomerulus is a tuft of capillaries. Cortex is pink, granular, darkly stained, while medulla is lightly stained and striated in appearance. A conical pyramid of medul1ary substance together with cap of cortical substance that covers its base constitutes a lobe of kidney.

Cortex contains all glomeruli and all proximal and distal convoluted tubules *(PCT & DCT)*. Medulla shows loop of Henle and collecting tubules, all run fairly straight courses.

PCT is lined by simple columnar to simple cuboidal cells with central prominent euchromatic nucleus and dark (pink) eosinophilic cytoplasm. these cells show ***prominent brush border*** on luminal side and vertical striations on the basal side. Cells are large in size so that nuclei are seen away from each or and are few in number lining the lumen. DCT has a prominent lumen lined by simple cuboidal epithelium.

B). Ureter T.S. - This is a tubular structure with muscle wall and can be easily distinguished from appendix, vas deferens, fallopian tube etc by the presence of urothelium. Ureteric wall shows three layers. Innermost layer is mucous membrane, which shows epithelium and lamina propria. Mucous membrane is thrown into folds so that lumen is **star shaped** in T.S.

C). Urinary Bladder-It shows same three layers like that of the ureter. lumen is lined by transitional epithelium, which can be stretched without being damaged. stretched epithelium is thinner and cells are flattened, while relaxed epithelium shows umbrella like cells. Second layer of bladder is smooth muscle (Detrusor) layer showing inner longitudinal, outer circular and outermost longitudinal layer. Third and last layer is adventitia of connective tissue or serosa.

15. Male Genital System

Male reproductive organs are testis, epididymis, ductus deferens & seminal vesicles all paired, while prostate, male urethra and penis are unpaired. Testes produce male gametes or spermatozoa. Other accessory sex organs help in their maturation, storage, nourishment and ejaculation.

Testis: Enclosed in a thick connective tissue capsule - Tunica Albuginea. Fibrous septa divide the tissue into lobules containing seminiferous tubules. These are long, convoluted and lined by germinal epithelium.

This epithelium contains two types of cells: Germinal cells - ***spermatogenic cells*** in various stages of maturation and produce sperms and supporting cells - ***Sertoli cells*** nourish the developing sperms.

Located in connective tissue are ***interstitial cells of Leydig*** which **secrete testosterone.**

Ductus deferens: Exhibits narrow and irregular lumen with longitudinal folds. The lumen is lined by ***pseudostratified columnar epithelium with stereocilia.*** Ductus deferens is muscular tube and it consists of 3 layers: inner longitudinal, middle circular, outer longitudinal. The outermost layer is of adventitia.

Epididymis: is long convoluted tubule lined by ***pseudostratified columnar epithelium*** (tall columnar cells ***with stereocilia***, small basal cells). In cut section, tubules of epididymis are surrounded by a thin layer of smooth muscle fibres.

Prostate: is a ***fibro-musculo-glandular*** tissue with glands surrounded by fibromuscular stroma.

Cut section of prostate gland shows glandular acini (simple columnar, light stained), lumen being wide & generally irregular. Excretory ducts resemble acini with simple columnar epithelium but cells stain darker. The lumen of acini contains spherical concretions called ***corpora amylacea*** or ***amyloid bodies***.

Seminal vesicle: shows highly convoluted and irregular lumen. Cut section shows primary and secondary mucosal folds. The epithelium is low pseudostratified to low columnar or cuboidal. Muscular layer consists of inner circular, outer longitudinal muscle layer.

Penis: Cut section shows two dorsal corpora cavernosa and single ventral corpus spongiosum showing cut section of penile urethra (pseudostratified or stratified columnar epithelium). All 3 are surrounded by deep penile (buck's) fascia which in turn is surrounded by connective tissue and epidermis.

16. Female Genital System

Female reproductive organs are right and left ovaries, uterine tubes, uterus, vagina and mammary gland.

1.Ovary: Surface is covered by single layer of ***low cuboidal germinal epithelium (misnomer).*** Ovary is divided into peripheral cortex and central medulla. Numerous ovarian follicles at various stages of development namely *primordial* (most numerous*), primary, secondary & mature follicles* are located in the stroma of cortex. The largest follicle is mature follicle which consists of theca interna, theca externa, granulosa cells, a large antrum with follicular fluid, and cumulus oophorus containing primary oocyte.

2.Uterine tube: Extensive mucous folds form an irregular lumen in uterine tube. The lining epithelium is simple columnar (ciliated and non-ciliated). Muscularis externa consists of inner circular and outer longitudinal layers. Outermost layer is serosa.

3.Uterus: Consists of three layers, inner endometrium, middle layer of smooth muscle myometrium and outer serous layer perimetrium. Endometrium is lined by *simple columnar epithelium*. Lamina propria is thick with simple tubular glands and stroma. Endometrium is divided into 2 layers- stratum functionalis and stratum basalis. In proliferative phase, glands are straight and arteries less coiled. In secretory phase, glands become convoluted and arteries highly coiled. Myometrium consists of thick layer of smooth muscle. Perimetrium is outer serous coat.

4.Vagina: wall of vagina consists of mucosa with *stratified squamous nonkeratinized epithelium*, smooth muscle layer and adventitia.

5.Placenta: shows cross section of villi. Villus consists of thin synctiotrophoblastic cells, basement membrane and endothelial cells of fetal capillaries.

6.Mammary gland: compound tubulo-alveolar gland consisting many lobes. Cut section shows many ***alveoli - simple cuboidal epithelium***, intra and interlobular ducts. Stroma consists of adipose tissue.

7.Umbilical cord: consists of myxomatous connective tissue surrounding two umbilical arteries, one umbilical vein.

17. Endocrine Glands

Endocrine tissue is made up of cells that produce secretion which is distributed directly into blood. Secretions of endocrine gland is called hormone. Endocrine tissues/glands are highly vascular. Secretory pole of an endocrine cell/tissue or gland is towards the wall of capillary (or sinusoid). Endocrine cells are distributed in three different ways:

1. Some organs are entirely endocrine in function called as endocrine gland.
2. Groups of endocrine cells may be present in organs that have other function eg: **islets of pancreas, interstitial cells of testis.**
3. Isolated endocrine cells may be distributed in the lining epithelium of organ. Such cells are seen mostly in gastrointestinal tract. These widely distributed cells are grouped together as **neuroendocrine system / APUD cell system.**

Thyroid Gland: is covered with capsule. Slide will show cut sections of follicles with ***squamous to low cuboidal to columnar epithelium*** depending on functional status of gland. In connective tissue there are **parafollicular cells.**

Parathyroid gland: slide consist of **chief cells** (*small & dark staining*) and **oxyphil cells** (*light staining*)

Pituitary gland: consists of capsule and parenchyma

Adenohypophysis—pars distalis consists of chromophils (acidophils, basophils), and chromophobes. ***Pars intermedia*** consists of follicles filled with colloid substance.

Neurohypophysis—consists of unmyelinated nerve fibres and pituicytes.

Adrenal gland: consists of cortex and medulla

Cortex consists of three zones

Zona glomerulosa—shows small cells (pyramidal or columnar) arranged in ovoid clusters. nuclei are spherical and stain intensely.

Zona fasciculata—large polyhedral cells lined in long straight cords 1-2 cell thick with sinusoidal capillaries in between. Lightly stained nuclei are seen.

Zona reticularis- shows smaller cells with deeply stained nuclei arranged in anastomotic cords.

Medulla—large pale staining epitheloid cells (chromaffin cells) which are modified neurons with a lot of sinusoidal capillaries.

18. Special senses

A) Cornea: thick transparent, non-vascular structure of eye.

Has five layers-

1. Epithelium is stratified squamous non keratinized
2. Anterior limiting membrane or bowman's membrane (collagen fibres)
3. Corneal stroma consists of substantia propria, collagen fibres and fibroblasts
4. Posterior limiting membrane or Desmet's membrane (collagen fibres)
5. Posterior epithelium is simple squamous or cuboidal

B) Retina: innermost coat of eyeball

Ten layers —

1. Pigment cell epithelium—cuboidal, melanin
2. Layer of rods and cones
3. Outer limiting membrane
4. Outer nuclear layer—nuclei of rods and cones
5. Outer plexiform layer
6. Inner nuclear layer
7. Inner plexiform layer
8. Layer of ganglion cells
9. Layer of optic nerve fibres
10. Inner limiting membrane

19. Nervous System

A) Cerebellar Cortex - Cerebellum consists of inner grey, outer white and outer most grey. Outermost grey matter is called cortex. It is very easy to identify because of a series of deeply convoluted folds or folia supported by a branching central medulla of white matter. Cortex has three layers. They are uniform in distribution so called as homotypical.

Molecular layer: It contains relatively few neurons and large number of unmyelinated nerve fibres. It is outermost layer covered by piamater. Stellate and basket cells are seen.

Purkinje cell layer: It is a single huge neuronal layer located at the junction between other two layers. This is a **characteristic neuron** present only in cerebellum.

Granular cell layer: It is extremely cellular more nuclei layer. It contains granular and Golgi neurons.

B) Cerebral cortex (LP)-There are six layers of isocortex. There is no clear cut demarcation between end of one layer and starting of the next layer.

Molecular layer- Outermost layer lined by piamater. It shows few nuclei of horizontal cells.

Outer granular layer- contains many granule (stellate) cells and few small sized pyramidalcells.

Outer pyramidal layer- contains many pyramidal cells and few granule cells.

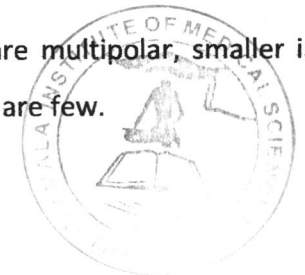
Inner granular layer- contains many granule cells. It is densely populated by neurons.

Inner pyramidal layer- Large sized pyramidal cells are seen in this layer.

Polymorph layer - It is the last layer at grey white junction and shows nuclei of fusiform and Martinotti neurons.

C) Dorsal root ganglion: aggregations of neural cell bodies located outside CNS. Consists of pseudo unipolar neurons. cell body is large and rounded, nucleus is central with prominent nucleolus. neurons lie in groups. Satellite cells are cuboidal in shape around cell bodies.

D) Sympathetic Ganglion: Neurons of sympathetic trunk are multipolar, smaller in size, nucleus is eccentrically placed with prominent nucleolus. Satellite cells are few.



Appendix

20. Charts for identification of slides

First of all, we categorize slides into three groups

Group 1

Solid /Basic: for example-*connective tissue, bones, cartilages and muscles.*

Group 2

Hollow/Tubular: it includes organs, which have lumen and wall. For example-*blood vessels, trachea, bronchus, oesophagus, stomach, intestine, gall bladder, ureter, urinary bladder, epididymis, vas deferens, seminal vesicles, uterus and uterine tubes.*

Group 3

Nonspecific: (*Non tubular and nonsolid tissue*) examples- *Lymphoid tissue, endocrine glands, exocrine glands, prostate, mammary gland, cerebellum, cerebrum, epiglottis, lung tongue, liver, kidney, testes, ovary, penis, cornea, retina, skin, placenta umbilical cord.*

We now have to determine where a given slide belongs to group 1, 2 or 3. For this see the slide under low power objective lens.

If the given slide shows homogenicity of structure with predominance of their cell type, fibre type or both, then slide is of group 1 i.e. Basic tissue. For example -if chondrocytes are present, n slide is of cartilage and if muscle fibre n muscle.

If given slide shows lumen and a wall, then it is tubular structure. But if organ is large and lumen is not seen on slide in such a case see both surfaces of given tissue. If given tissue shows a lining epithelium (whatever may be type) on one side, and opposite side shows fibrous or serous coat then also slide is of a tubular structure. For example - uterus - on one side has columnar epithelium and opposite surface shows fibrous adventitia.

If given slide does not show features mentioned above then slide belongs to group 3. Non tubular and

non-solid tissue. For example epiglottis on one surface has stratified squamous epithelium and opposite surface also shows same epithelium.

(1). If the slide is of Basic tissue, then see for predominant fibre type or cell type and their arrangement.

No predominance of any cell type or fibre type, but mixture of all fibre types and cells with large spaces filled with matrix then it is loosereolar tissue.

Predominance of collgen fibres with parallel arrangement and fibroblast trapped between them. Dense regular connective tissue e.g. tendon,Ligament.

Predominance of chondrocytes with in surrounding matrix then it is cartilage. Now see matrix and perichondrium

Predominance of muscle fibres then muscle tissue. Now see for shape, position of nuclei, striations and branching fibres.

Unstained slide → Groundbone

Shows trabeculae with lamellar pattern and lacunae → Decalcified bone

Matrix	Perichon -drium	Type of cartilage
Homogenous	Present	Hyaline
Homogenous	Absent	Articular
Non-homogenous contains elastic fibres randomly arranged.	Present	Elastic
Non-homogenous, contains collagen fibres with parallel arrangement	Absent	Whitefibrocar t-ilage

Nuclei	Fibres	Type of muscle
Flattened and peripherally placed	Multinucleate and show cross striations with no branching	Skeletal muscle
Oval or elongated and centrally placed	Mononucleate, spindle shaped fibres without cross striations and branching	Smoothmu scle
Oval & centrally placed	Elongated fibres made up of Mononucleate myocytes. Cross striations & branching present.	Cardiacmus cle

(2). If the slide belongs to category no.2 i.e. tubular structure then see for muscularis mucosa in the will i.e. to see wall is four layered orthree layered.

Muscularis mucosa present i.e. wall is four layered Then see for epithelium

Muscularis mucosa absent i.e. wall is three layered (see the chart on next page)

If stratified squamous epithelium then slide is of Oesophagus

If simple columnar epithelium then see for villi

Villi present then see in submucosa

villi absent then see for goblet cell in epithelium

if submucosa shows mucous gland then Duodenum

if submucosa contains more lymphoid tissue then Ileum

if non of these two features, then Jejunum

if Goblet cell absent in epithelium see in lamina propria

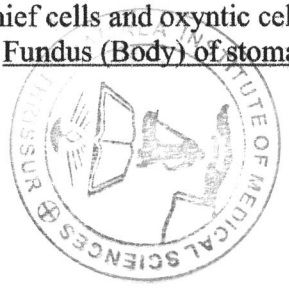
if Goblet cell present in epithelium then see see in submucosa

Presence of Gastric glands lined by chief cells and oxyntic cells then - Fundus (Body) of stomach

Presence of Gastric glands lined by mucous secreting cells then -Pyloric stomach

Plenty of lymphoid tissue in submucosa which forms a ring and star shaped lumen then - Appendix.

Less lymphoid tissue in submucosa which does not form ring and large lumen then - Large intestine



InTubular structure if muscularis mucosa is absent i.e. wall is three layered then see for eithelium

- If simple squamous epithelium then bloodvessels then see for tunica adventitia, media and lumen.
  - Media is thinner than adventitia and tumen collapsed then -Vein
  - Media is thinner than adventitia and lumen patent then - Artery Now see for Tunica media
    - Tunica media made predominantly of muscle then Muscularartery
    - Tunica media made predominantly of elastic fibres then Elastic artery
- If simple or ciliated columnar epithelium then look for mucosal folds
  - Mucosal folds are present then see for branching and anastomosing
    - If mucosal fold branch & anastomose then Gallbladder
    - If mucosal folds branch but do not anastomose then Fallopiantube
  - Mucosal folds are absent then Uterus only longitudinal and well differentiated muscle coat then Ureter.
- If transitional epithelium then see for muscle coat and mucosal folds
  - Mucosal folds are numerous and irregular & illdifferentiated muscle coat then Urinary bladder **More then one piece then Bronchus
  - Mucosal folds are
- If pseudostratified columnar epithelium then see for hyaline cartilage in lumen
  - If hyaline cartilage +ve then see for no of pieces **Single piece then Trachea -
    - Single tubular then vasdeferens
    - Many number of tubes in one section then see for mucosal folds
      - Absent then Epididymis
      - Present then Seminalvesicle.
  - Absent then see for number of tubes cut in one section

(3). If the slide is not a tubular structure or basic structure (tissue) then see whether it is a
A) Lymphoid tissue, B) Glandular tissue. C) Conical structure or D) None of the above.

-If the slide shows large number of lymphocytes which may or may not be arranged in nodular form then slide is of lymphoid tissue.
- if a slide shows large number of epithelial cells arranged in group or clusters or acinar from with or without duct system then slide is of Glandular tissue.
- If the slide shows a central core and two surfaces similar or dissimilar then that slide is of conical structure.
-If the slide does not show any of the above feature then that slide is having its own identification points and groups as None of above

A) If the slide is of lymphoid tissue then see for the arrangement of lymphocytes i.e. cortex and medullary arrangement

If lymphocytes are arranged in cortex and medulla from then see for follicular or nodular arrangement of lymphocytes.

Cortex contains lymphocytic Follicles or nodules then slide is of Lymphnode

Cortex does not contain follicles or nodules but Medulla shows Hassal's corpuscles then slide is of - Thymus

If the lymphocytes are not arranged in cortex and medulla from then see for surrounding capsule or epithelium.

** Capsulated organ with lymphatic nodules surrounded by red pulp - Spleen

** Noncapsulated with lymphatic nodules associated with Stratified squamous epithelium -Tonsil.

** Noncapsulated with lymphatic nodules or follicles associated simple columnar epithelium - Payers patches.

B) If the slide is of Glandular tissue then see for duct.

If the duct is absent then see for arrangement of cells

Cells arranged in cords or clumps then

**Intraglandular follicles seen with pars anterior and posterior on either side of it then Hypophysis cerebri

**Subcapsular cortex shows glomerular, fascicular and reticular arrangement of cells then - Adrenal gland

**Cells are arranged in cords and associated with thyroid tissue then Parathyroid.

Cells are arranged in follicular formation then Thyroid

If ducts are present then see for arrangement of cells

Acinar arrangement present then see for type of secretary cells

**Mucous acini with scanty stroma - Mucous salivary gland.

**Serous acini with scanty stroma - Serous salivary gland.

**Both Mucous and Serous acini with scanty stroma - Mixed salivary gland.

** Serous acini with islets of Langerhans - Pancreas

**Acini lined by columnar cells and fibrofatty stroma - Mammary gland.

**Acini Lined by Columnar cells with fibromuscular stroma - Prostate gland.

Follicular arrangement then Prostate.

C) **If slide shows a central core and two surfaces or conical structure then see**

Central core	One surface	Or surface	Name
Elastic cartilage	Stratified squamous epithelium	Stratified squamous epithelium or pseudostratified columnar epithelium	Epiglottis
Skeletal muscle and condensed connective tissue.	Skin	Simple cuboidal or simple columnar epithelium	Eyelid
Irregularly arranged skeletal muscle	Stratified squamous epithelium with papillae	Stratified squamous epithelium without papillae	Tongue
Hyaline cartilage	Pseudostratified columnar epithelium	Pseudo stratified columnar epithelium	Nasal septum

D) If slide does not show any of above features n see for following

Lungs: Empty spaces showing honey combed appearance lined by squamous epithelium. Bronchi and Bronchiole are present.

Liver-Hexagonal lobular pattern filled with radiating cords of cells. Portal triads are present at angles of lobules.

Kidney-Cortex and Medulla present. Cortex contains Malphigian or renal corpuscles and tubules with ill-defined lumen. Medulla contains tubules with well-defined lumen:

Testes-Tubules cut in different planes i.e. of irregular shape and lined by several layers of cells. Lumen contains spermatozoa.

Ovary-Ovarian follicles at different stages of development in cortex i.e. towards periphery and blood vessels with connective tissue in central medulla.

Skin: Shows dermis and epidermis. Epidermis - Keratinised stratified squamous epithelium. Dermis-Connective tissue, sweat gland and sebaceous gland. If hair follicles are absent -Thick skin.

Cerebral Cortex-Laminar pattern of neurons and fibres. Pyramidal cells of different sizes seen.

Cerebellar cortex: - Laminated pattern of neurons and fibres. Shows three layers. Purkinje (Flask shaped) cells seen in a single row at equal distance.

Cornea: - Five layered structure with thick central core formed by collagen fibres i.e. Substantia propria (Homogenous appearance). On their surfaces re is epithelial covering. On one side it is stratified squamous epithelium and or surface is lined by simple cuboidal or squamous epithelium.

Retina: Ten layered structure, out of which three layers are of nuclei in which number of nuclei goes on decreasing successively from outside to inside.

Placenta: Irregularly cut small masses of tissue separated from each or by empty spaces. Each mass has central core of connective tissue containing blood vessels and cells lining surface.

Penis-Three cylindrical masses of erectile tissue covered by skin.