

HISTOLOGY OF URINARY SYSTEM

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- The main organs of this system are:
 - Kidneys
 - Ureters
 - Urinary bladder
 - Urethra

KIDNEY

Comprises of

Capsule

Parenchyma

Cortex

Medulla

Cortical labyrinth

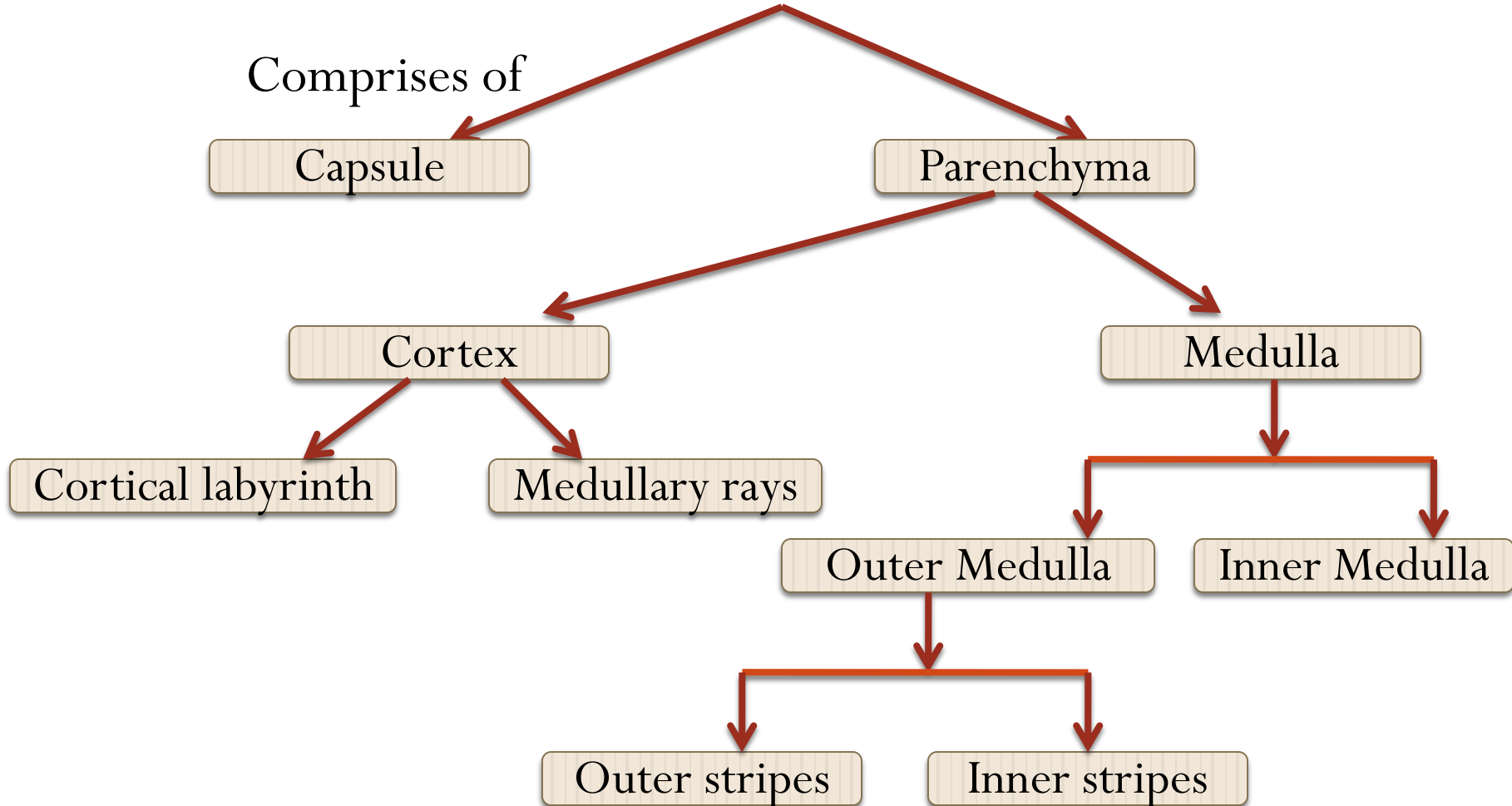
Medullary rays

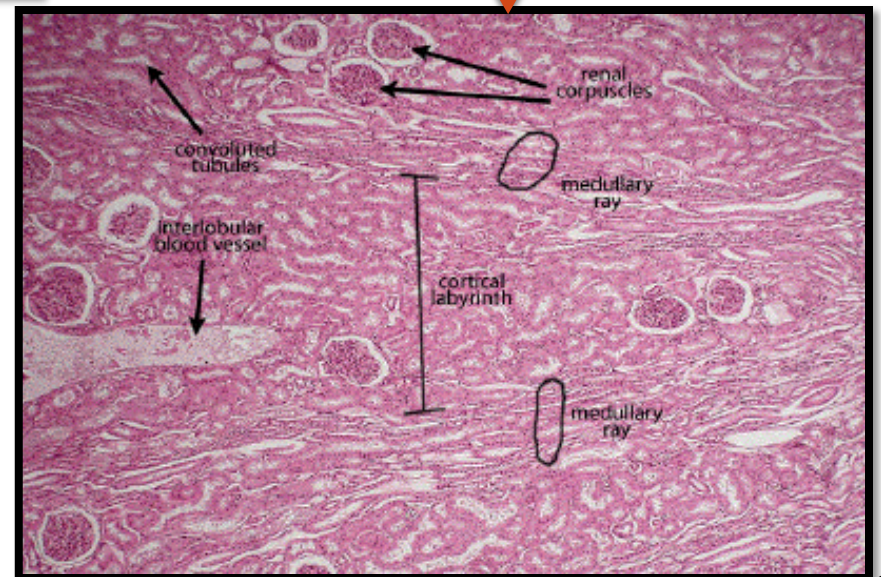
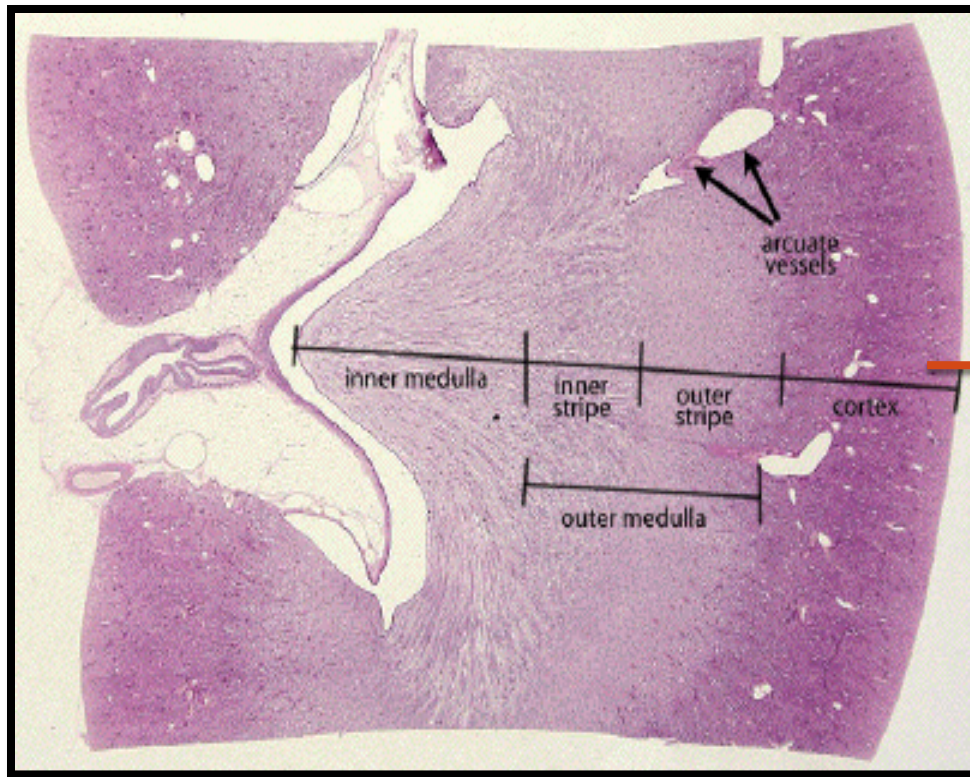
Outer Medulla

Inner Medulla

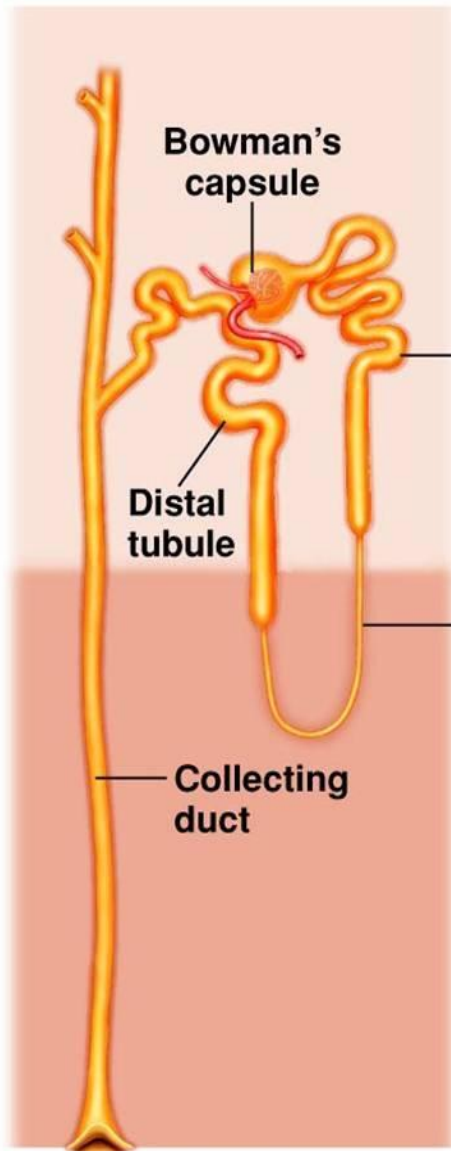
Outer stripes

Inner stripes

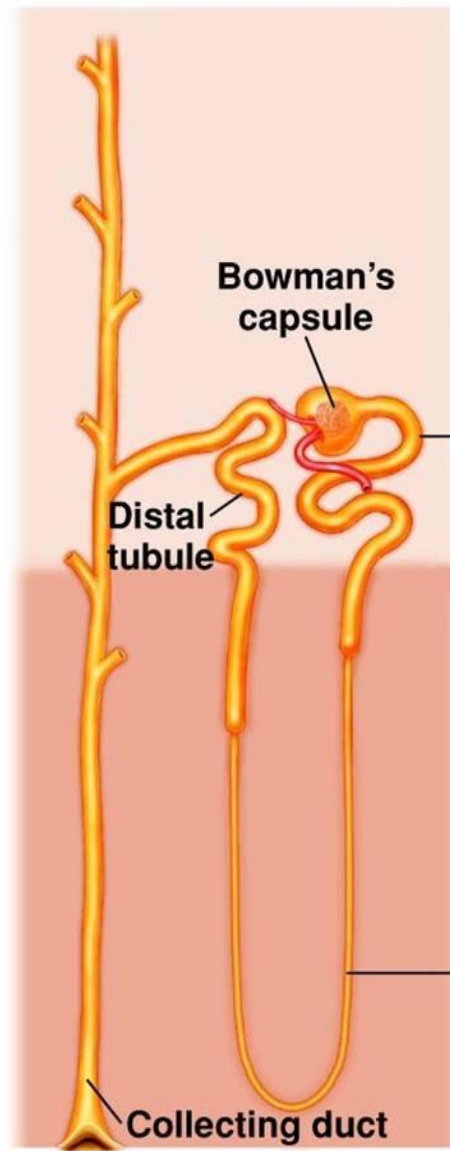




- **Capsule** is made up of collagen fibers, some smooth muscle fibers and blood capillaries.
- The **Parenchyma** consists of millions of **nephrons**, branches of renal arteries, veins, lymphatics and nerves.
- The **Nephrons** are the structural and functional unit of kidney.
- **Nephrons can be classified**
- **On the basis of location of their glomeruli:**
 - Superficial (near the capsule)
 - Mid cortical (near the medulla/Juxtamedullary)
- **On the basis of the length of the loop of henle:**
 - Short looped- generally have superficial or mid cortical glomeruli and the tubules extend only into the outer medulla before it reflects back into the cortex.
 - Long looped- have juxtamedullary glomeruli and tubules extend into the inner medulla before reflecting back into the cortex.



(a) Cortical nephron



(b) Juxtamedullary nephron

Renal
cortex

Renal
medulla

Nephrons comprises of:

1. Renal corpuscles

- Glomerulus
 - Glomerular capillaries
 - Mesangium
- Bowman's capsule
 - Parietal layer
 - Visceral layer

2. Proximal tubules

- Proximal convoluted tubule (PCT)
- Proximal straight tubule (PST)

3. Henle's loop

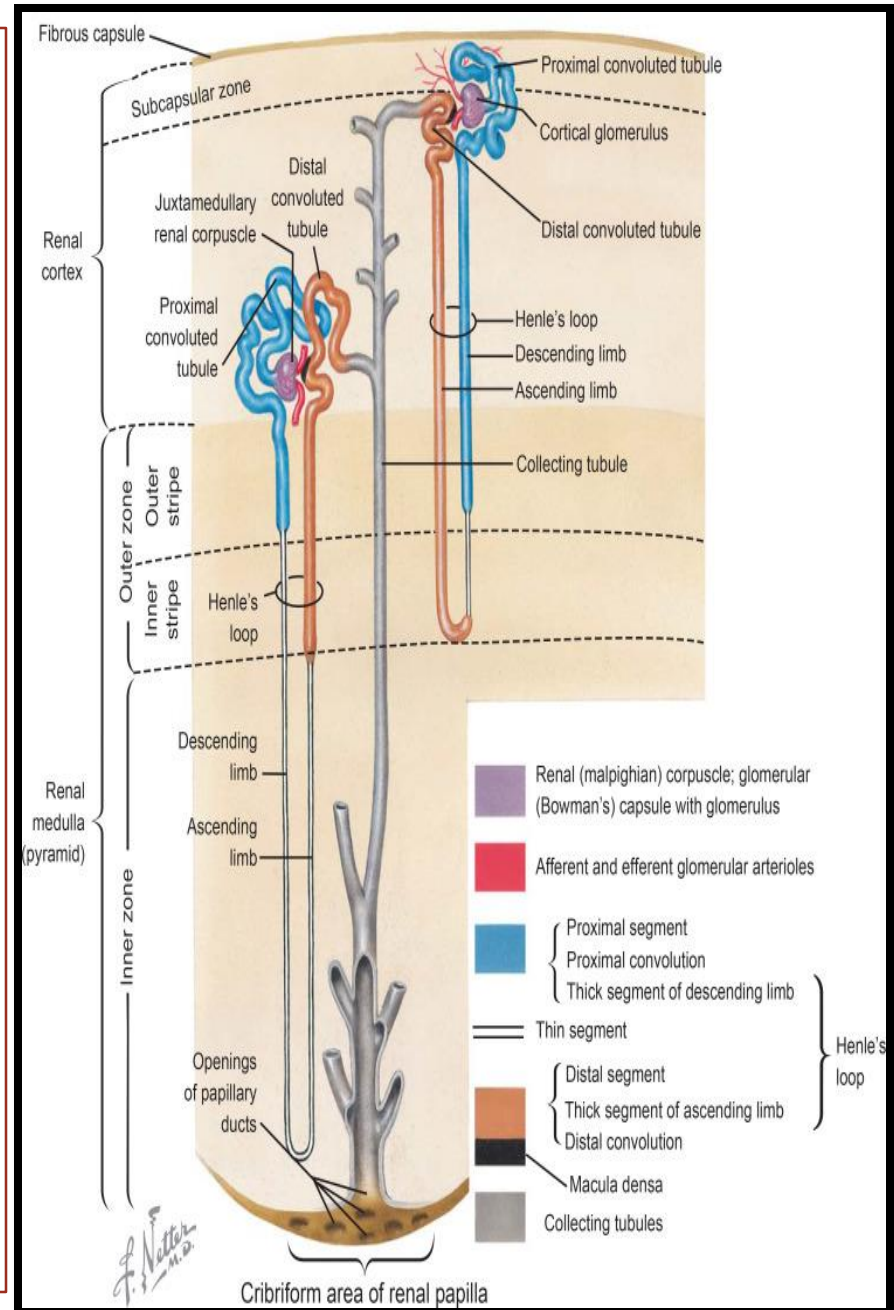
- Thin descending portion
- Thin ascending portion
- Thick ascending portion

4. Distal convoluted tubule

5. Connecting segment

6. Collecting duct

- Arcade- initial collecting tubule
- Straight portion-
 - Cortical collecting duct
 - Outer medullary duct
 - Inner medullary duct



Renal Cortex

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graph TD; A[Renal Cortex] --> B[Cortical labyrinth]; A --> C[Medullary rays]; B --> D["PCT, DCT, Connecting segment, Renal corpuscles, Thick ascending limb, Initial collecting tubule"]; C --> E["Cortical collecting ducts, Cortical thick ascending limb and Proximal straight tubule"]
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Cortical labyrinth

PCT, DCT, Connecting segment, Renal corpuscles, Thick ascending limb, Initial collecting tubule

Medullary rays

Cortical collecting ducts, Cortical thick ascending limb and Proximal straight tubule

Renal Medulla (Pyramids)

Outer Medulla

Inner Medulla

Outer stripes

Inner stripes

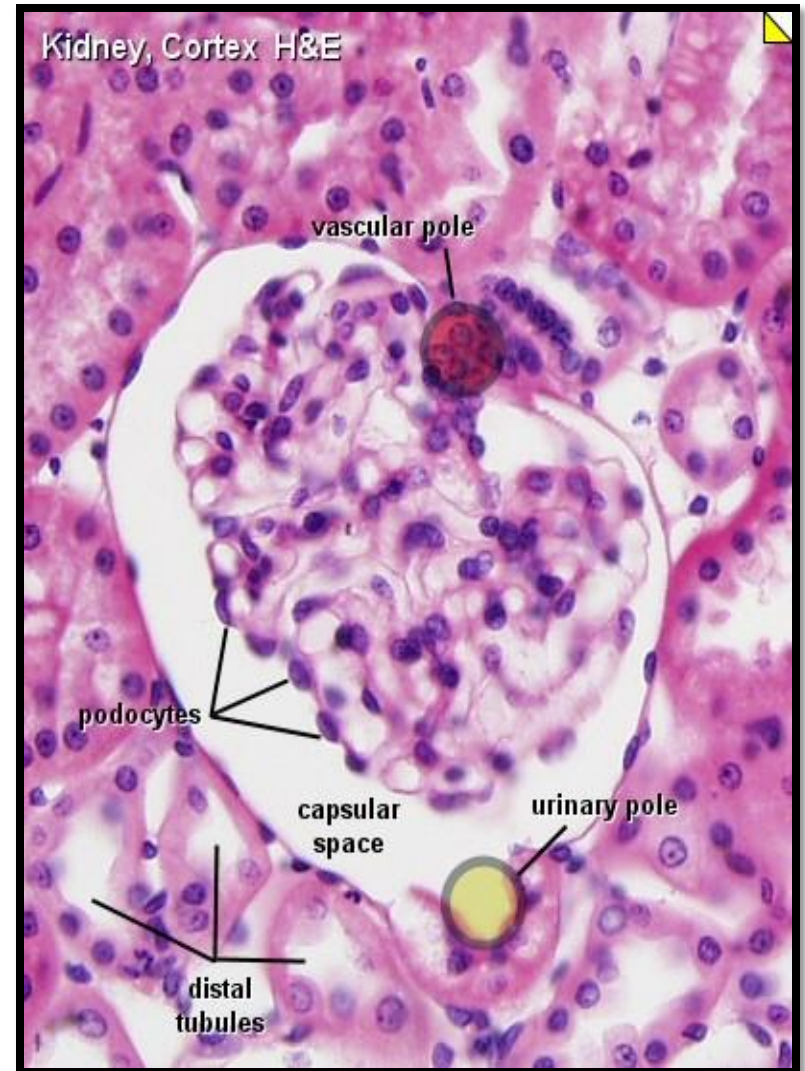
Proximal straight tubule,
Thick ascending limb,
Collecting duct

Transition of PST to thin
descending limb of
henle's loop, Collecting
duct.

Collecting duct, Loop of
Henle's thin descending
and ascending limb.

Renal corpuscles:

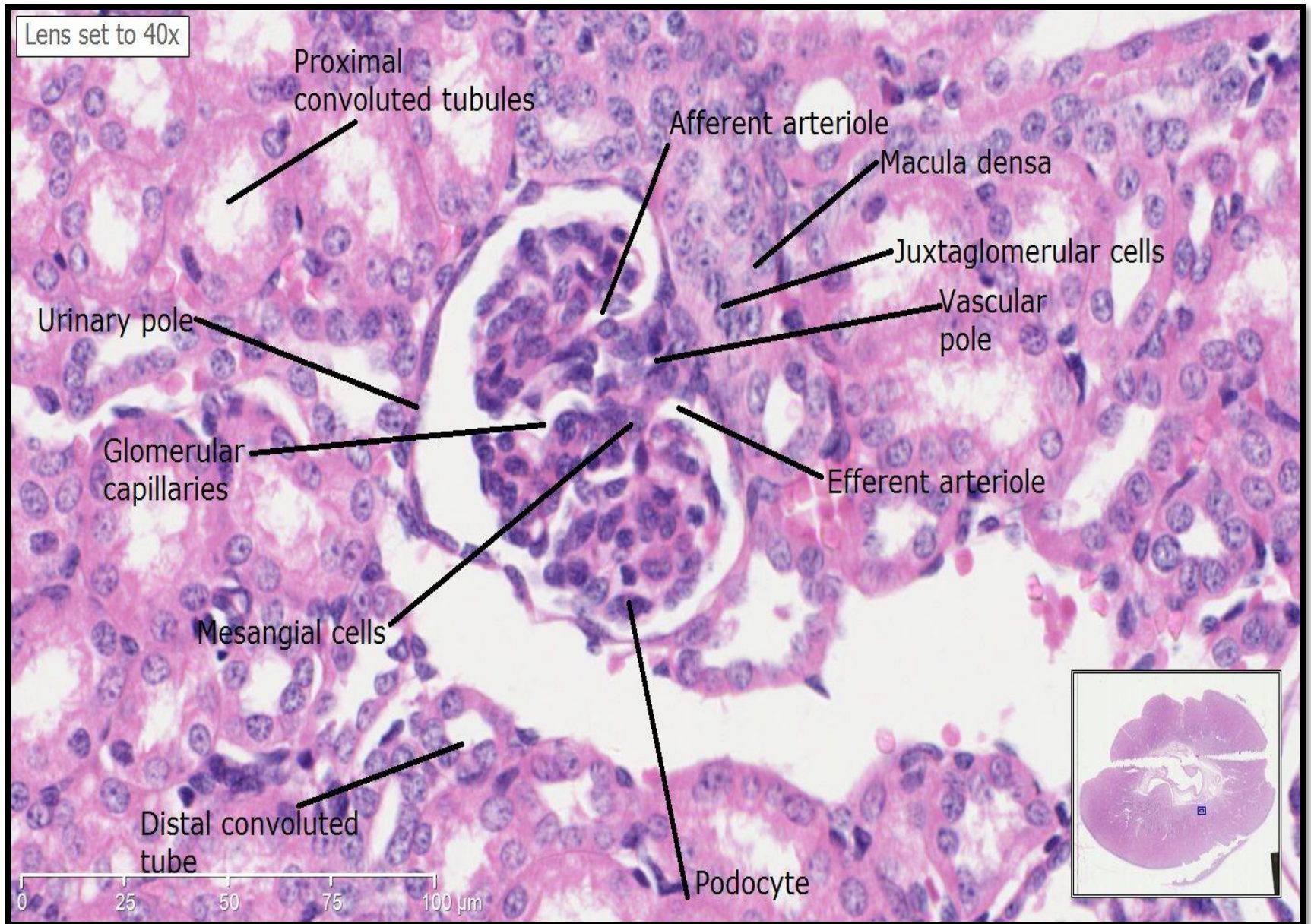
- Spherical structure and varies in size among species.
- Comprises of **Glomerulus** and **Bowman's capsule**.
- The **glomerulus** is a network of blood capillaries tucked into the bowman's capsule. The glomerular blood vessels (**Afferent** and **Efferent**) enters and exit the glomerulus at the **vascular pole**.
- The **urinary pole** is opposite the vascular pole where the bowman's capsule opens into the PCT.



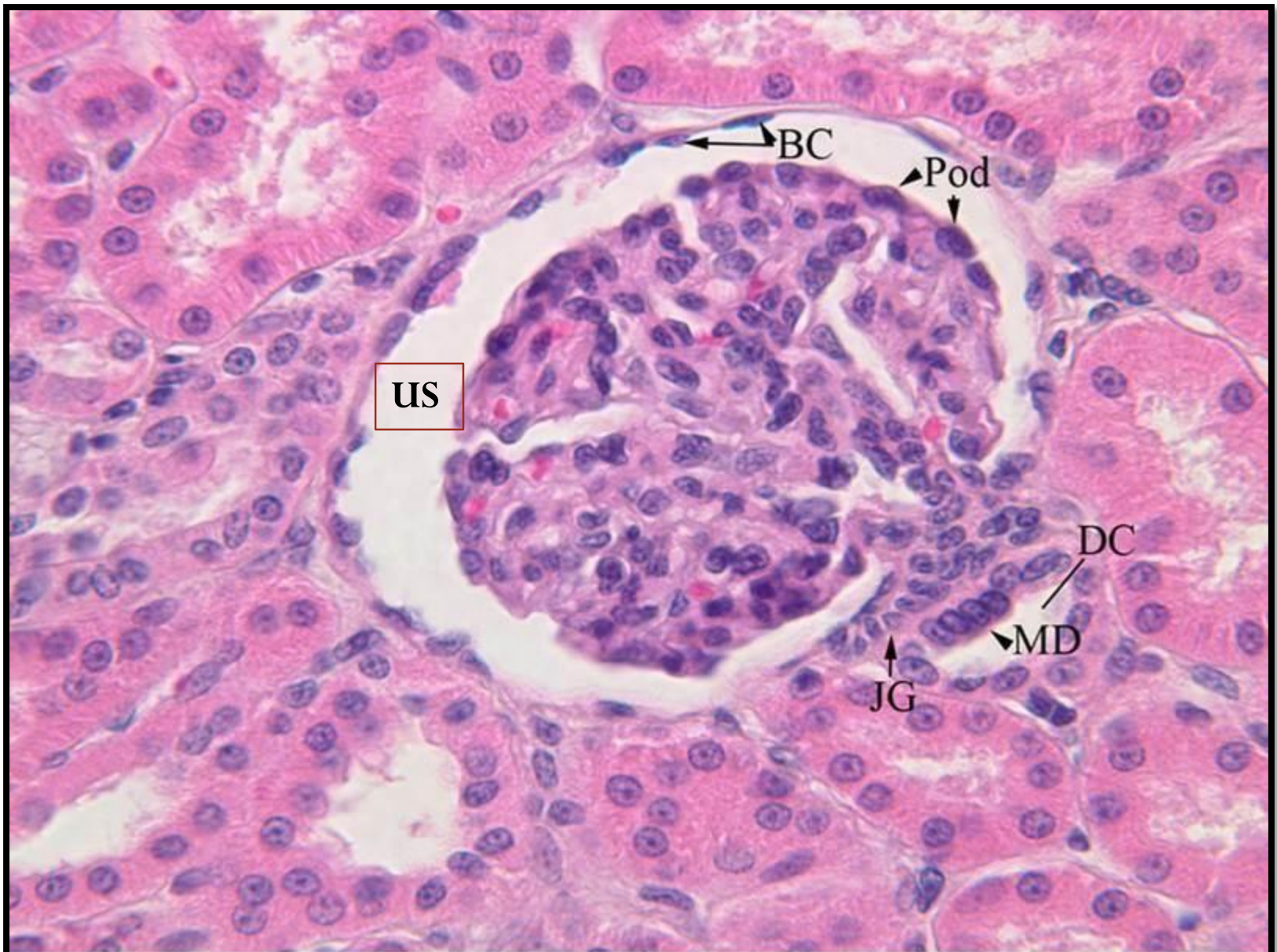
- The glomerular capillaries are lined by an extremely thin layer of **fenestrated endothelium**.
- Beneath the endothelium is the Glomerular basement membrane (**GBM**).
- The GBM is made up of collagen fibers, heparan sulfate and glycoproteins.
- Beneath the GBM there is visceral layer of Bowman's capsule.

- Mesangium forms the core of the glomerulus and is composed of specialized contractile cells embedded in an acellular matrix.
- **Mesangial cells** have elongated, irregular cell processes, contain bundles of microfilaments made up of contractile proteins.
- it is responsible for phagocytosis, production of mesangial matrix, maintenance of capillary loops and blood flow.

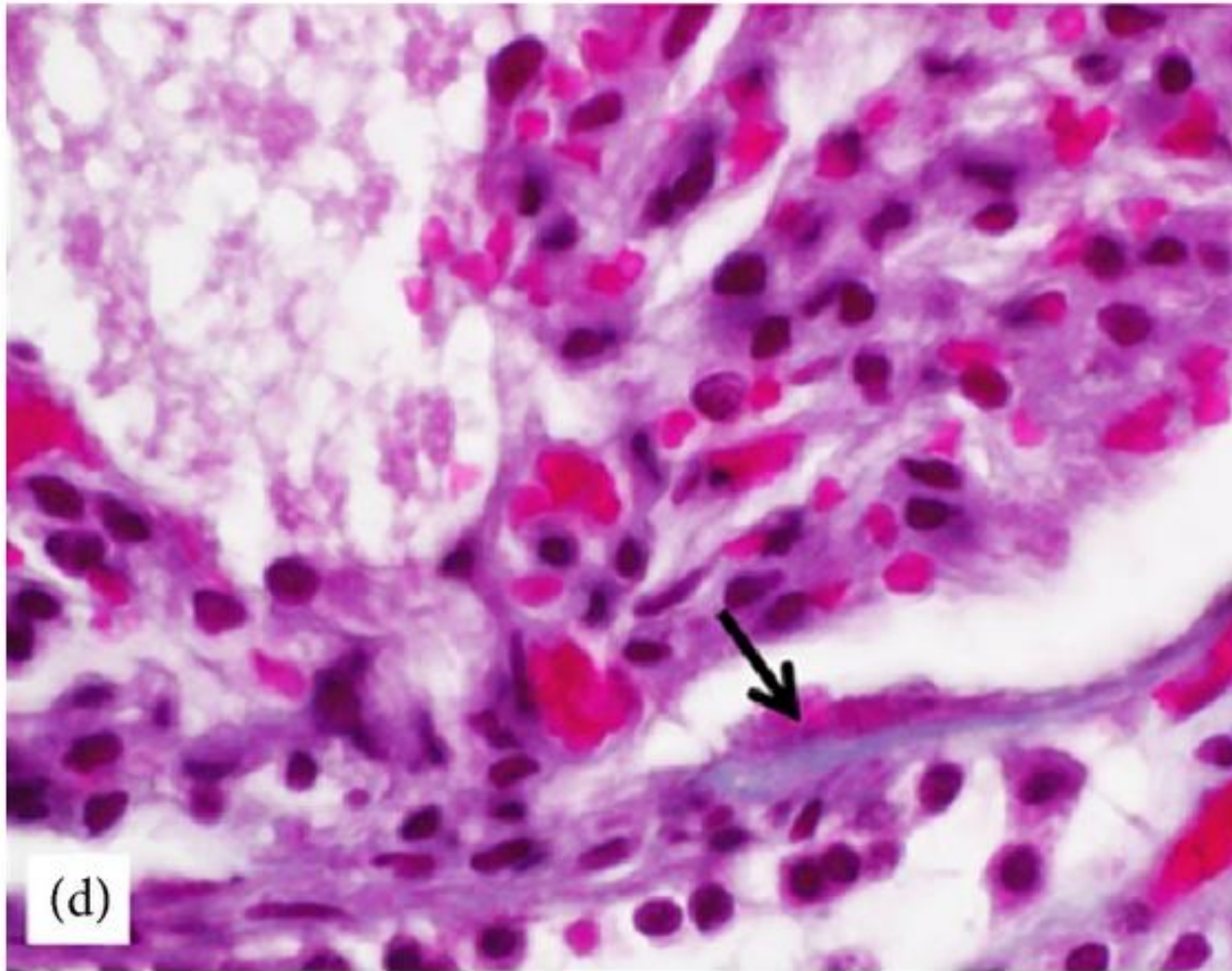
Lens set to 40x



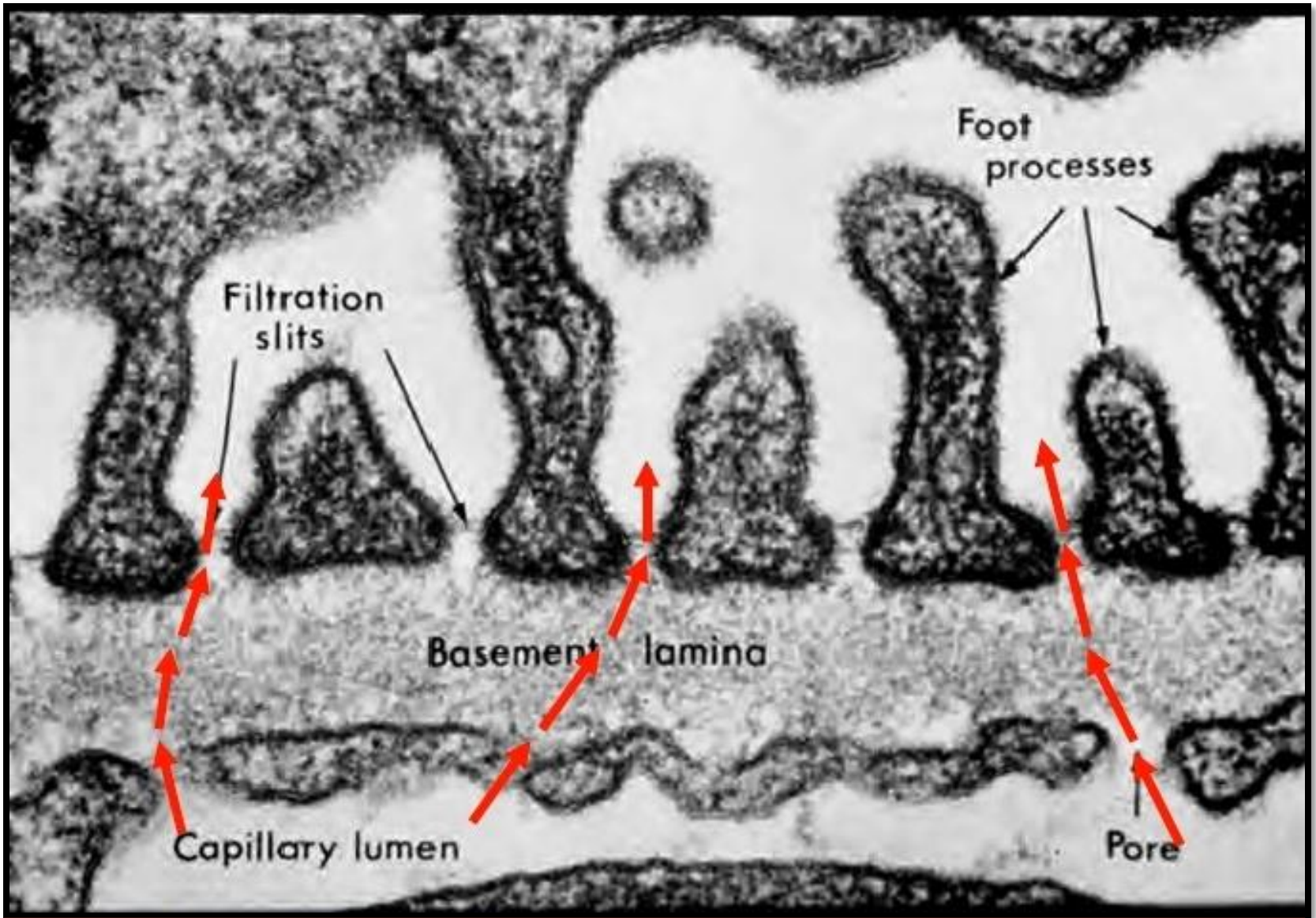
- Bowman's capsule comprises of **visceral** and **parietal** layer.
- In between the two layers, **Urinary space (US)** is present which continues with the lumen of PCT.
- Visceral layer is lined by **Podocytes**. They have primary, secondary and tertiary processes, the smallest of these are called **foot processes** or **pedicels**.
- Narrow space between foot processes are called **Filtration slits** which are bridged by the **slit diaphragm**.
- Parietal layer is lined by **simple squamous epithelium** that abruptly changes to simple cuboidal at the urinary pole.
- An additional epithelial cell in the bowman's capsule is the **Peripolar cell**, located at the vascular pole at the junction between the parietal and visceral layer.
- Its cytoplasm contains dark stained, membrane bound granules.



BC - Bowman's capsule (parietal layer) Pod - podocyte (visceral layer of Bowman's capsule)
MD - macula densa JG - juxtaglomerular cells DC - distal convoluted tubule



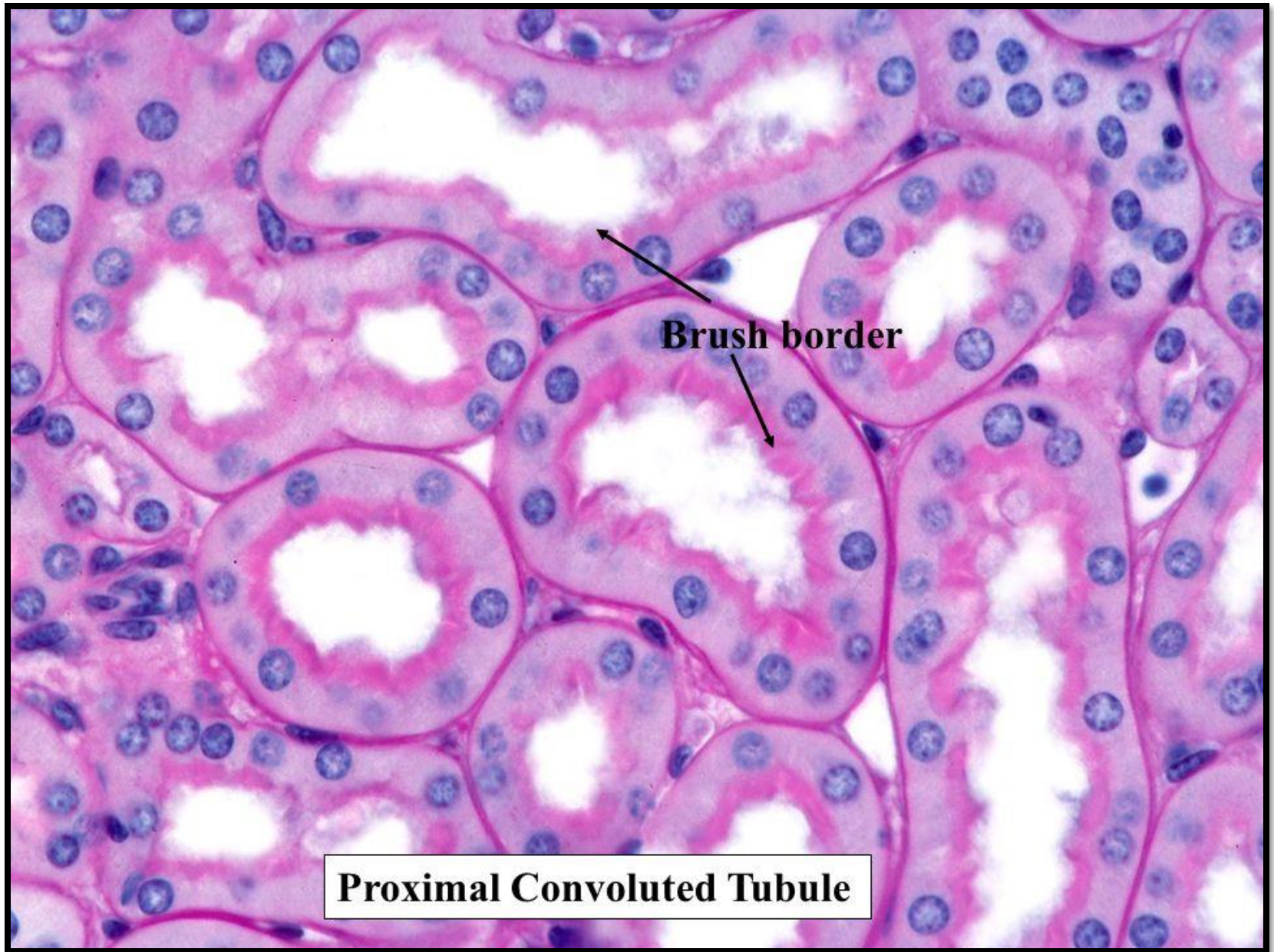
Arrow indicates peripolar cell at the vascular pole between the junction of parietal and visceral layer of bowman's capsule.



Ultra structural photograph showing Filtration slit, Foot processes, Basement membrane and Fenestrated (Pore) epithelium of glomerular capillary.

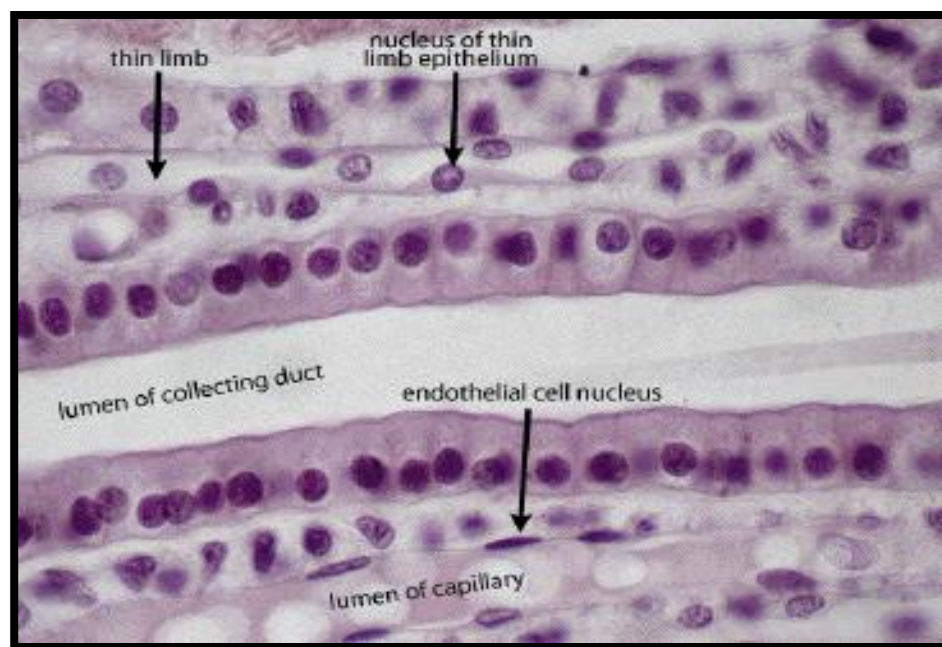
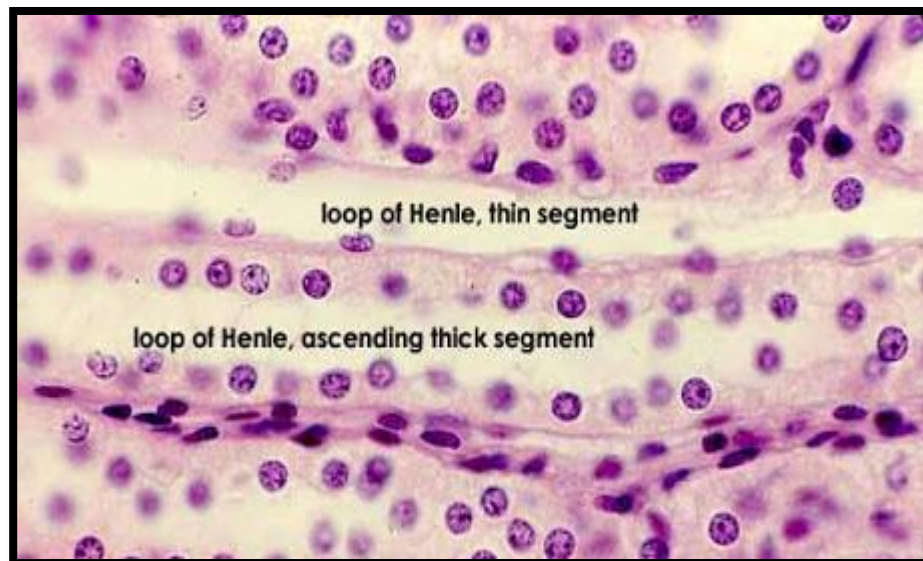
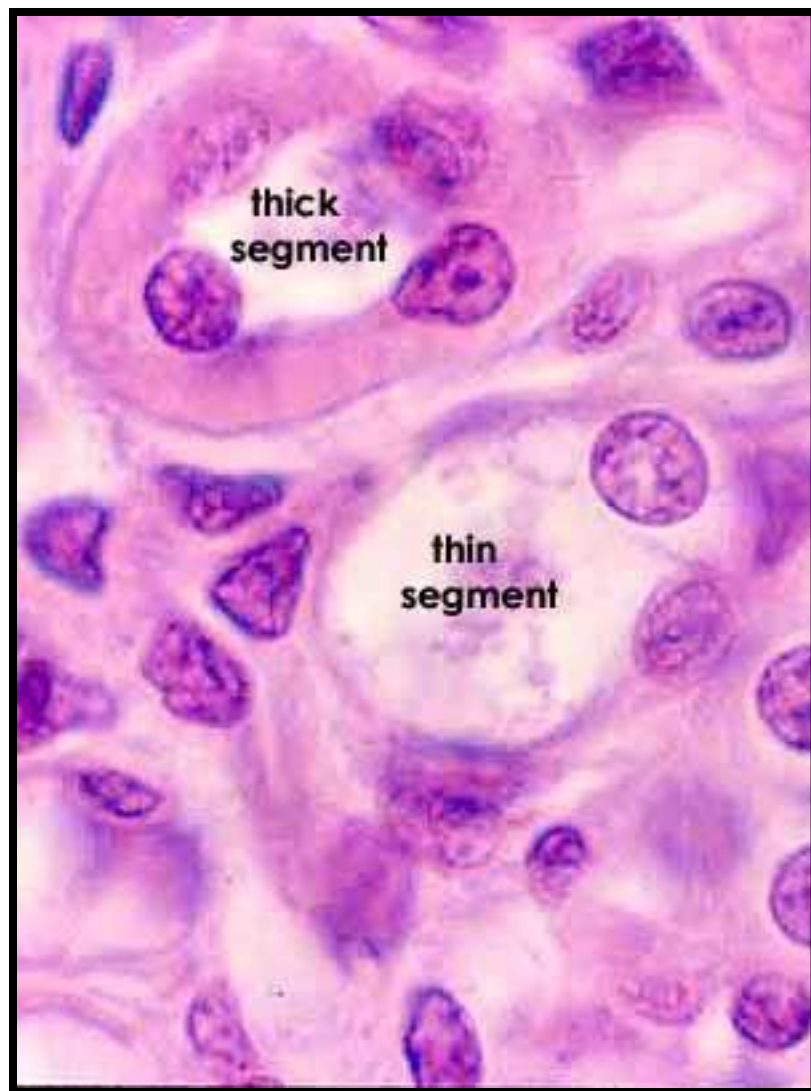
Proximal Tubules:

- It twists and turns in the cortical labyrinth (PCT) until it enters the medullary rays where it becomes straight and called as PST.
- Lining epithelium is simple cuboidal with brush border.
- The brush border appearance is due to numerous microvilli on the apical cell membrane of cuboidal cells.
- Nucleus is single, spherical and situated in the middle to basal part of the cell.
- The cuboidal cells have eosinophilic granular cytoplasm.
- Cell boundaries are not distinct because of extensive basal and lateral cell membrane interdigitation with neighbouring cells.
- The lumen is small and uneven.



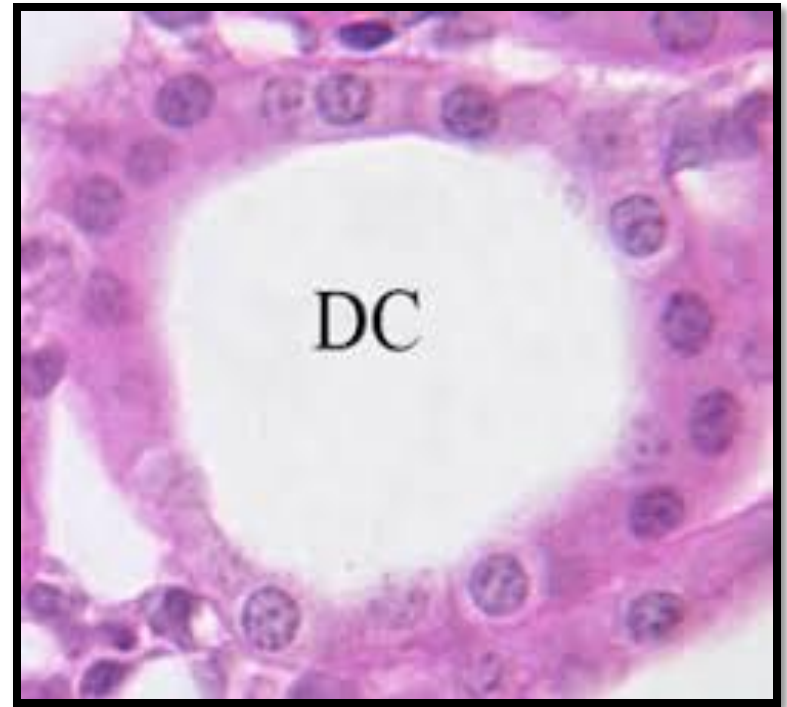
Loop of Henle:

- The **Thin limb** has **simple squamous epithelium** that gradually changes to low cuboidal at the end of the thin segment.
- The nuclei protrude into the lumen to a greater degree than do the nuclei of the endothelial cells of adjacent capillaries.
- The **Thick ascending limb** has **simple cuboidal epithelium** with stubby apical microprojections and undulating cell borders.
- No brush border.



Distal Convoluted Tubule:

- The lining epithelium is tall cuboidal without any brush border (microvilli are absent).
- Apical cell borders are simple without undulation.
- Nucleus is located close to the apical border of the cell.
- The lumen appears larger in DCT as compared to PCT.

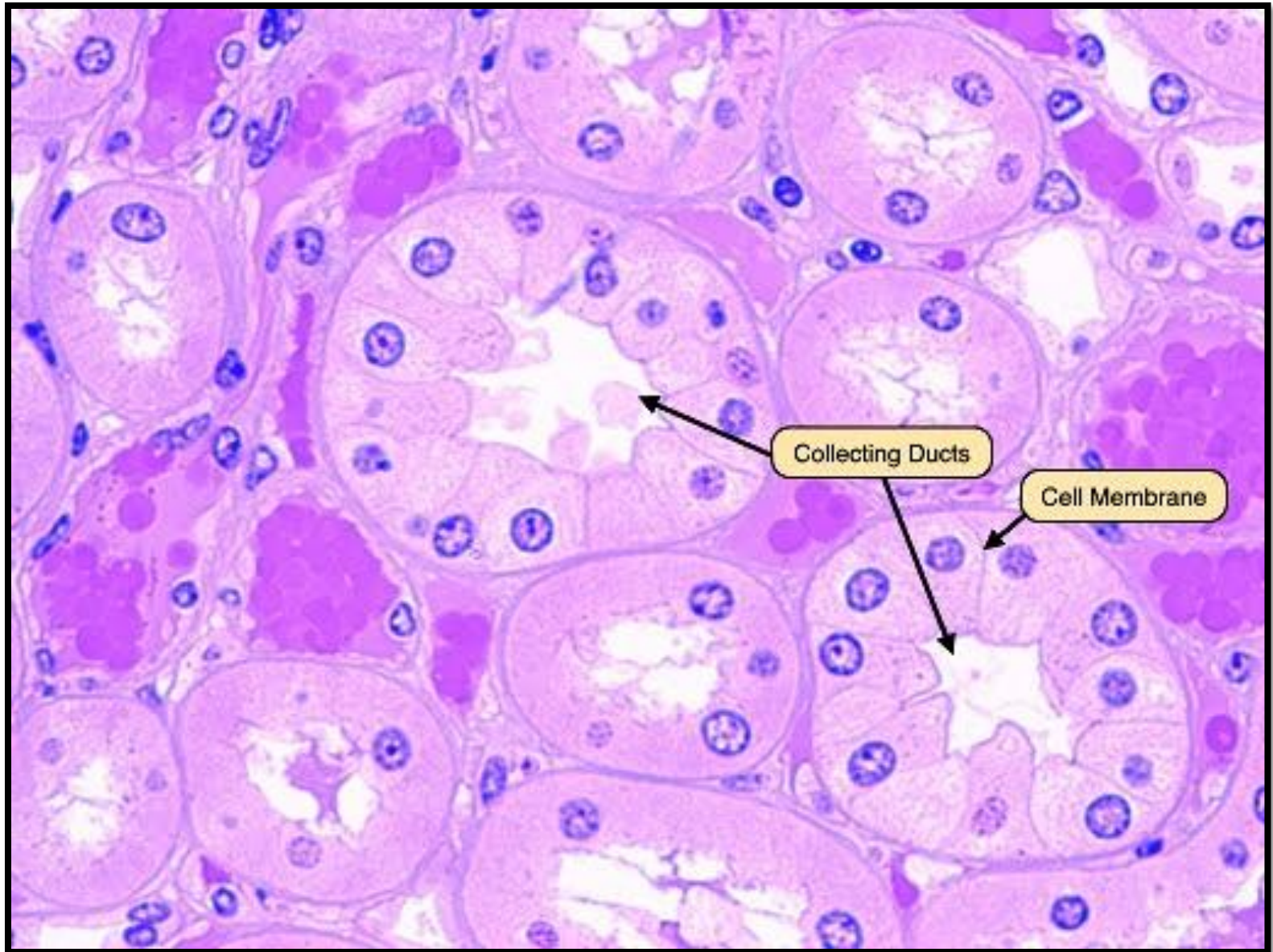


Connecting segment:

- It contains a variety of epithelial cell types which includes tall cuboidal cells, connecting segment cells, intercalated cells and principal cells.
- The mixture of variety of cell types with different cell heights, staining density and shape produces an irregular appearance in light microscopy.
- **Principal cells** are low cuboidal cells with smooth apical surface and few short apical micro projections.
- **Intercalated cells** are epithelial cells traditionally associated with the regulation of acid-base homeostasis.

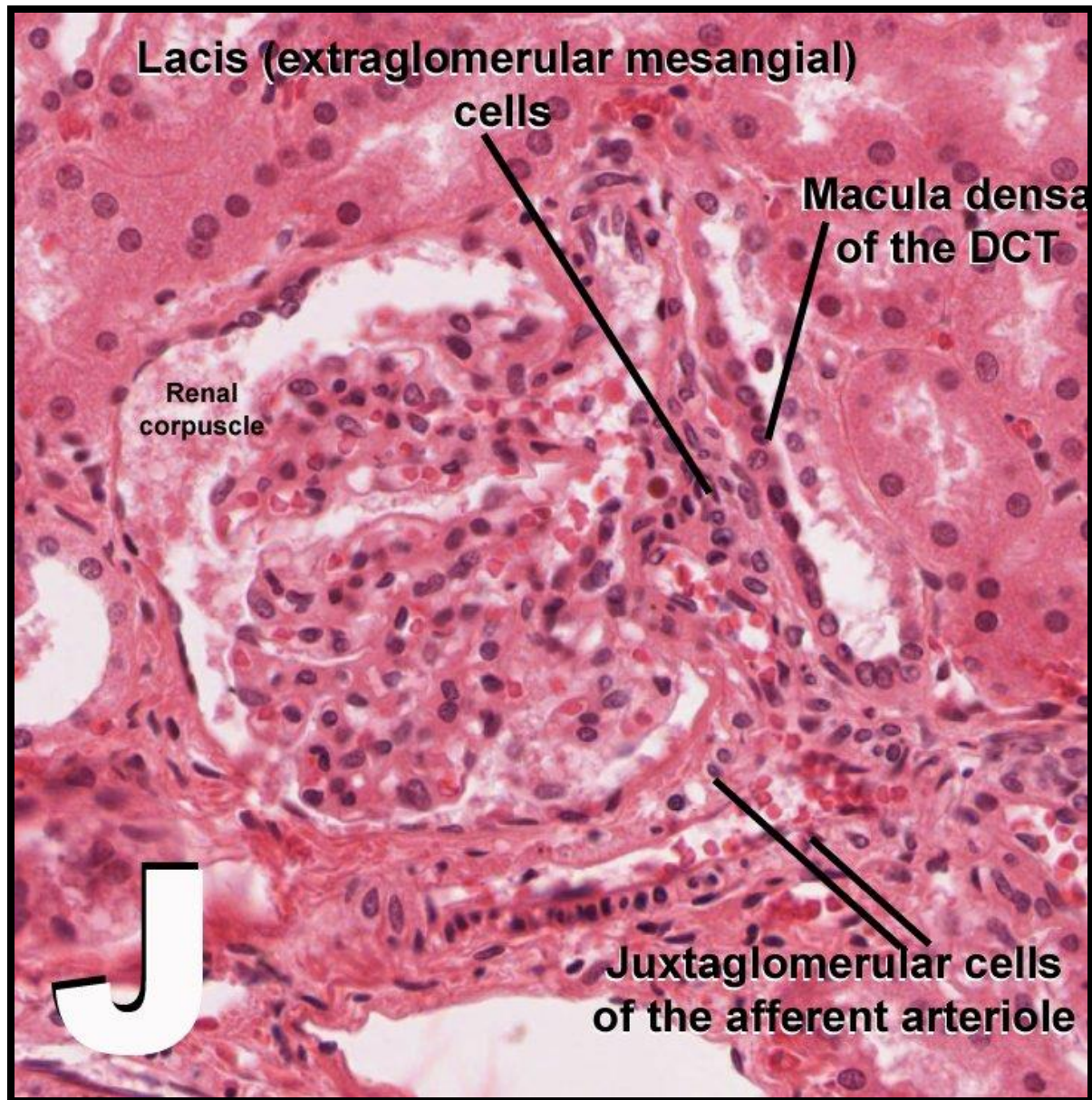
Collecting ducts:

- Connecting segments merge with the initial collecting tubule in the cortical labyrinth and these merge with the cortical collecting duct in the medullary rays.
- The lining epithelium is **simple cuboidal**.
- Collecting ducts can be recognised by **clear lateral demarcation** between neighbouring epithelial cells.
- These collecting ducts extend towards the renal papillae and the renal calyx.
- The collecting ducts at the tip of the medullary pyramids are called **ducts of Bellini**.



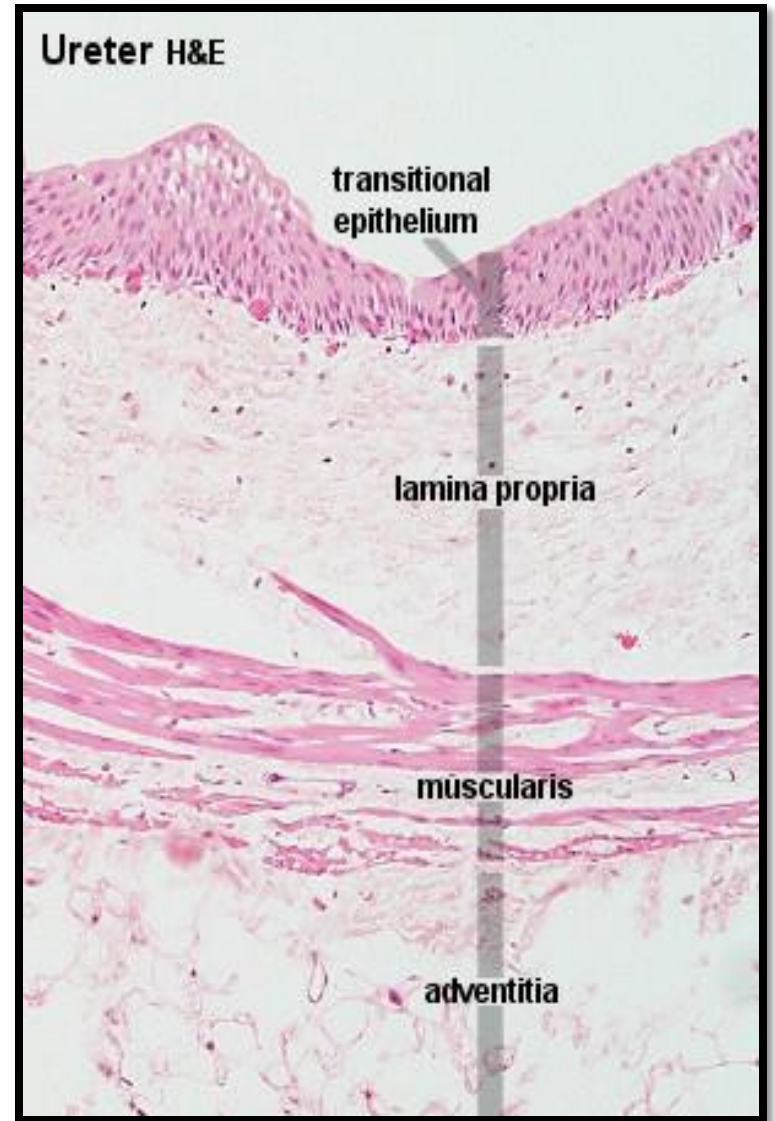
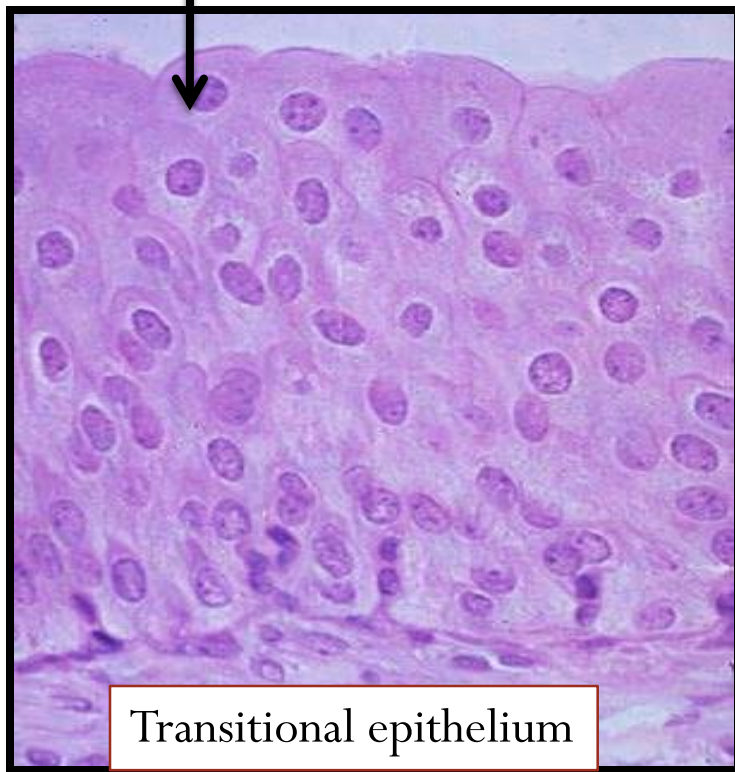
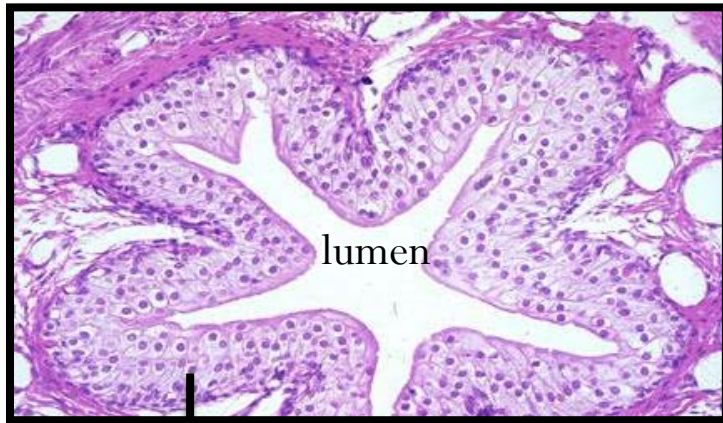
Juxtaglomerular Apparatus:

- Located at the vascular pole of the glomerulus.
- Includes
 - Macula densa
 - Extraglomerular mesangial cells/ Polkissen cells/ Lacis cells
 - Juxtaglomerular cells (JG cells)
- **Macula densa** is a patch of specialized epithelial cells in the thick ascending limb where it passes between the afferent and efferent arterioles. Cells are tall and narrow and the intercellular space is dilated. It regulates the glomerular blood pressure and renin-angiotensin system.
- **Lacis cells** are found between the macula densa and the two arterioles.
- **JG cells** are found in the afferent arterioles and are specialized smooth muscle cells.



Ureter:

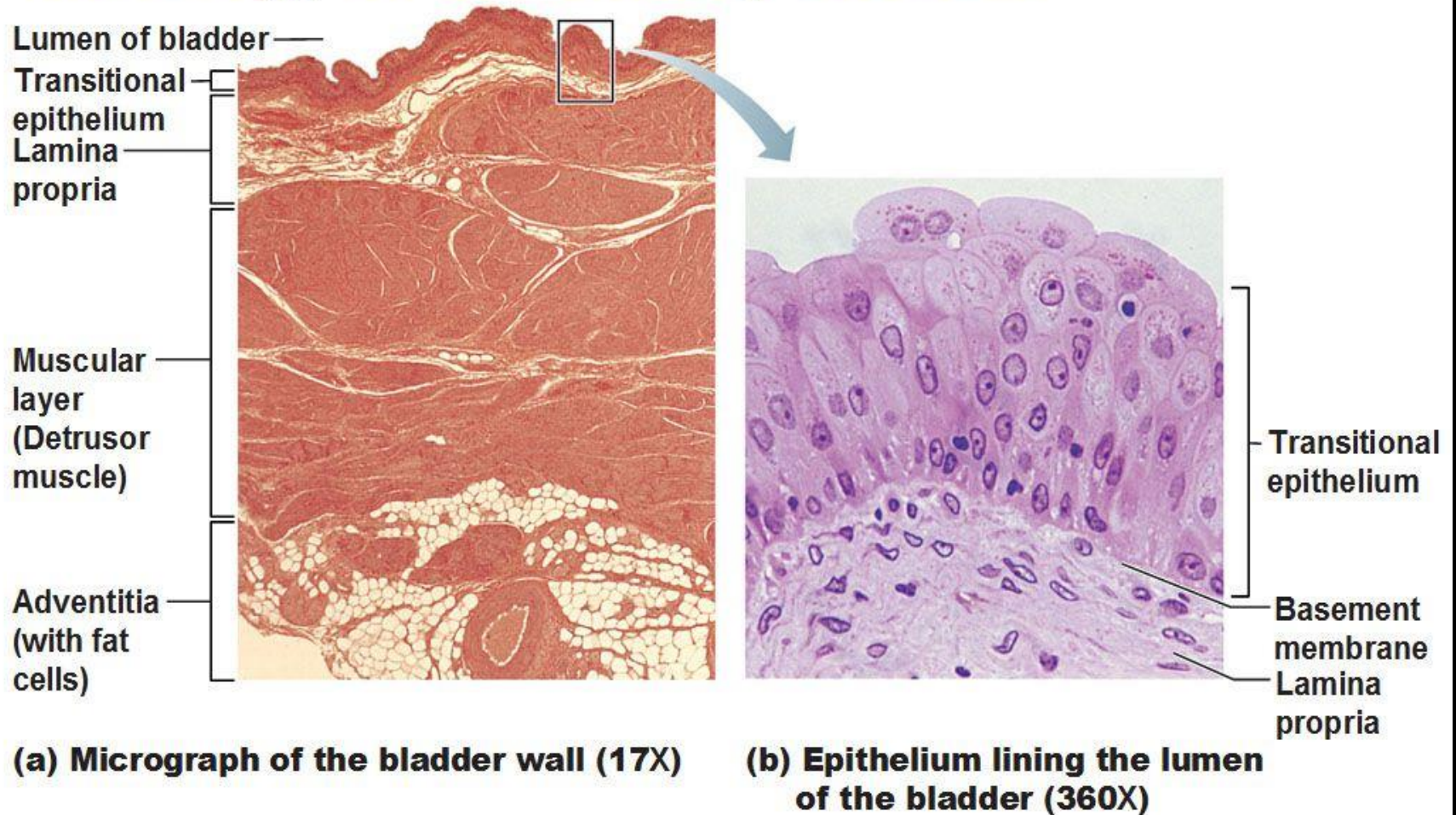
- The **lumen** of ureter is **stellate shaped** and the **wall** comprises of following layers from inside outwards:
- **Tunica mucosa-** the lining epithelium is **transitional epithelium**. The epithelium is 3-5 cell layers thick. Beneath the epithelium is lamina propria. The **lamina muscularis is absent**, hence the lamina propria intermingles with the underlying tunica submucosa to form **propria-submucosa**. It consists of loose connective tissue.
- **Tunica muscularis-** upper 2/3rd of the ureter is made of two layers of smooth muscle cells.
 - Inner longitudinal and outer circular layer
- Lower 1/3rd of the ureter has a third outer longitudinal layer (inner longitudinal, middle circular and outer longitudinal).
- **Tunica serosa/ adventitia-** made of fibrous connective tissue.



Urinary Bladder:

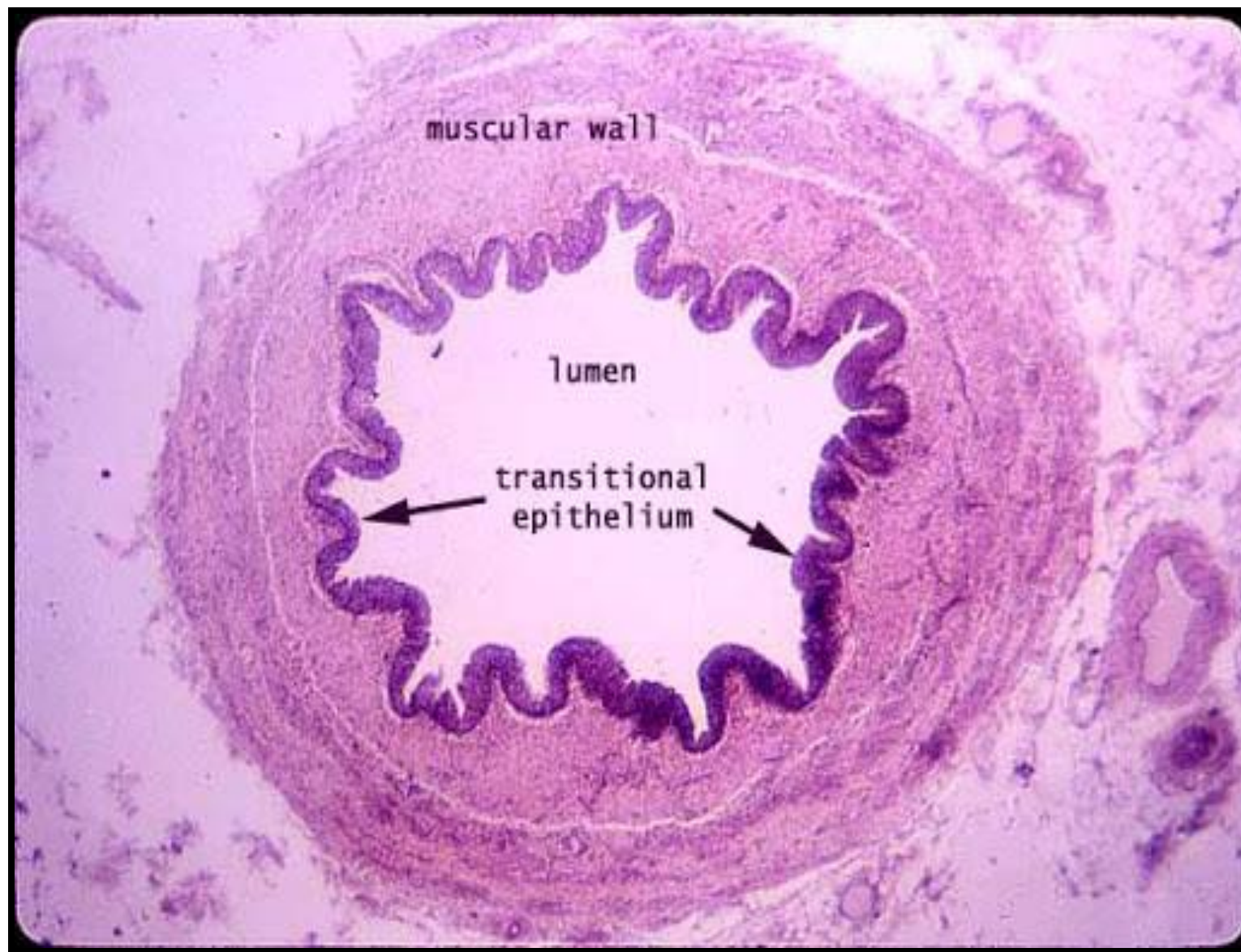
- The histological details of urinary bladder is same as that of the ureter except that:
- The lamina muscularis is present as small isolated bundles of smooth muscles.
- The tunica muscularis is thick and the muscles are collectively called as **Detrusor muscle**.
- Rest of the features are same.

Histology of the Urinary Bladder



Urethra:

- The histological details include the basic four layers:
- **Tunica mucosa:** The epithelium is **transitional** but changes to stratified squamous at the external urethral orifice.
- **Tunica submucosa:** It is a connective tissue layer and has cavernous spaces that are typical of erectile tissue.
- **Tunica muscularis:** It has inner and outer longitudinal and a middle circular layer of smooth muscles as in bladder but towards the external urethral orifice, it acquires an external layer of skeletal muscle called **Urethralis muscle**.
- **Tunica serosa/ adventitia:** is a fibrous layer.



Assignment:

- A well labelled pictorial representation of Histology of different organs and parts of the Urinary system in practical note book.

Thanks!