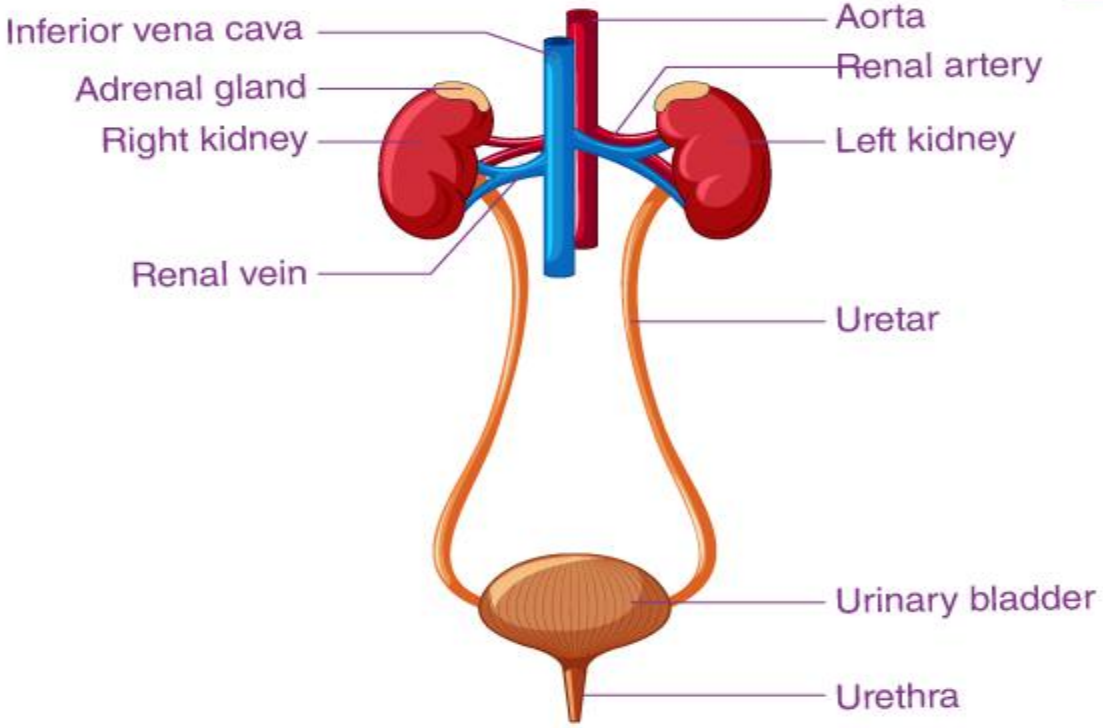
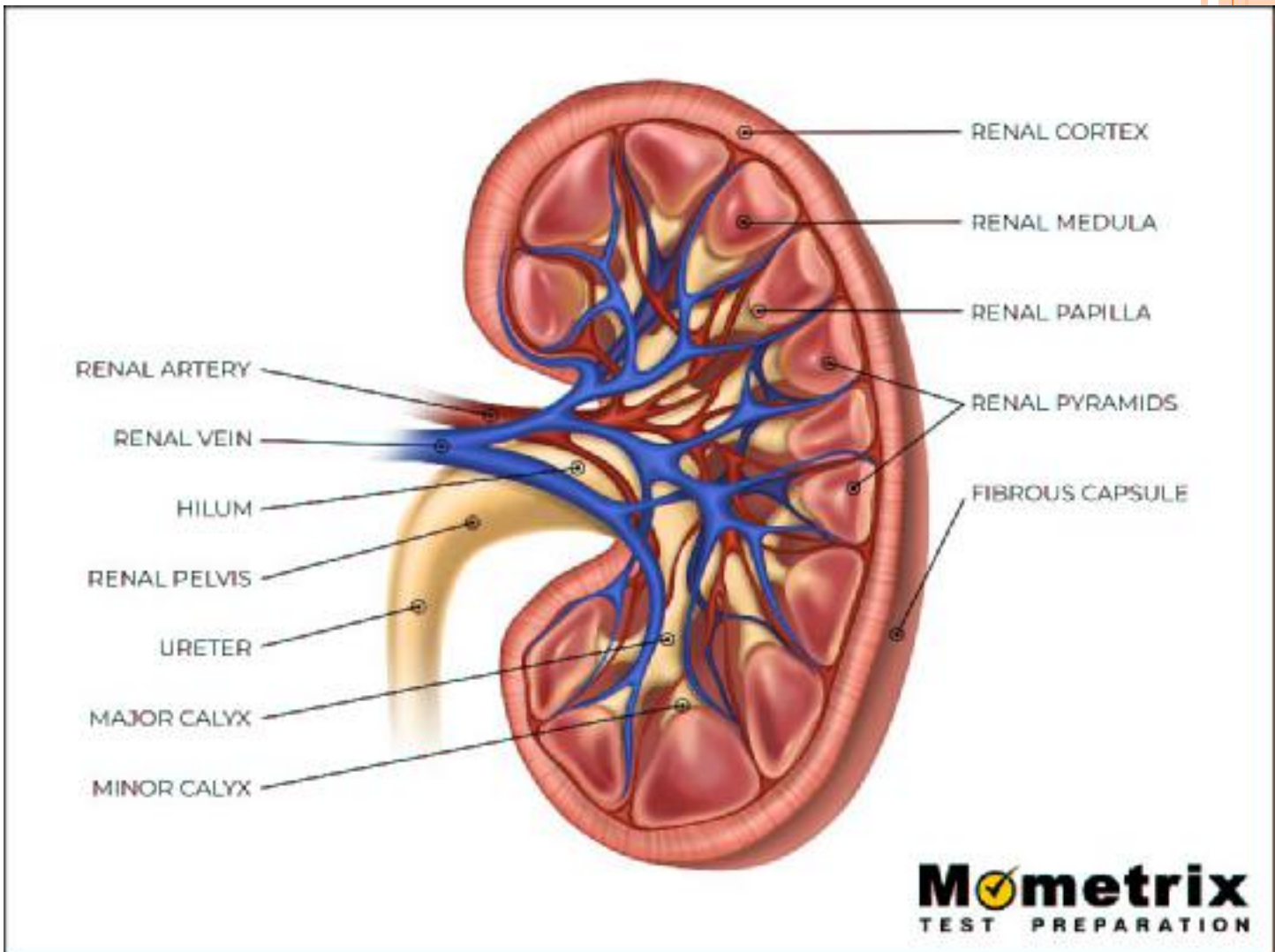


Histology lab- Urinary system

Rola Alwaheidi, MD

KIDNEY


RENAL CORTEX
RENAL MEDULA
RENAL PAPILLA
RENAL PYRAMIDS
FIBROUS CAPSULE
RENAL ARTERY
RENAL VEIN
HILUM
RENAL PELVIS
URETER
MAJOR CALYX
MINOR CALYX
Mometrix
TEST PREPARATION

Kidney

The kidney is a compound tubular gland formed of 1-2 million uriniferous tubules (structural unit of the kidney).

The renal tubules are held together by the renal interstitium formed mainly of a network of reticular fibers.

The uriniferous tubule is formed of:

A- Nephron

B- Collecting duct

Histological Structure of the Kidney

The kidney is a large compound tubular gland formed of:

1. Stroma:

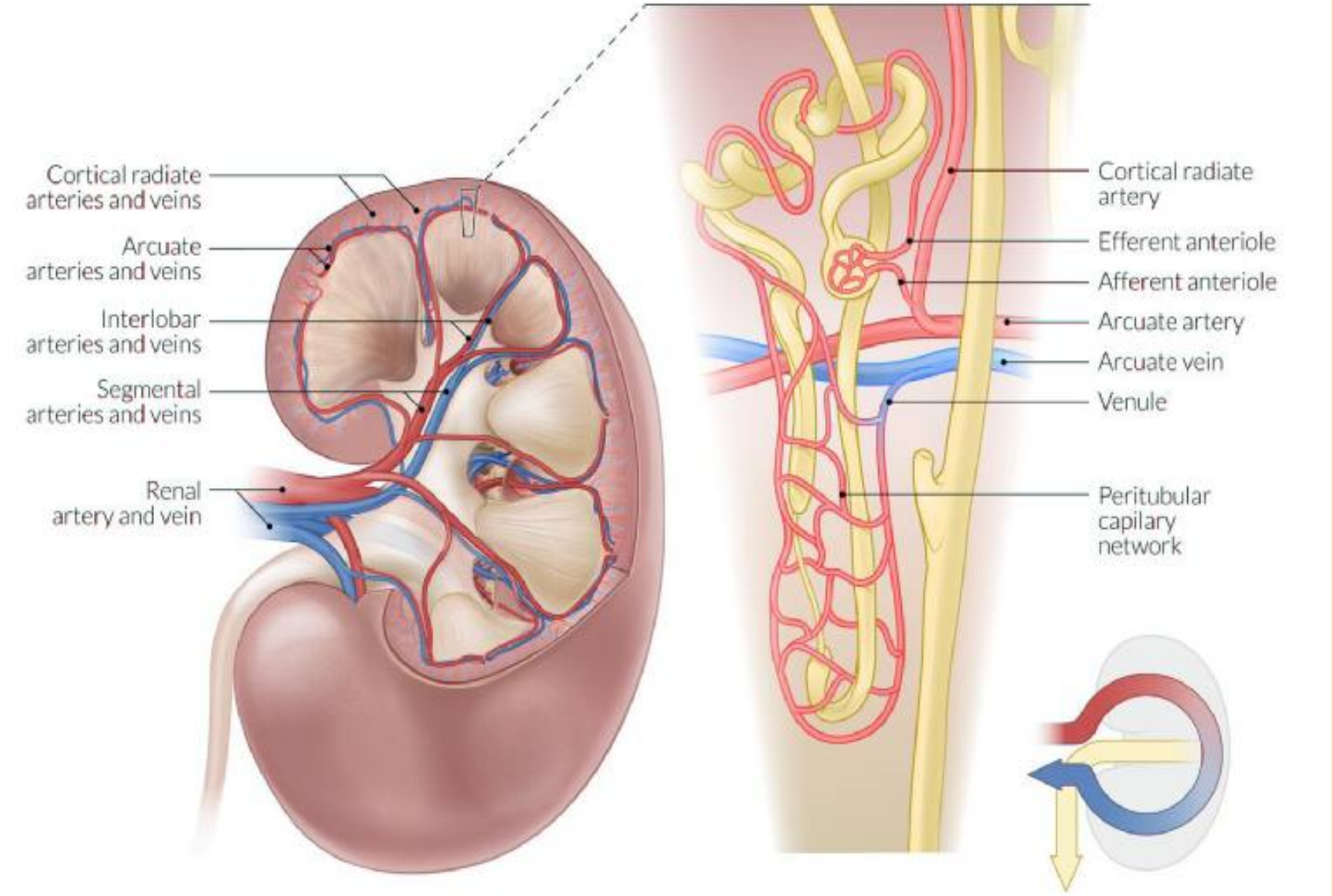
A- Capsule: Thin fibrous C.T., surrounded by adipose tissue.

B- Renal Interstitium:

2- Parenchyma:

A- Cortex

B- Medulla


Cortical radiate arteries and veins
Arcuate arteries and veins
Interlobar arteries and veins
Segmental arteries and veins
Renal artery and vein
Cortical radiate artery
Efferent anteriole
Afferent anteriole
Arcuate artery
Arcuate vein
Venule
Peritubular capilary network

The nephron consists of:

-Renal Corpuscle

-Proximal convoluted tubules PCT

-Loop of Henle

-Distal convoluted tubules DCT

-A connecting tubule

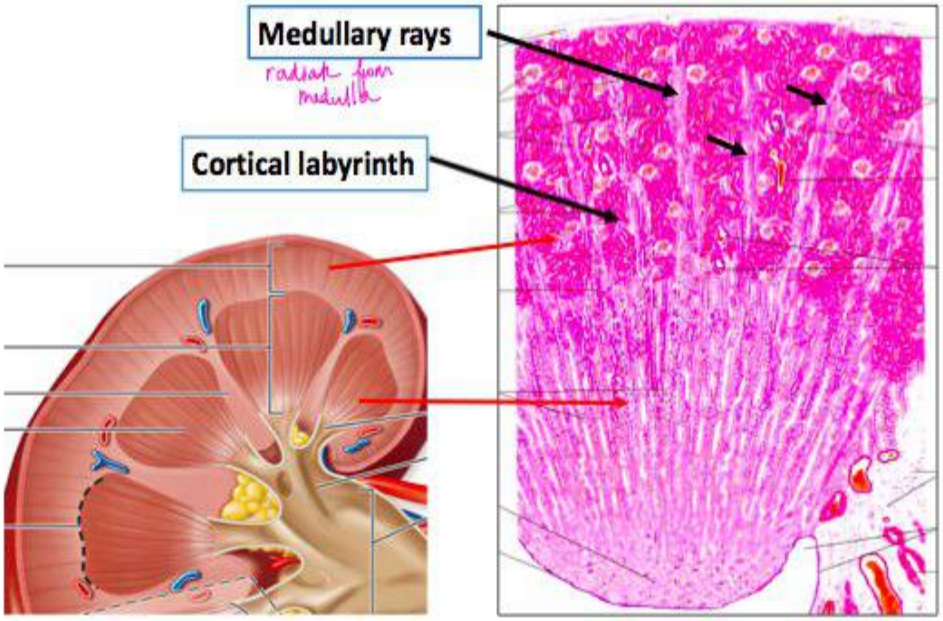
Histological Section of the KIDNEY

CORTEX

It is the dark outer layer

It has a granular appearance due to presence of renal corpuscles and the convoluted renal tubules.

Cortico-medullary architecture



The Renal cortex

It contains: renal corpuscle's, convoluted tubules, medullary rays and peritubular capillaries.

• It is formed of:

. Cortical Labyrinth: cortical tissue surrounding medullary rays (the parallel straight tubules of loop of Henle and collecting tubules in the cortex)

. Columns of Bertin: cortical tissue on either side of renal pyramids in the medulla

Medulla

It is the pale inner layer

It has a striated appearance due to the longitudinally arranged straight renal tubules, collecting ducts and the surrounding vessels (Each pyramid shows radial striations that are attributed to the presence of parallel straight tubules of loop of Henle, collecting tubules, ducts of Bellini and vasa rectae.)

The renal medulla

It is composed of 8-12 pyramids.:

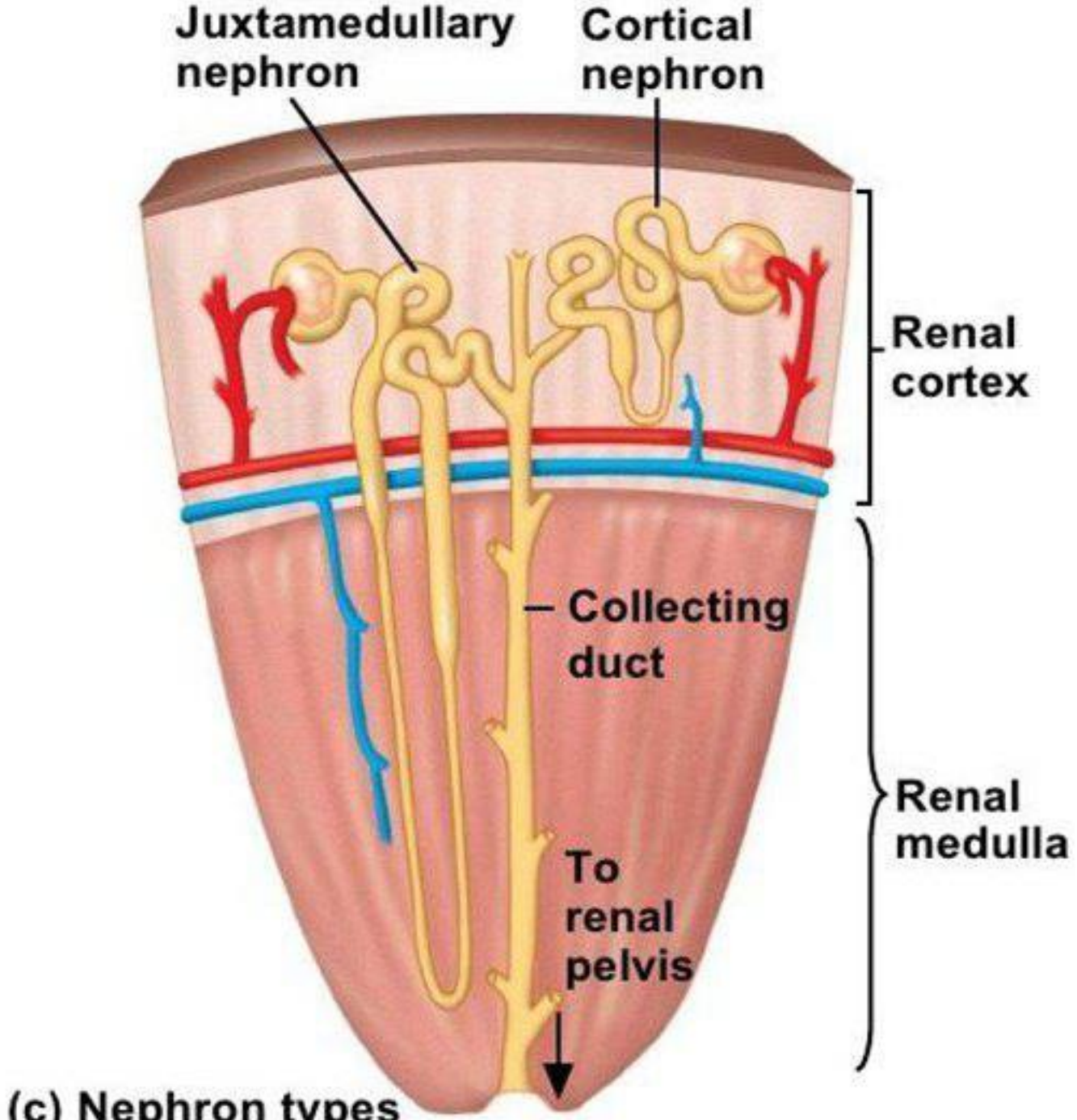
-Their bases form the corticomedullary junction

-Their apices (The renal papillae): protrude into the minor calyces.

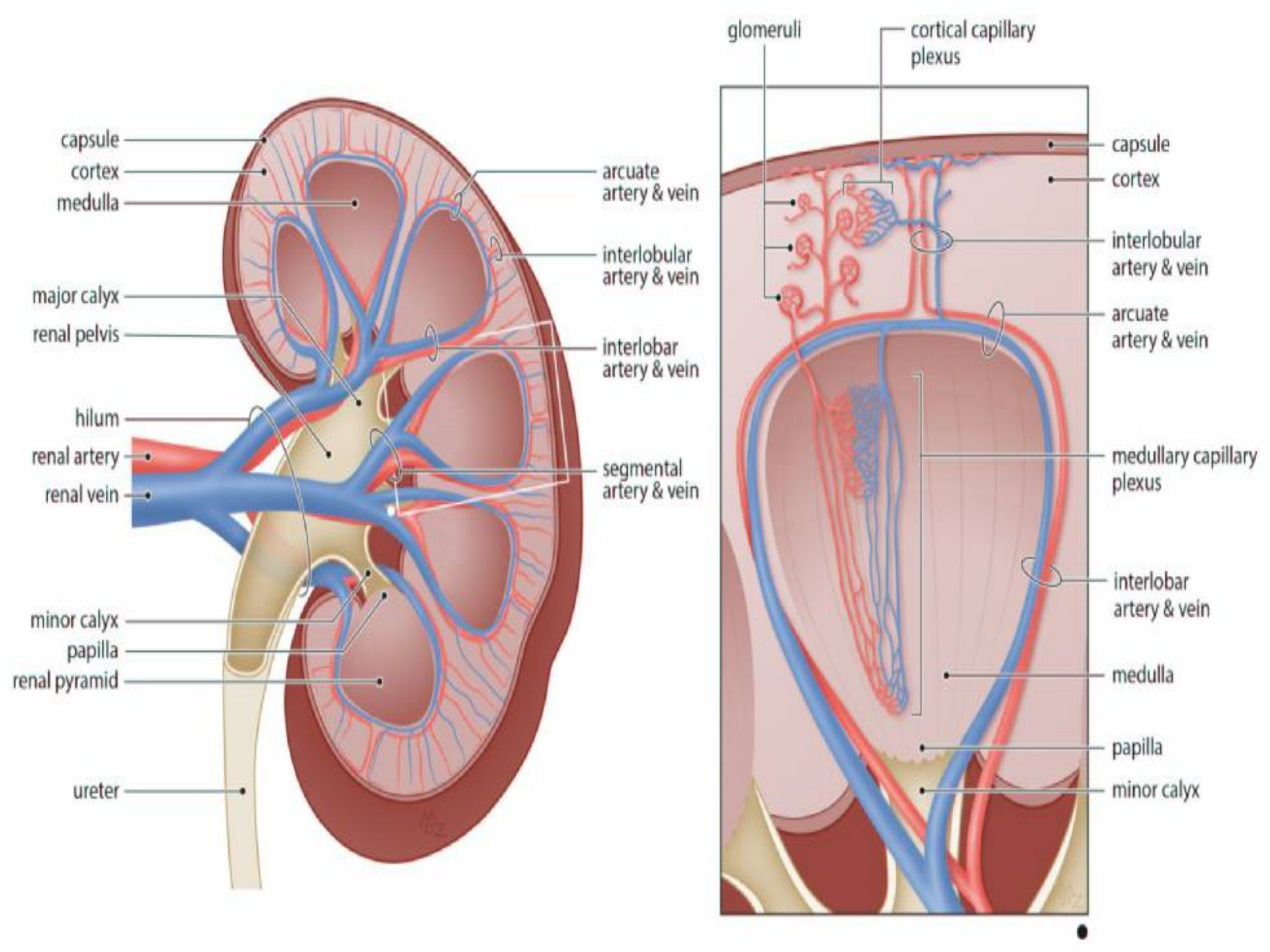
-The apex of the pyramid is perforated by 20 or more openings of collecting ducts (ducts of Bellini).

-The tip of the papilla is perforated by the openings of the larger collecting ducts and so, it is called The Area Cribrosa

-The apex projects into a minor calyx. 3-4 minor calyces join to form a major calyx which empty in renal pelvis (the expanded upper end of the ureter)



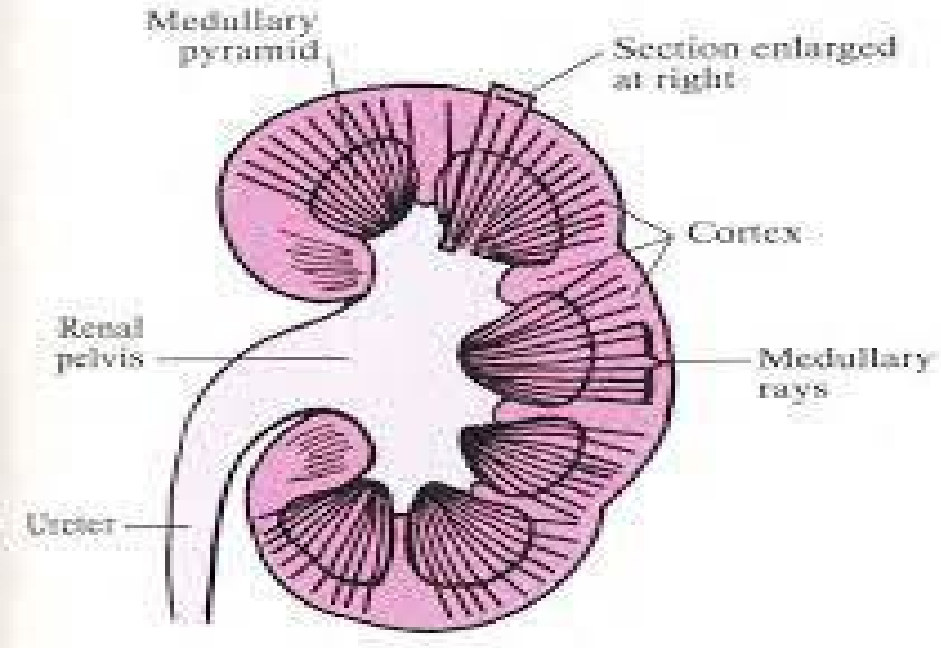
(c) Nephron types

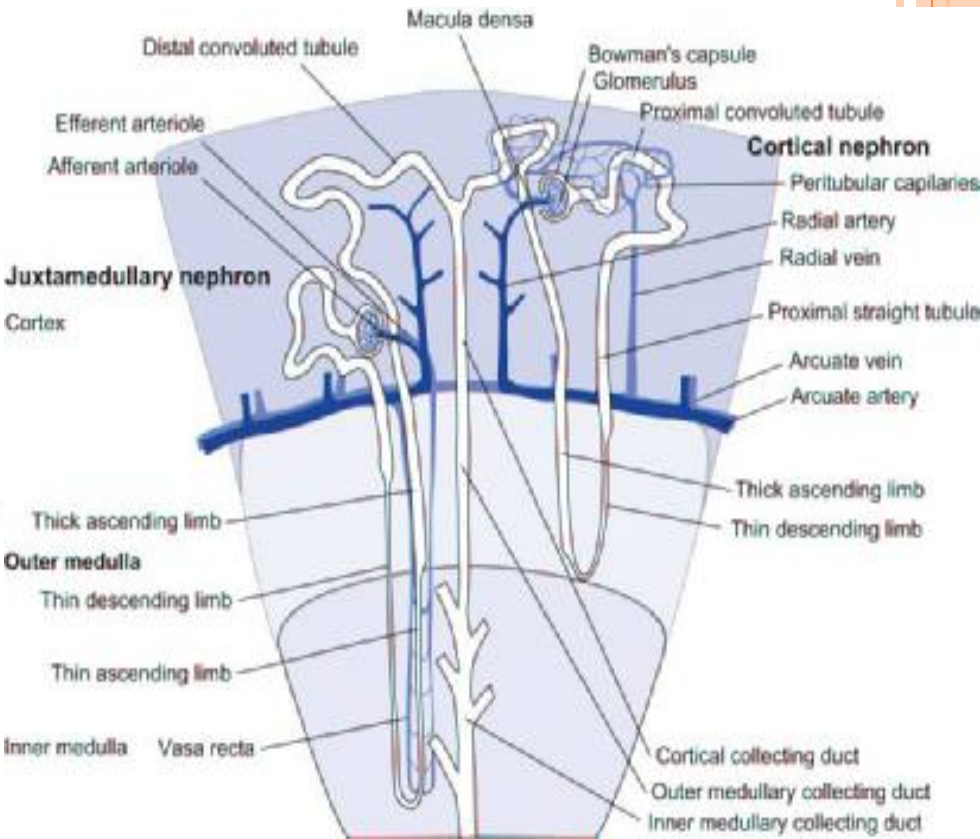

capsule
cortex
medulla
major calyx
renal pelvis
hilum
renal artery
renal vein
minor calyx
papilla
renal pyramid
ureter
arcuate artery & vein
interlobular artery & vein
interlobar artery & vein
segmental artery & vein
glomeruli
cortical capillary plexus
capsule
cortex
interlobular artery & vein
arcuate artery & vein
medullary capillary plexus
interlobar artery & vein
medulla
papilla
minor calyx

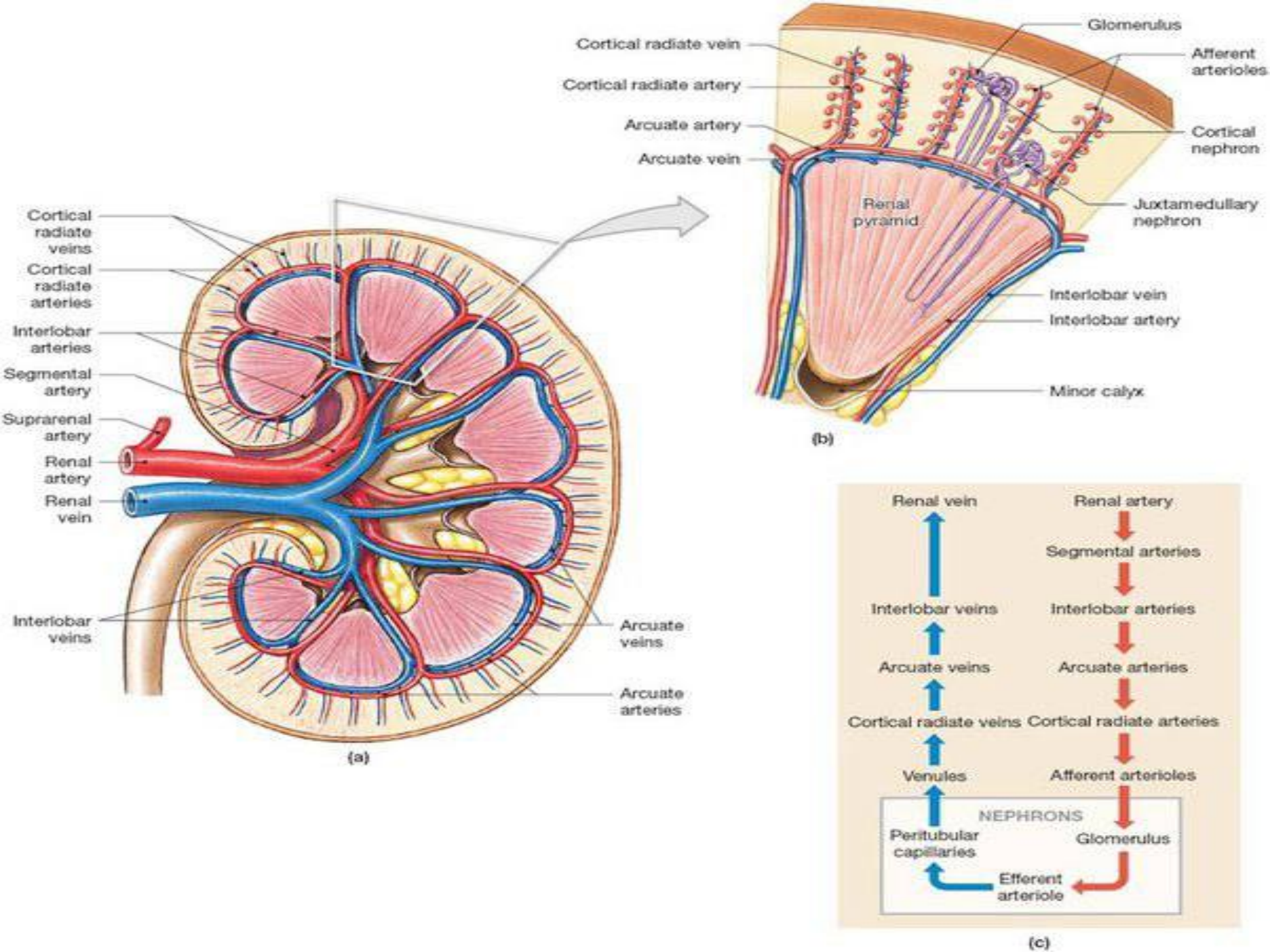
Important Terms

Medullary Rays

Striations extend from the medulla into the cortex, represent straight segments of renal tubules + cortical collecting ducts

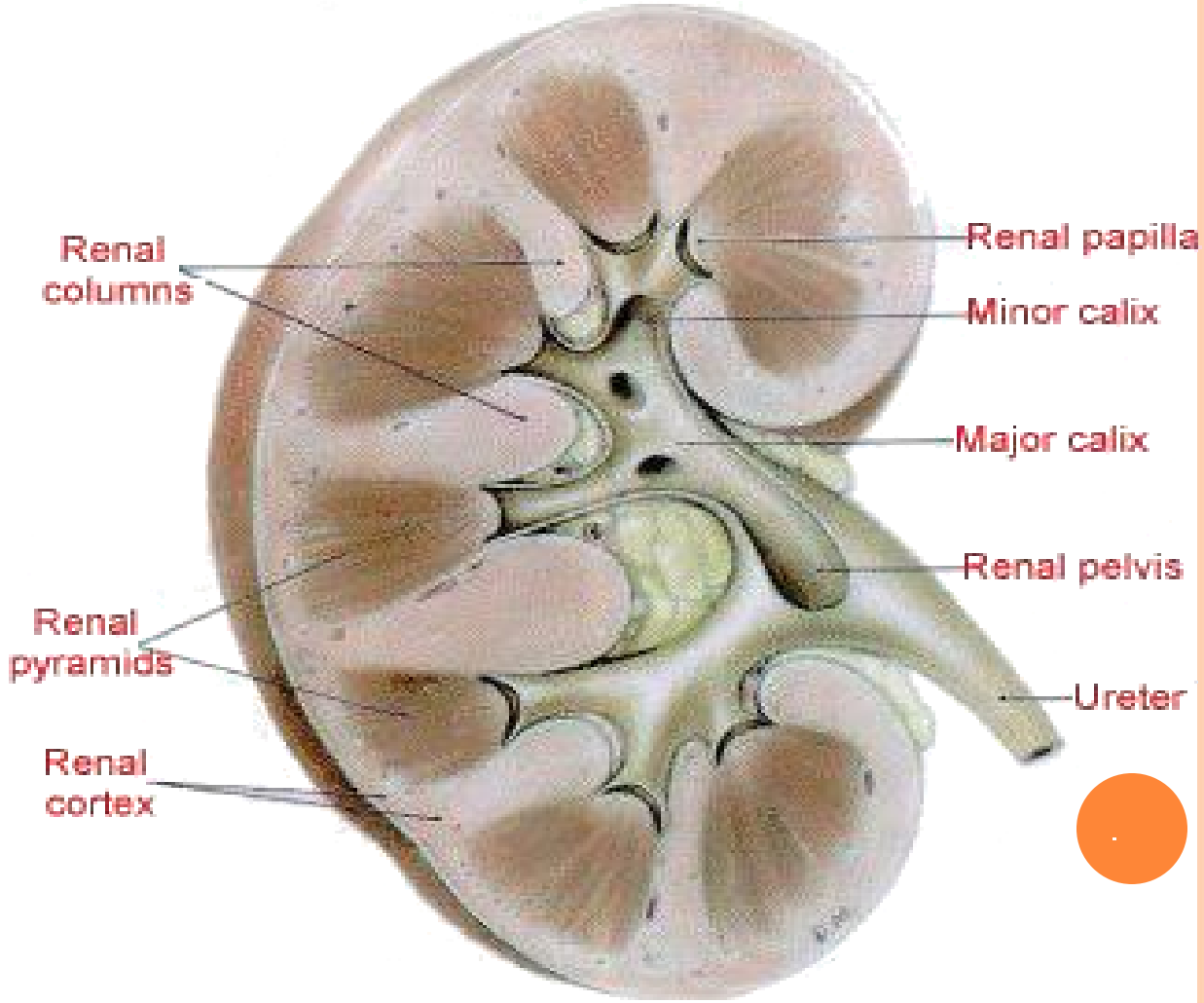





Cortical radiate veins
Cortical radiate arteries
Interlobar arteries
Segmental artery
Suprarenal artery
Renal artery
Renal vein
Interlobar veins
Arcuate veins
Arcuate arteries
(a)
Cortical radiate vein
Cortical radiate artery
Arcuate artery
Arcuate vein
Glomerulus
Afferent arterioles
Cortical nephron
Juxtamedullary nephron
Renal pyramid
Interlobar vein
Interlobar artery
Minor calyx
(b)
Renal vein
Renal artery
Segmental arteries
Interlobar veins
Interlobar arteries
Arcuate veins
Arcuate arteries
Cortical radiate veins
Cortical radiate arteries
Venules
Afferent arterioles
NEPHRONS
Peritubular capillaries
Glomerulus
Efferent arteriole
(c)

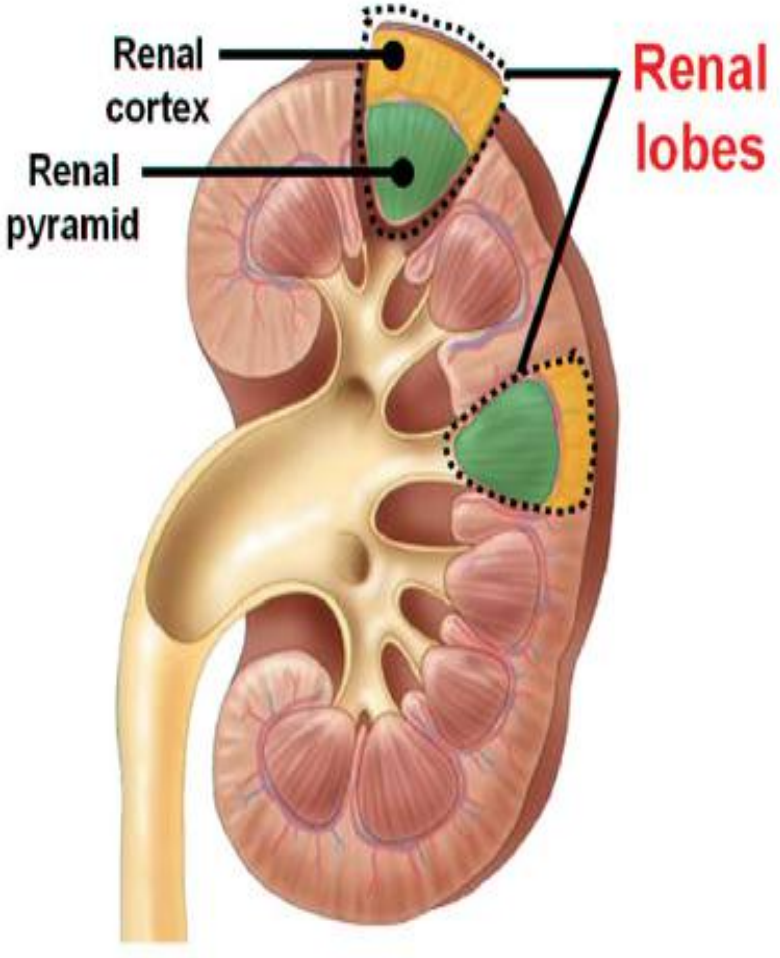
Renal Columns

Extension from cortex into the medulla between the medullary pyramids



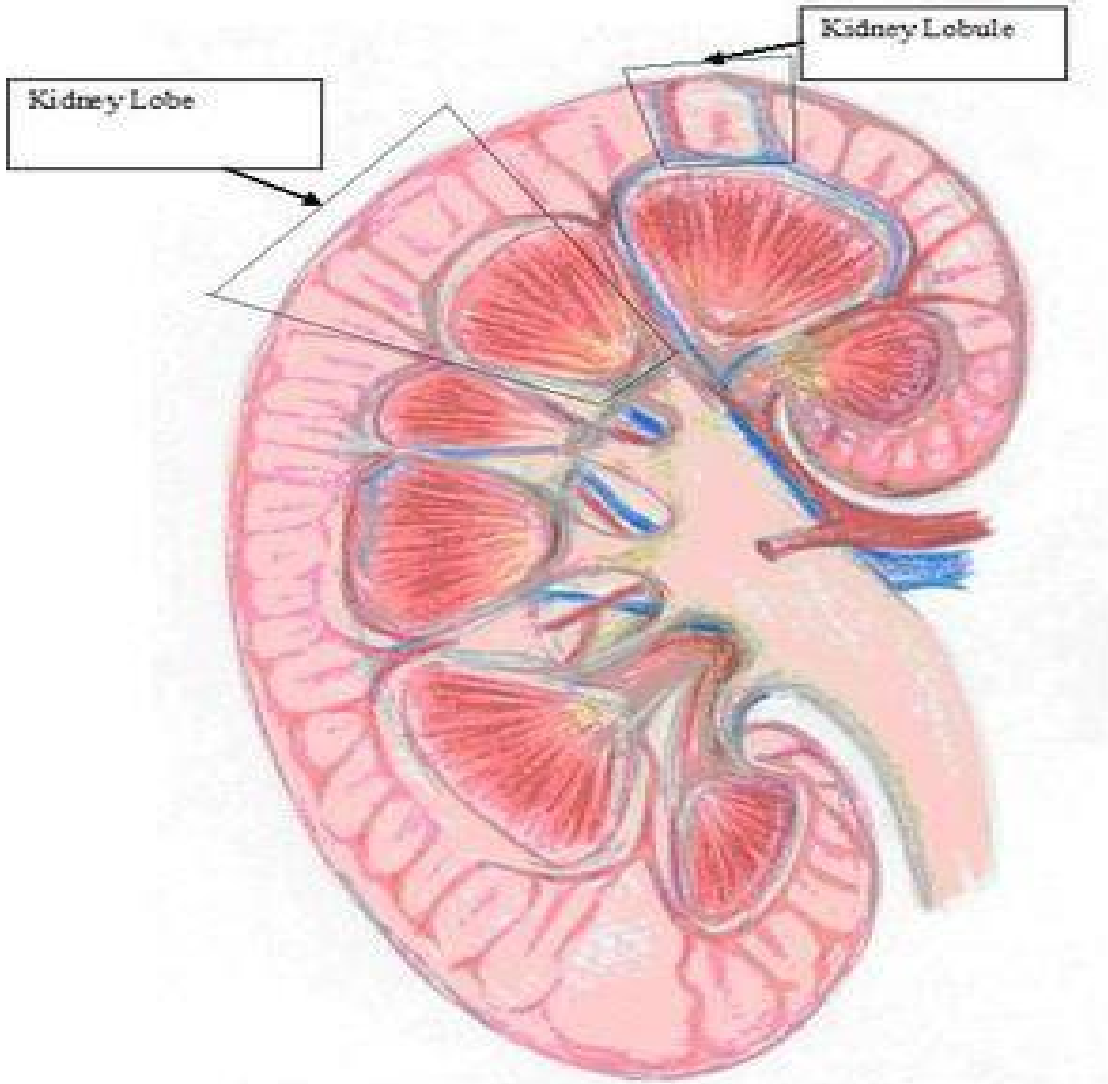
Renal Lobe

Medullary pyramid + mass of cortical tissue surrounding it at the base and sides (1/2 of adjacent renal columns)



Renal lobule

Medullary ray + mass of cortical tissue surrounding it



URINARY SYSTEM

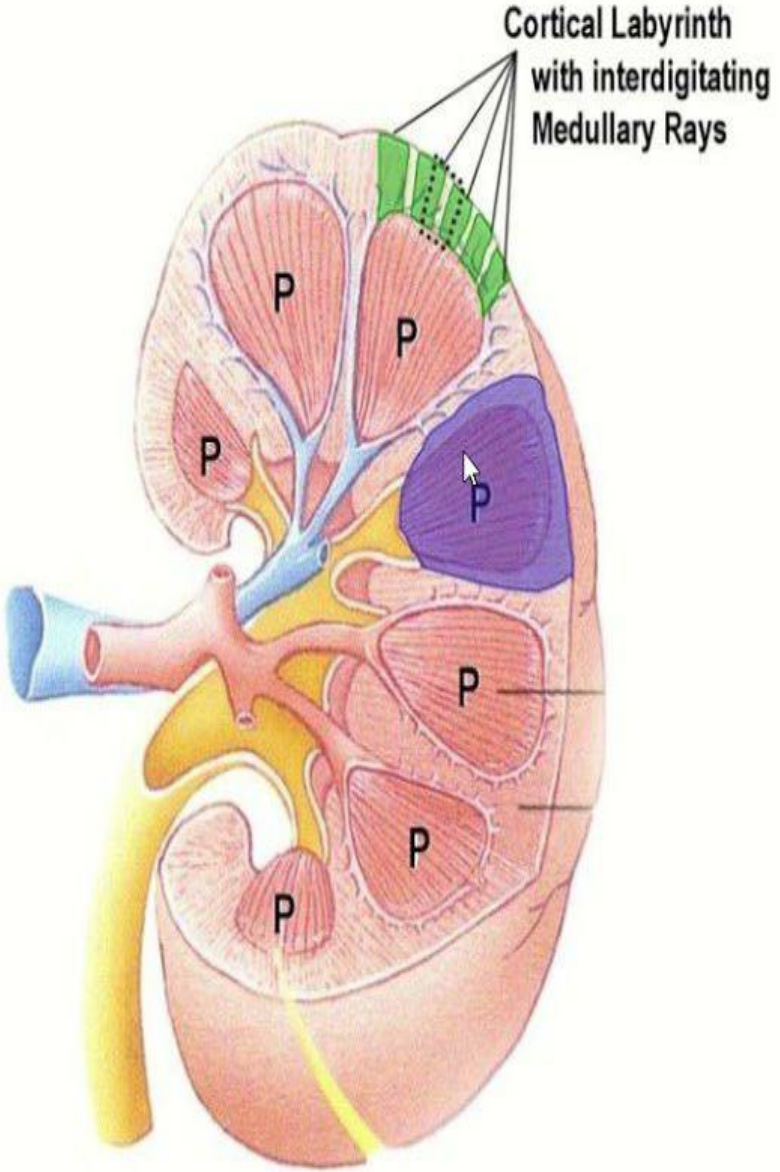
- KIDNEY (ORGANIZATION)

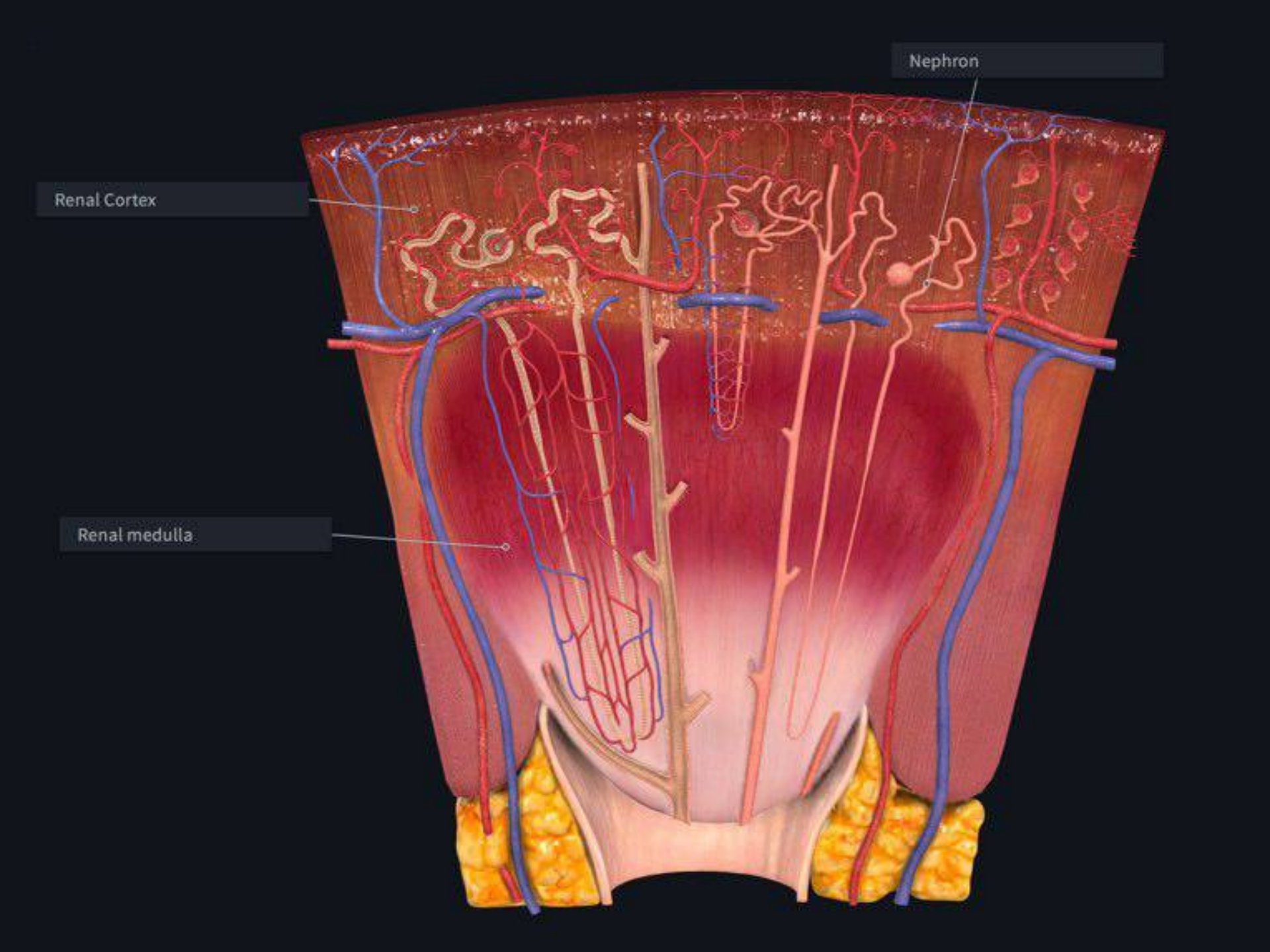
RENAL LOBE

- a single pyramid with its associated overlying cortex

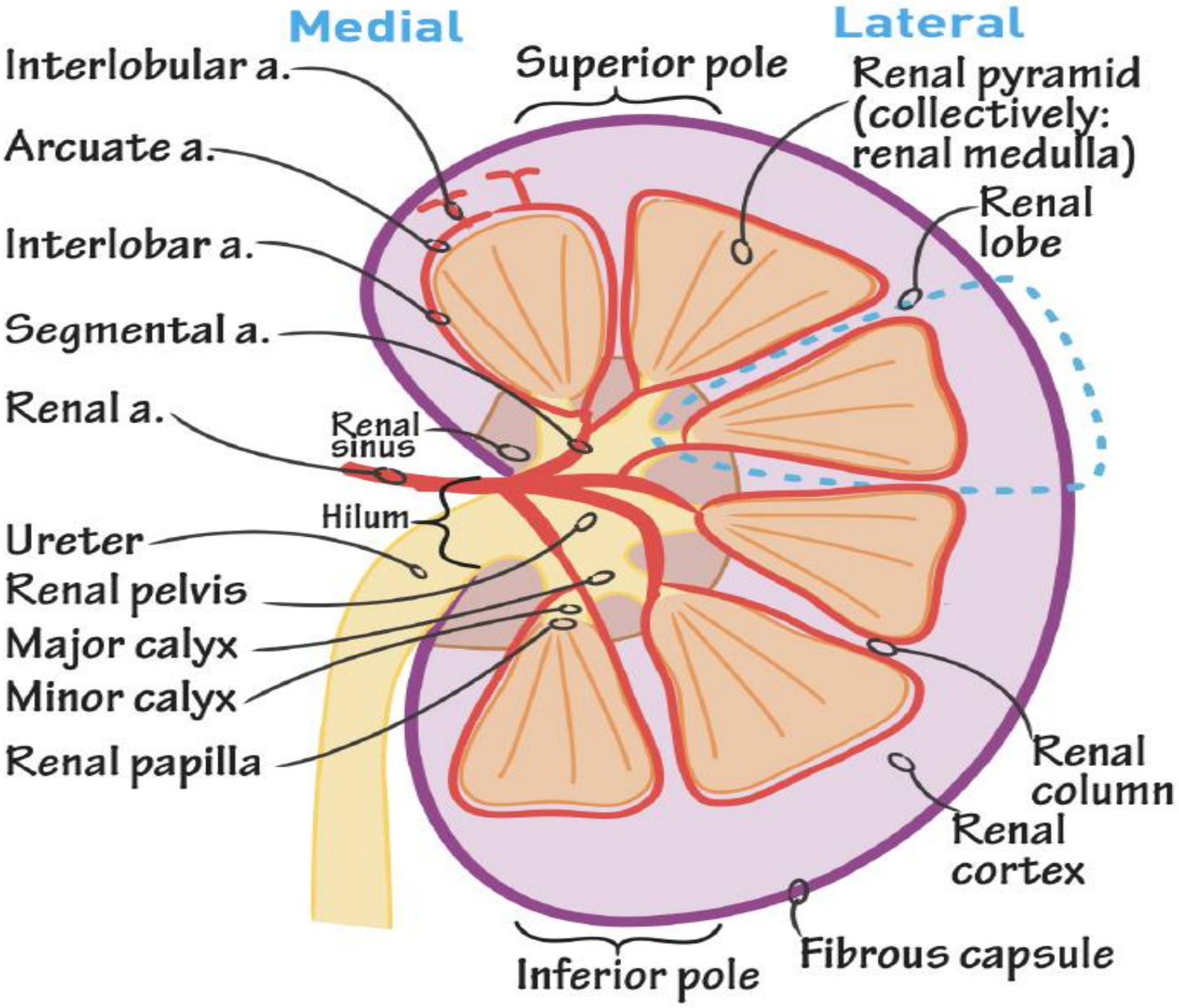
RENAL LOBULE

- defined within cortex and involves a single medullary ray (central axis of lobule) with adjacent adjacent cortical labyrinth
- defined as a functional unit that consists of a collecting duct and all the nephrons that it drains




Nephron
Renal Cortex
Renal medulla

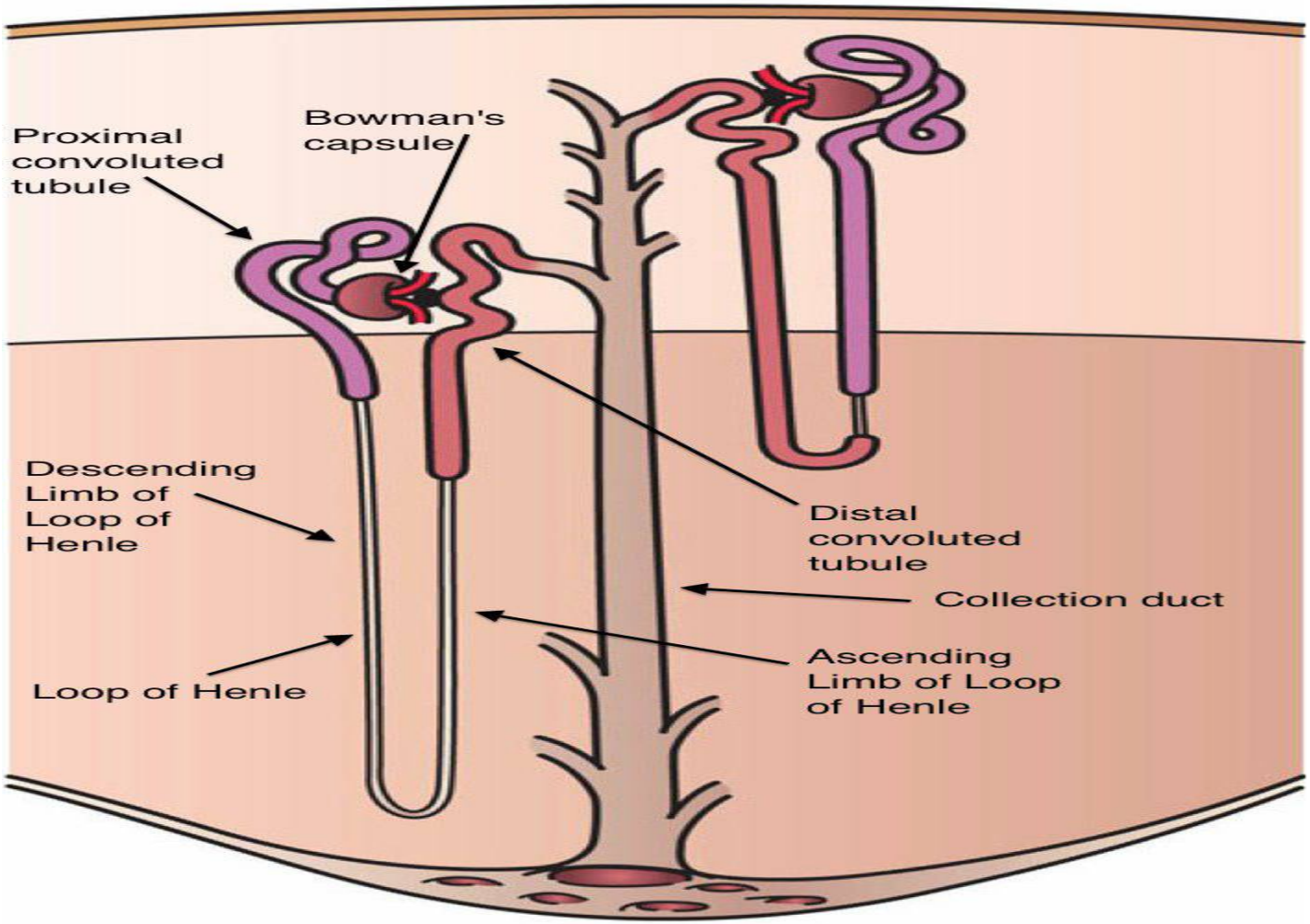
KIDNEY
(Left; Coronal Section)



Types of nephrons

Cortical Nephron

Juxtamedullary Nephron

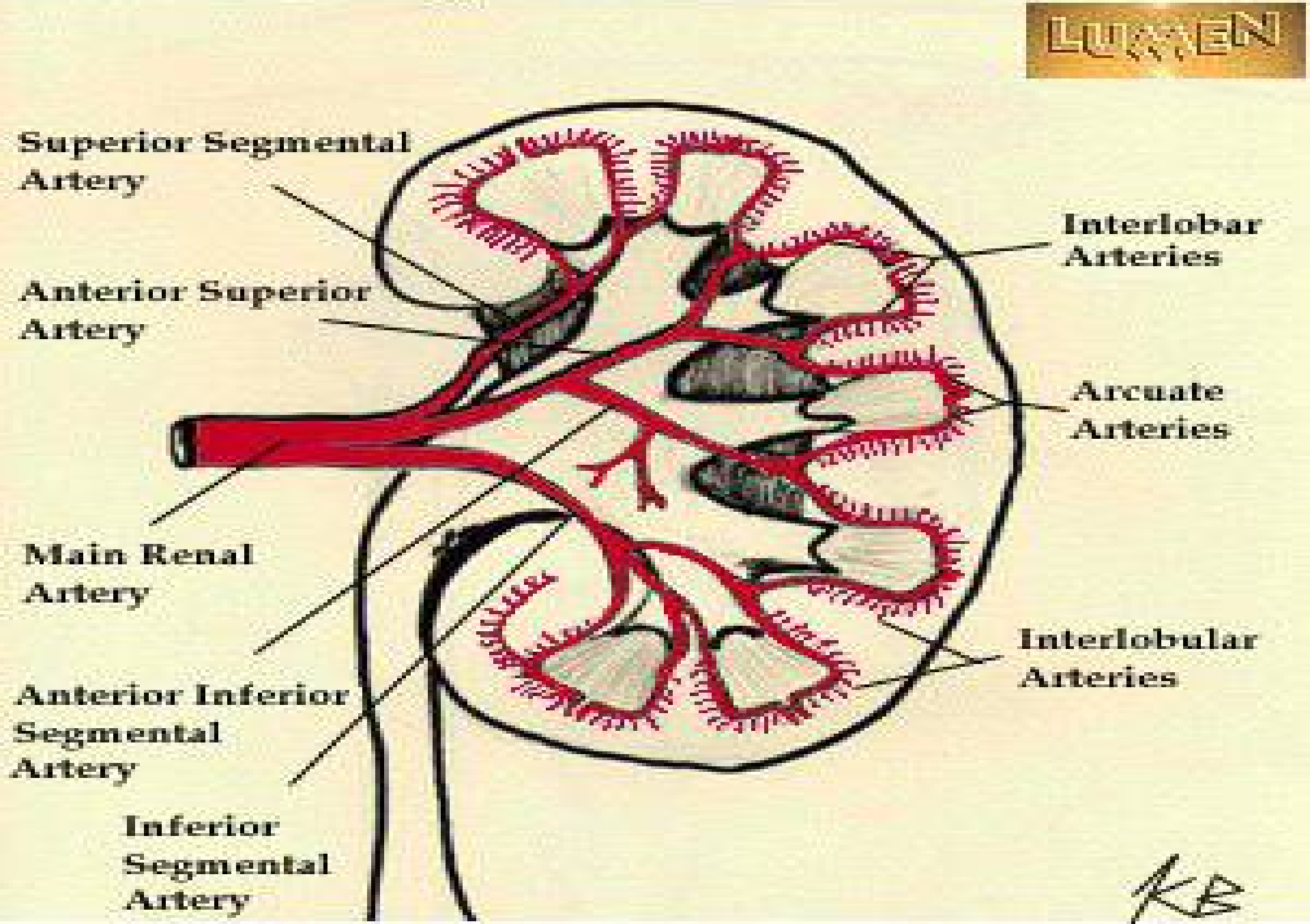


Cortical nephrons	Juxtamedullary nephrons
• About 85% of the nephrons are of such type.	• About 15% of the nephrons are of such type.
• The Renal Corpuscles of these nephrons are present in outer cortex.	• The Renal Corpuscles of these nephrons are present in the inner cortex.
• The Henle's loop in these nephrons is shorter and limited to upper medulla only.	• The Henle's loop in these nephrons is longer, and elongated upto deep Medulla.
• Vasa recta is lacking.	• Vasa recta is well developed
• Mainly related with excretion.	• Mainly related with Osmoregulation.

Blood Supply of the kidney

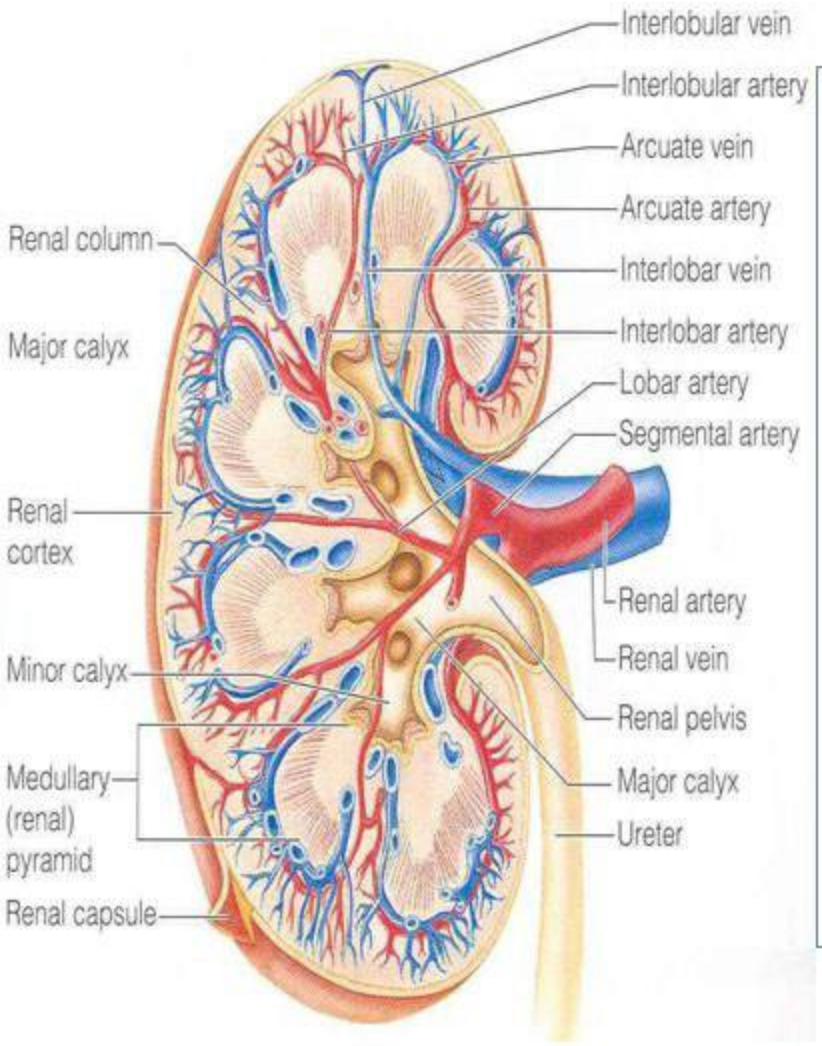
The **renal artery** enters the renal hilum >>>> **interlobar arteries** run between renal pyramids >>>> the **arcuate arteries** at the corticomedullary junctions, follow an arched course along the bases of the pyramids >>>> **interlobular arteries** >>>> the **afferent arteriole** >>>> renal corpuscles >>>> **glomerular capillaries** (first capillary network) >>>> the **efferent arteriole** >>>> a second capillary network

Histology Lab Part 16: Slide 47



Blood Supply

- Abdominal aorta
- Renal artery
- Segmental arteries
- lobar arteries
- Interlobar arteries
- Arcuate arteries
- Interlobular arteries
- **afferent glomerular arterioles**



- Inferior vena cava
- Renal vein
- Interlobar veins
- Arcuate veins
- Interlobular veins

The arrangement of the second capillary network differs according to the position of renal corpuscle:

-In cortical nephrons (sub capsular corpuscle):

Efferent arterioles give rise to the peritubular cortical capillaries that surround the nearby renal tubules

-In the juxtamedullary corpuscles:

Efferent arterioles give rise to the vasa recta (straight capillary loops run close and parallel to the loop of Henle and the collecting ducts).

The Venous Drainage

Follows the same course as the corresponding arteries (the venous ascending limbs of vasa recta drain directly into the arcuate veins).

Function of vasa recta

Together with loop of Henle : counter current multiplier mechanism

Function: concentration of urine

-Loop of Henle: create hyperosmolar medullary interstitium

-Vasa recta: maintain this hyperosmolarity

Urine formation Preview

Glomerular filtration

Creates a plasma like filtrate of the blood

Tubular reabsorption

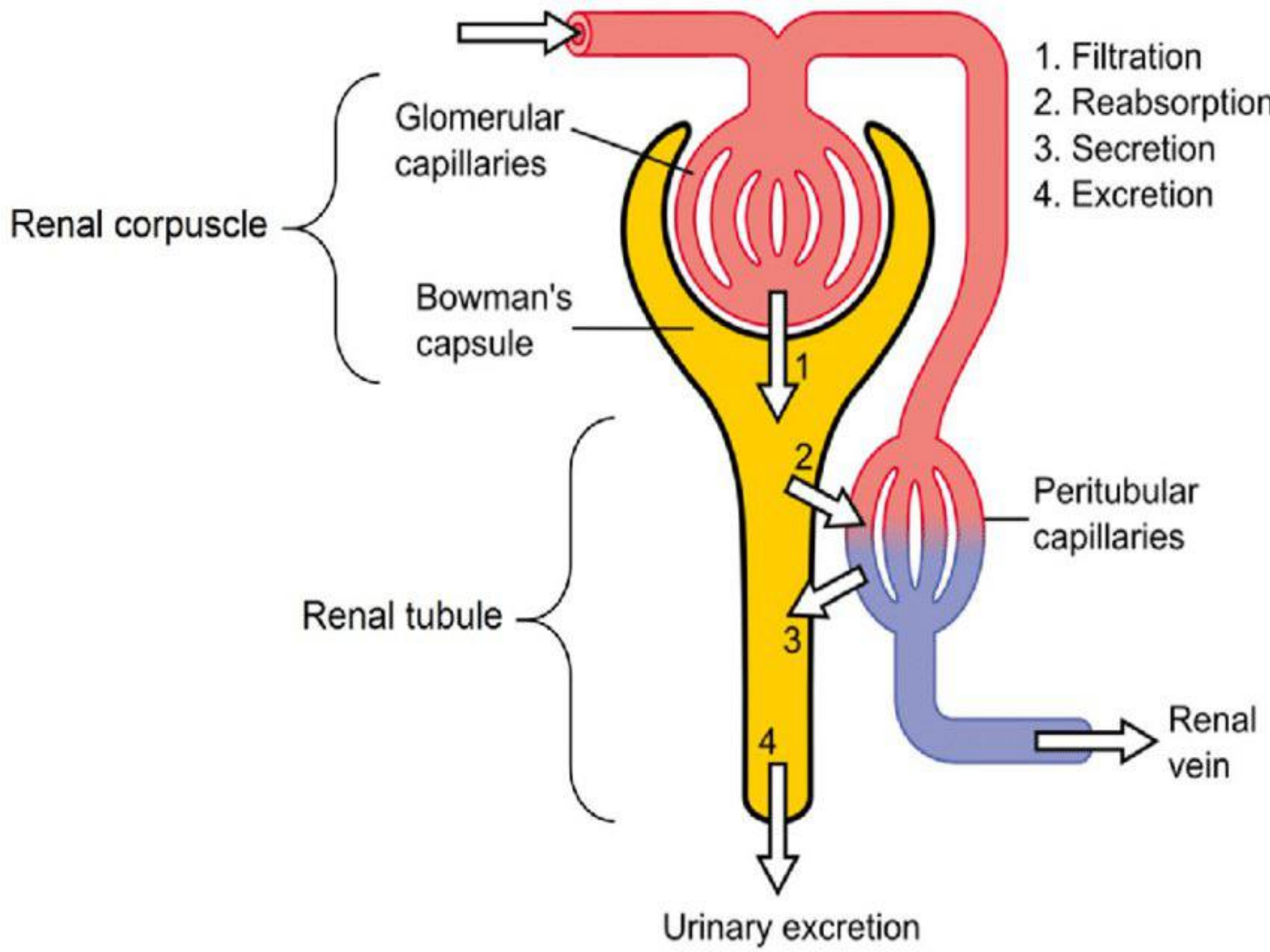
Removes useful solutes from the filtrate, returns them to the blood

Tubular secretion

Removes additional wastes from the blood, adds them to the filtrate

Water conservation

Removes water from the urine and returns it to blood, concentrates wastes


1. Filtration
2. Reabsorption
3. Secretion
4. Excretion
Glomerular capillaries
Renal corpuscle
Bowman's capsule
1
2
Peritubular capillaries
Renal tubule
3
4
Renal vein
Urinary excretion

1- Renal Corpuscle (Malpighian corpuscle)

- Located in the renal cortex
- Formed of a tuft of capillaries (the glomerulus) enclosed by the Bowman capsule
  - The glomerulus forms the vascular pole of the corpuscle
  - The Bowman capsule forms the urinary pole of the corpuscle
- Within the Bowman capsule is the Bowman space, which is continuous with the renal tubule
- The Bowman capsule is separated from the capillaries of the glomerulus by the glomerular filtration barrier

Components of Renal corpuscle

- Glomerulus: a tuft of capillaries within the Bowman capsule formed of three parts
  - Afferent arterioles: the blood vessel that enters and supplies the glomerulus of the kidney for filtration
  - Branch into anastomosing glomerular capillaries, between capillaries, lie intraglomerular mesangial cells (contractile cells capable of phagocytosis and lysosomal degradation)
  - Efferent arterioles: the blood vessel that carries previously filtered blood away from the glomerulus (drains from the glomerulus)

Bowman capsule: cup-like sac that surrounds the glomerular capillaries

- Outer (parietal) surface: simple squamous epithelium
- Inner (visceral) surface: podocytes
- The space between the parietal and visceral surfaces, which is continuous with the proximal convoluted tubule , is referred to as the Bowman space.

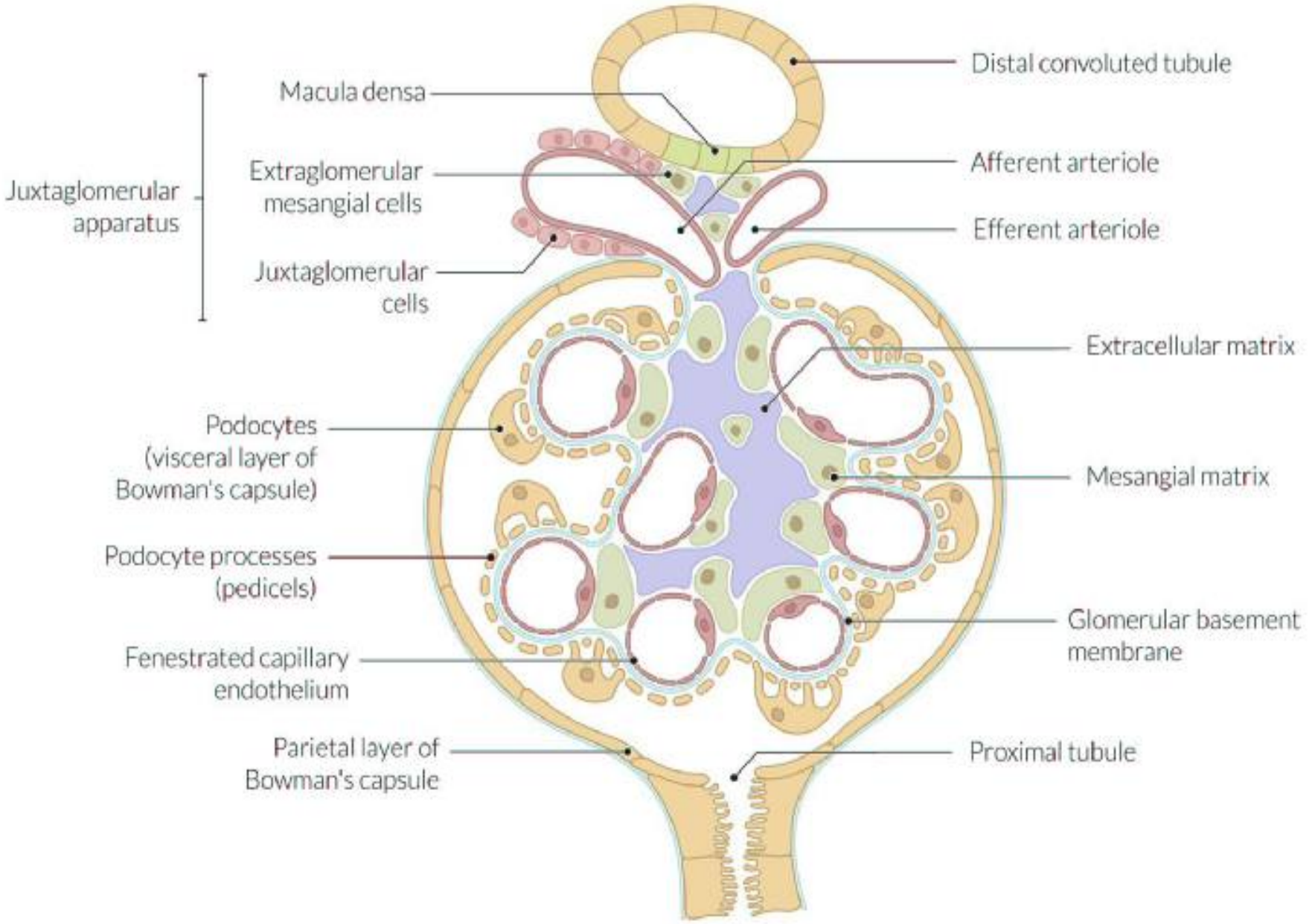
Mesangium: It is the connective tissue filling the interstitial spaces between the glomerular capillaries at the surfaces that are not covered by the podocyte.

Components:

A) The mesangial matrix
B) The intra glomerular mesangial cells

Function:

A) Support the glomerular capillary walls where podocytes are lacking
B) Continuous turnover of glomerular basement membrane by phagocytosis of the filtration residues (its renewal is done by podocytes and glomerular endothelial cells).


Distal convoluted tubule
Macula densa
Juxtaglomerular apparatus
Extraglomerular mesangial cells
Afferent arteriole
Efferent arteriole
Juxtaglomerular cells
Extracellular matrix
Podocytes (visceral layer of Bowman's capsule)
Mesangial matrix
Podocyte processes (pedicels)
Glomerular basement membrane
Fenestrated capillary endothelium
Parietal layer of Bowman's capsule
Proximal tubule

Function

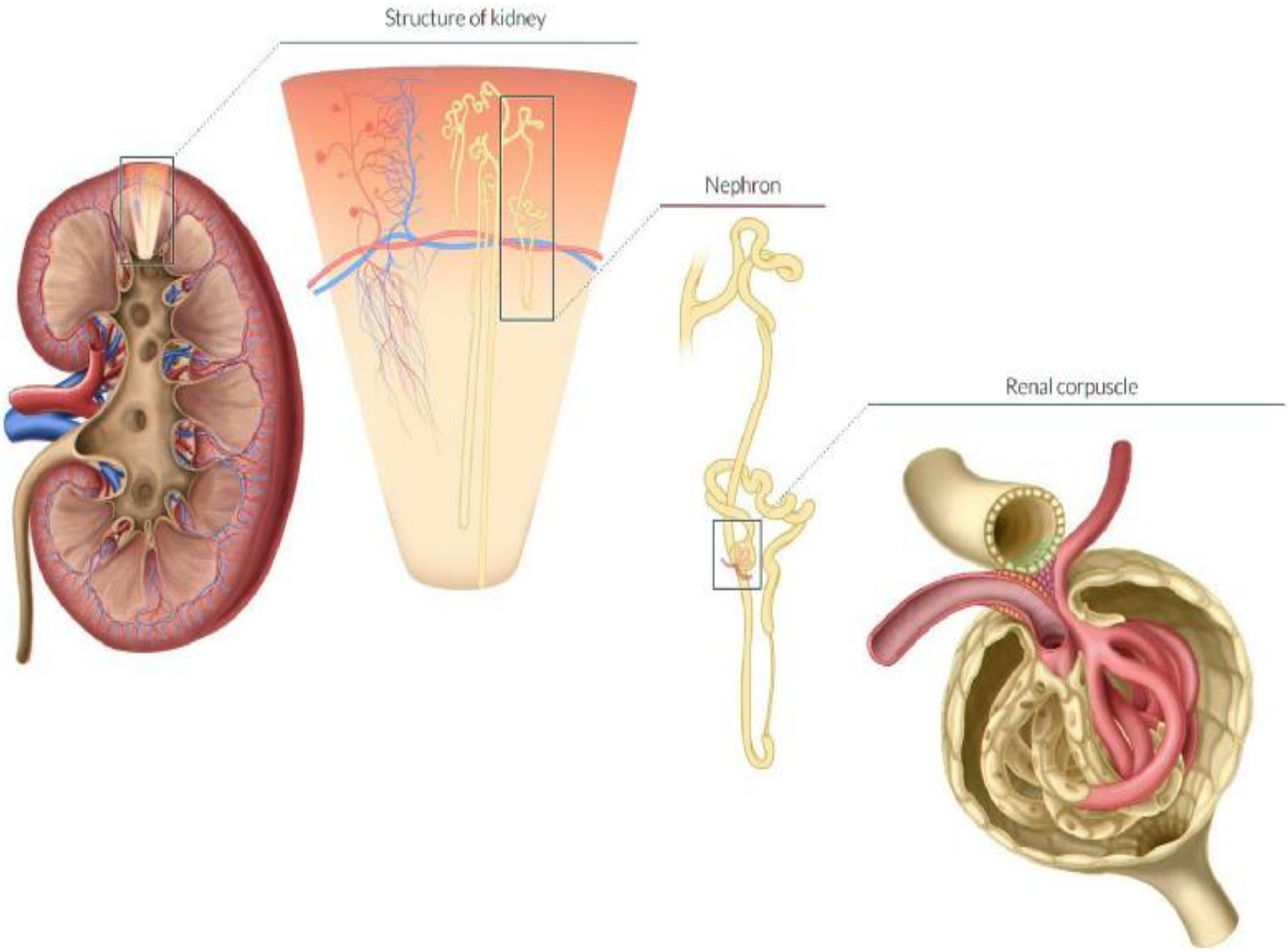
filtration of blood across the glomerular filtration barrier, forming ultra filtrate within the Bowman space

The glomerular filtration barrier separates the blood within the glomerular capillaries from the ultra filtrate in the Bowman space.

Water, electrolytes, and other small molecules cross the filtration barrier to form the ultra filtrate.

Cells and large or negatively-charged molecules, e.g., proteins, cannot cross the filtration barrier and remain within the blood (size and charge selectivity).

The glomerular filtration barrier is composed of three layers: the fenestrated glomerular capillary endothelium, the glomerular basement membrane, and the podocyte layer.

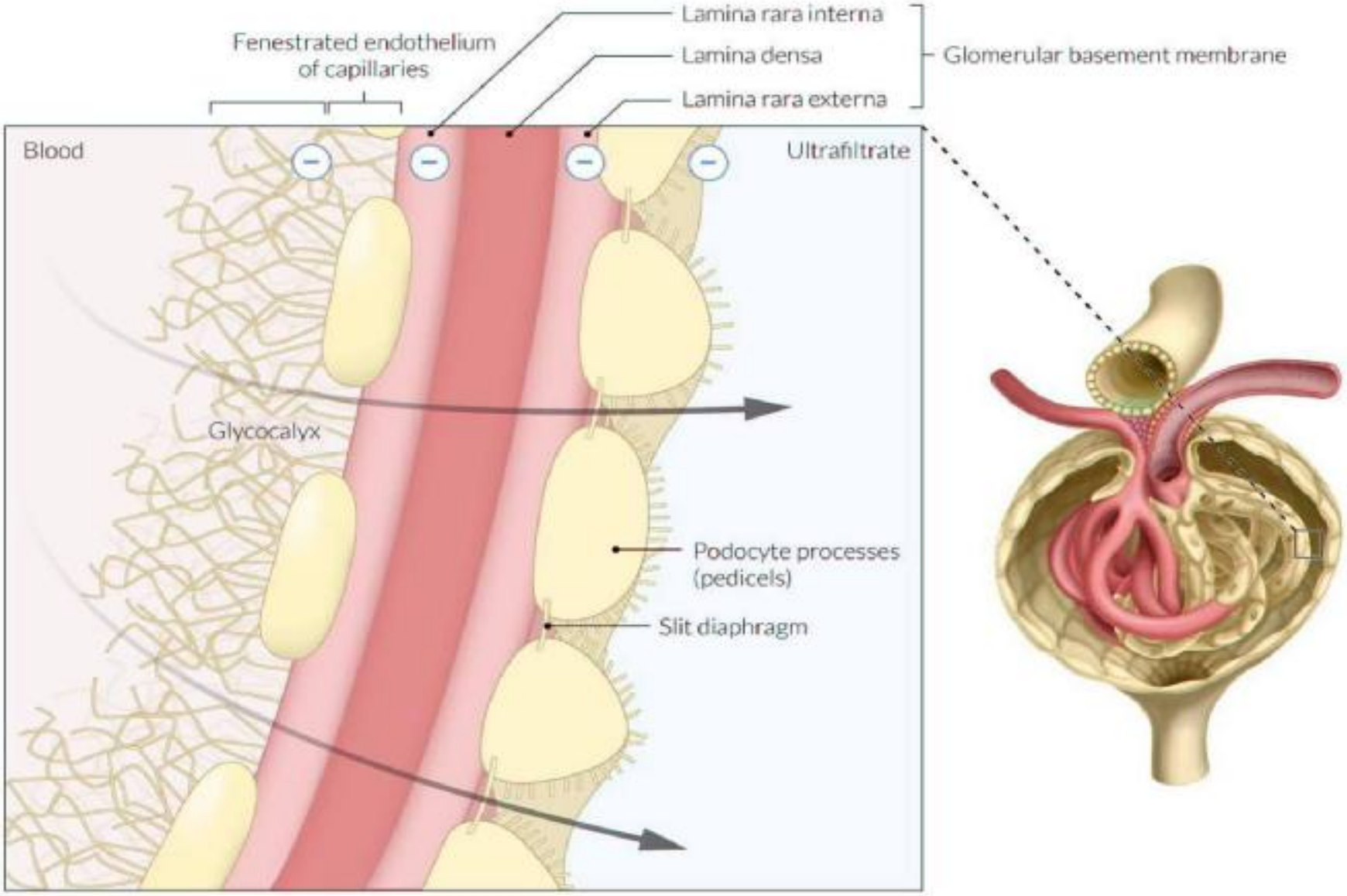

Structure of kidney
Nephron
Renal corpuscle

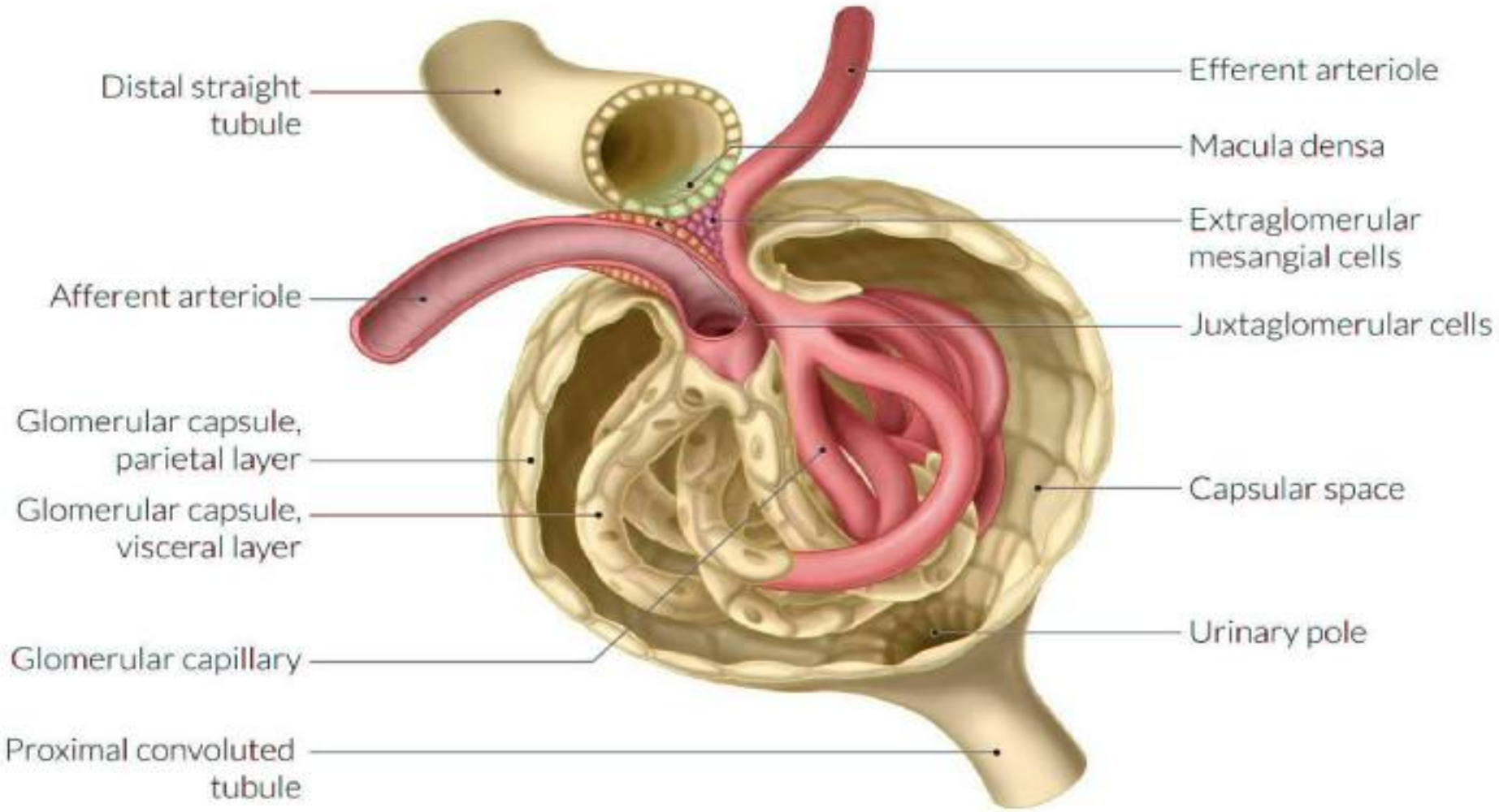
Layers of the glomerular filtration barrier

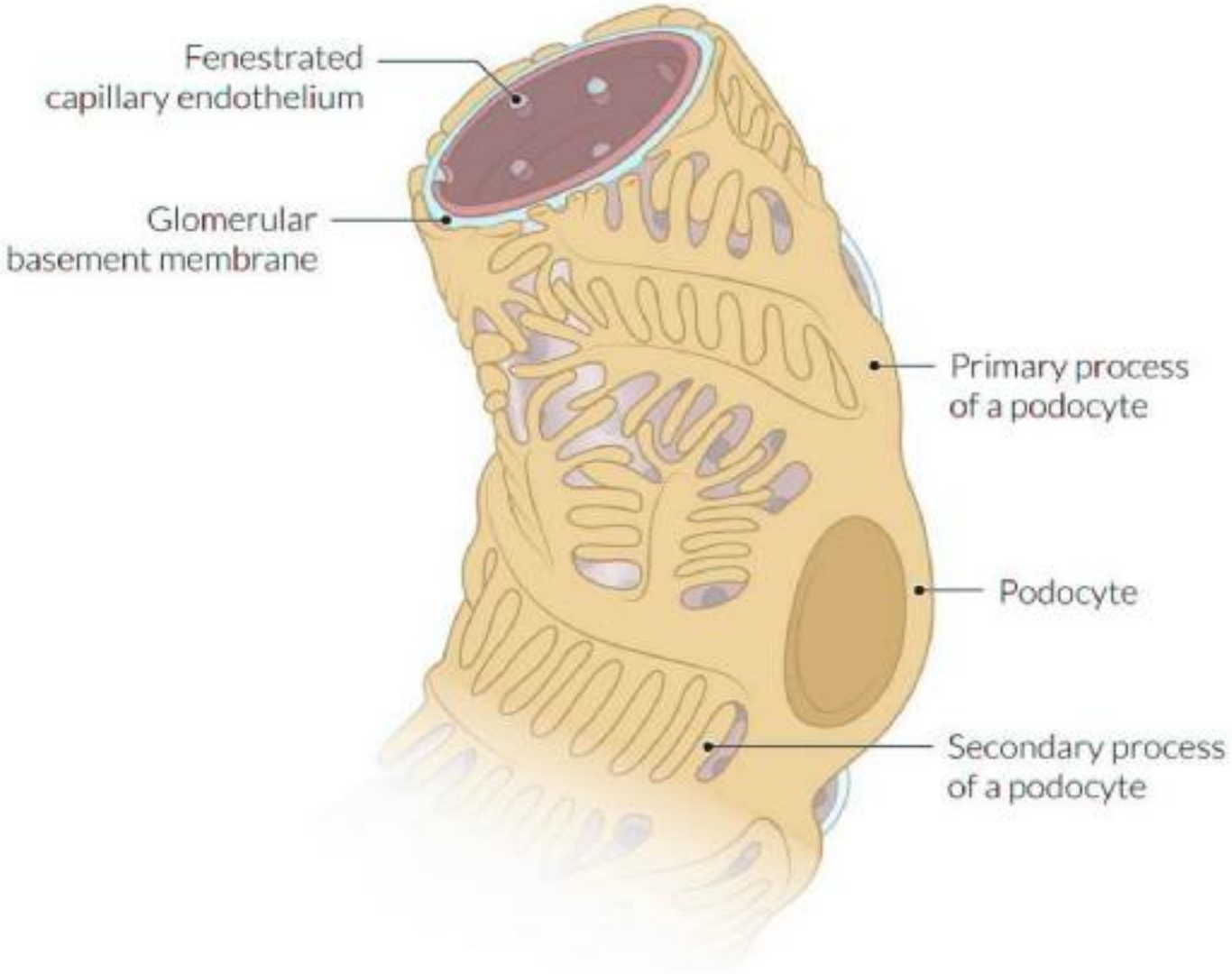
Fenestrated glomerular capillary endothelium	Porous capillary endothelium (fenestrated endothelium)
Glomerular basement membrane (GBM)	Consists of 3 layers Lamina rara interna: covers the endothelium and contains heparan sulfate Lamina densa: consists of type IV collagen and laminin Lamina rara externa: covers podocytes and contains heparan sulfate
Podocytes	Form the visceral epithelial layer of the Bowman capsule Foot processes surround the glomerular capillaries and leave filtration slits (slit diaphragms)

Negatively charged glycoproteins (e.g., with heparan sulfate on the GBM) prevent the entry of negatively charged molecules (e.g., albumin).

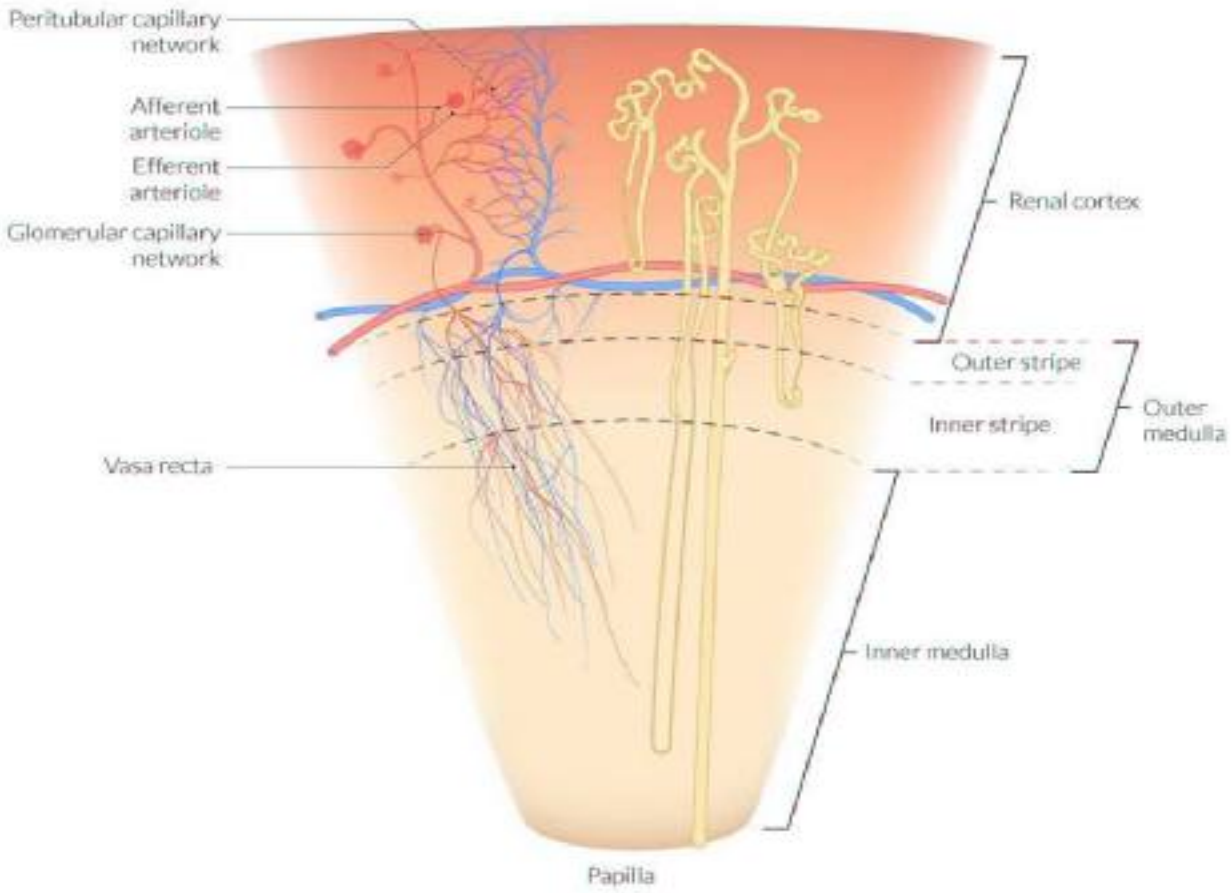
The glomerular filtration barrier ensures that large and/or negatively charged molecules in the blood cannot pass into the Bowman capsule.

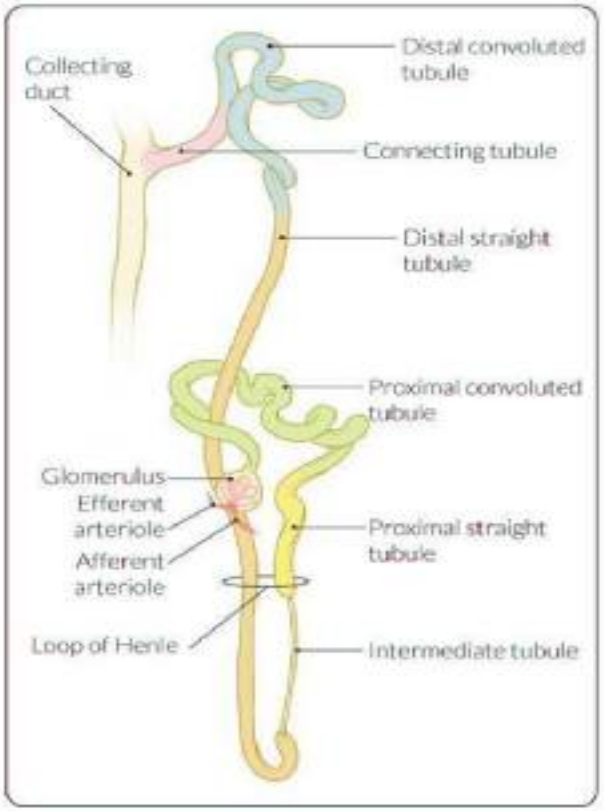

Lamina rara interna
Lamina densa
Lamina rara externa
Glomerular basement membrane
Fenestrated endothelium of capillaries
Blood
Ultrafiltrate
Glycocalyx
Podocyte processes (pedicels)
Slit diaphragm


Distal straight tubule
Afferent arteriole
Glomerular capsule, parietal layer
Glomerular capsule, visceral layer
Glomerular capillary
Proximal convoluted tubule
Efferent arteriole
Macula densa
Extraglomerular mesangial cells
Juxtaglomerular cells
Capsular space
Urinary pole


Fenestrated
capillary endothelium
Glomerular
basement membrane
Primary process
of a podocyte
Podocyte
Secondary process
of a podocyte

2- Renal Tubules





Renal tubules

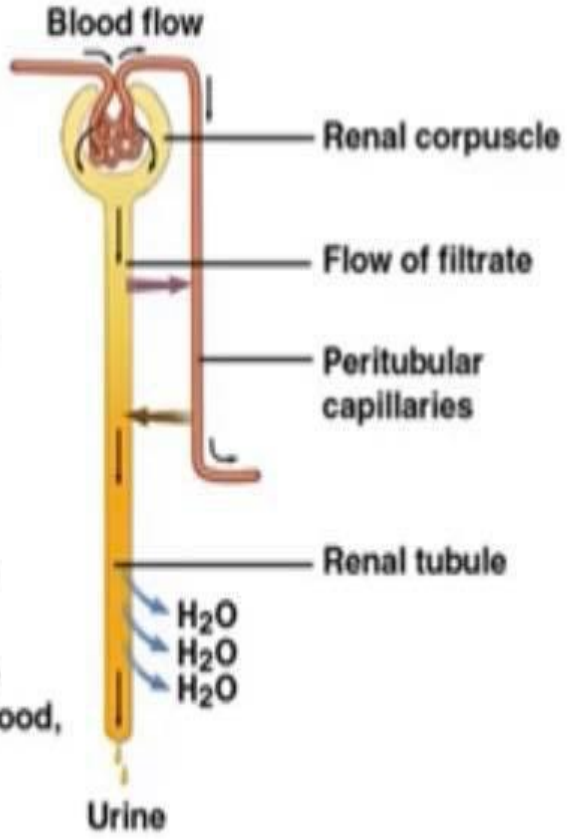
Urine Formation Preview

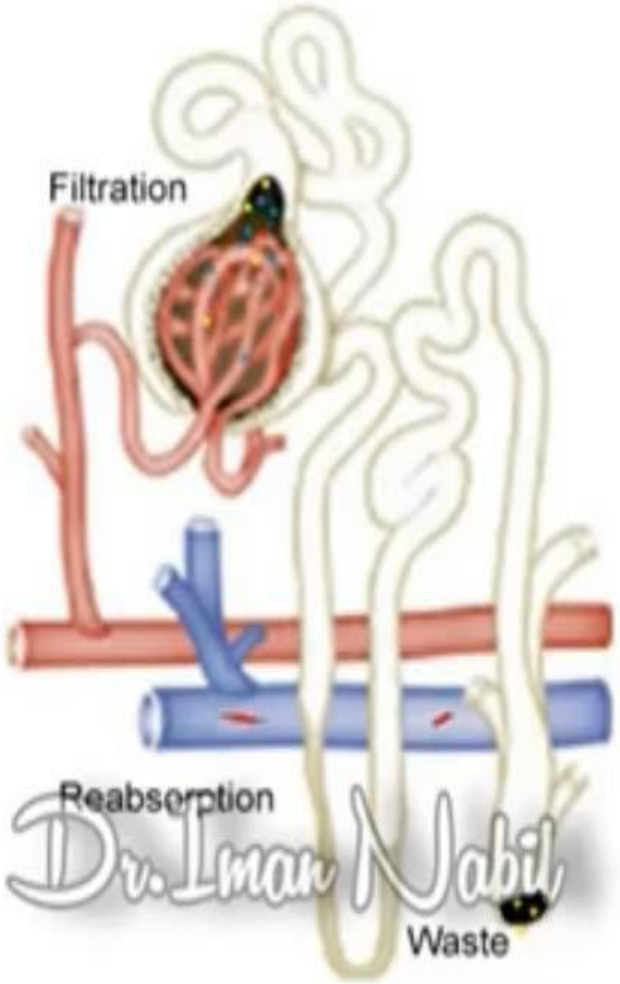
① **Glomerular filtration**
Creates a plasmalike filtrate of the blood

② **Tubular reabsorption**
Removes useful solutes from the filtrate, returns them to the blood

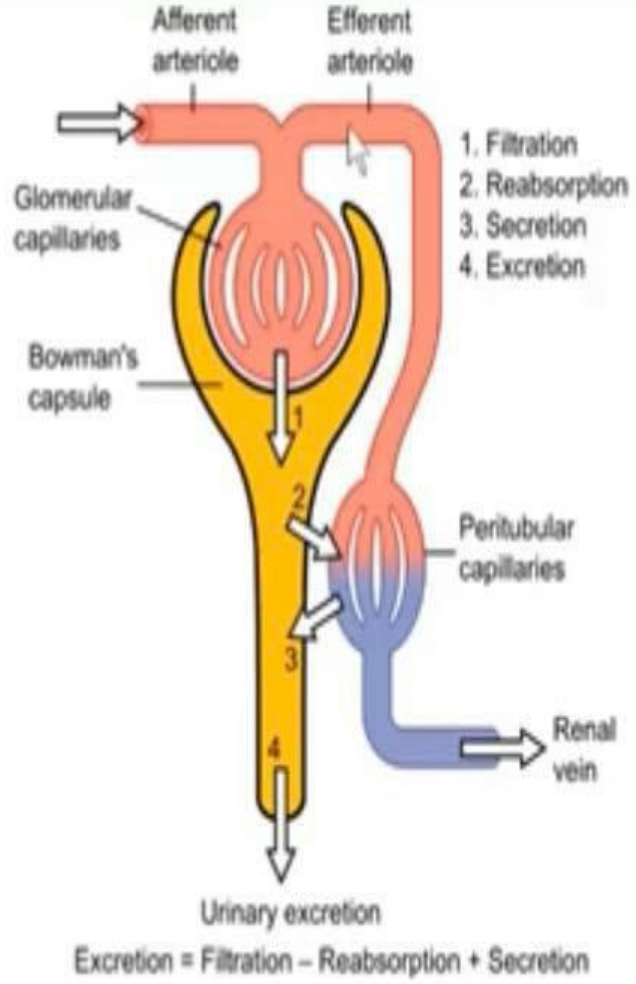
③ **Tubular secretion**
Removes additional wastes from the blood, adds them to the filtrate

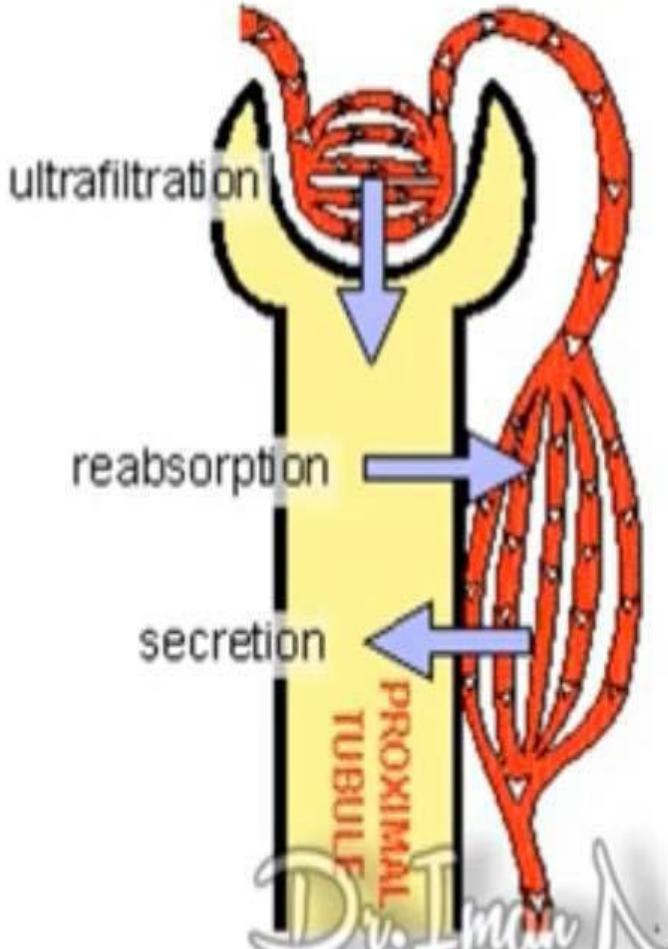
④ **Water conservation**
Removes water from the urine and returns it to blood, concentrates wastes





Renal tubules





Proximal convoluted tubule (PCT)	Renal cortex	Tall, cuboidal cells with brush border (long apical microvilli) Basal invaginations with multiple mitochondria Contains lysosomes	
Loop of Henle	**Thin descending loop of Henle**	Renal medulla	Smaller diameter than PCT Flat, squamous epithelium (resembles capillary endothelium)
	Thick ascending loop of Henle		Wider diameter than the descending segment Epithelium with variable short brush border and tight junctions (impermeable to water)

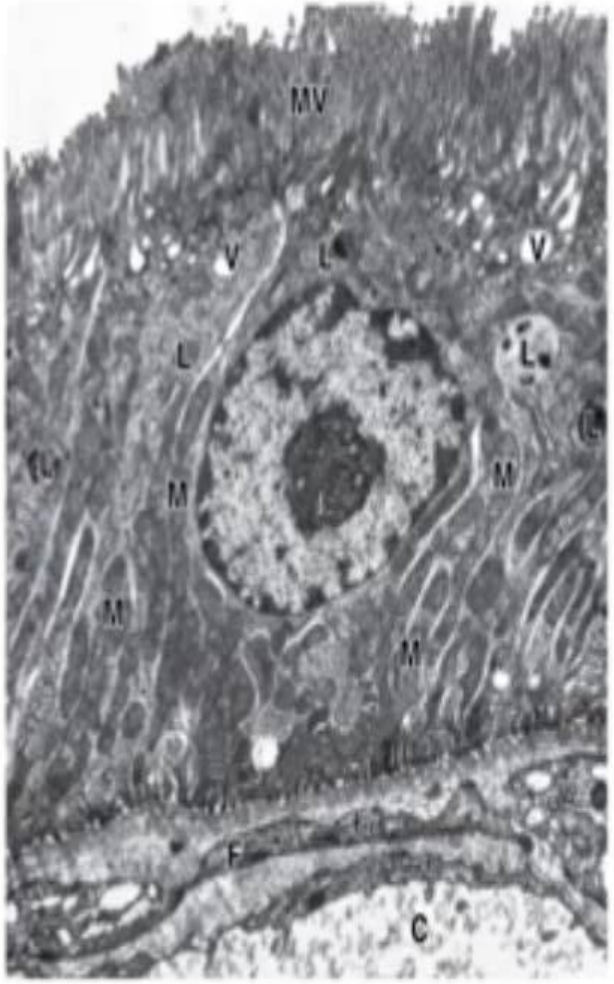
Distal convoluted tubule	Renal cortex	Directly adjacent to the nephron's glomerulus Squamous epithelium of variable thickness with short brush border and tight junctions (impermeable to water)
Connecting tubule and collecting duct	Renal cortex and renal medulla	Connecting tubule collects urine from several nephrons Cuboidal or columnar epithelium Principal cells with tight junctions (with aldosterone receptors) α-Intercalated cells and β-intercalated cells with tight junctions

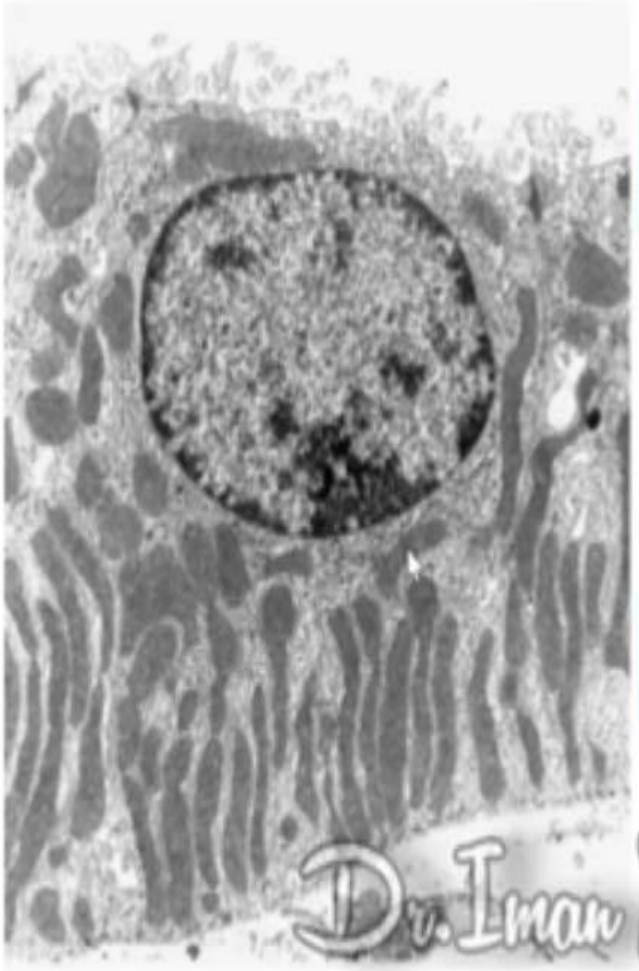
	PCT	DCT
1- Length	Longer.	Shorter.
2-Diameter	Larger.	Smaller.
3- LM		
• Shape& number of cells	3-5 tall pyramidal.	5-8 small cuboidal
• Lateral boundaries	Indistinct.	More distinct
• Lumen	Narrow;occluded.	Wide.
• Brush border	Well developed.	Absent.
• Basal striation	Prominent.	More prominent
• Cytoplasm	Deep acidophilic.	Pale acidophilic.
• Nucleus	Spherical, near to base.	Spherical, near to apex.
4- EM		
• Apically	Long microvilli, endocytotic vesicles.	Short microvilli, few endocytotic vesicles.
• Basolateral membrane	Lateral interdigitations & basal infoldings occupied by mitochondria.	Less interdigitations & extensive basal infoldings.
• Mitochondria	abundant	Less.
5- Function	Obligatory reabsorption of 65% of ultrafiltrate.	1- Facultative reabsorption of Na,H2O, secretion of K. 2- Share in acidification of urine.

Differences between PCT & DCT

More reabsorption

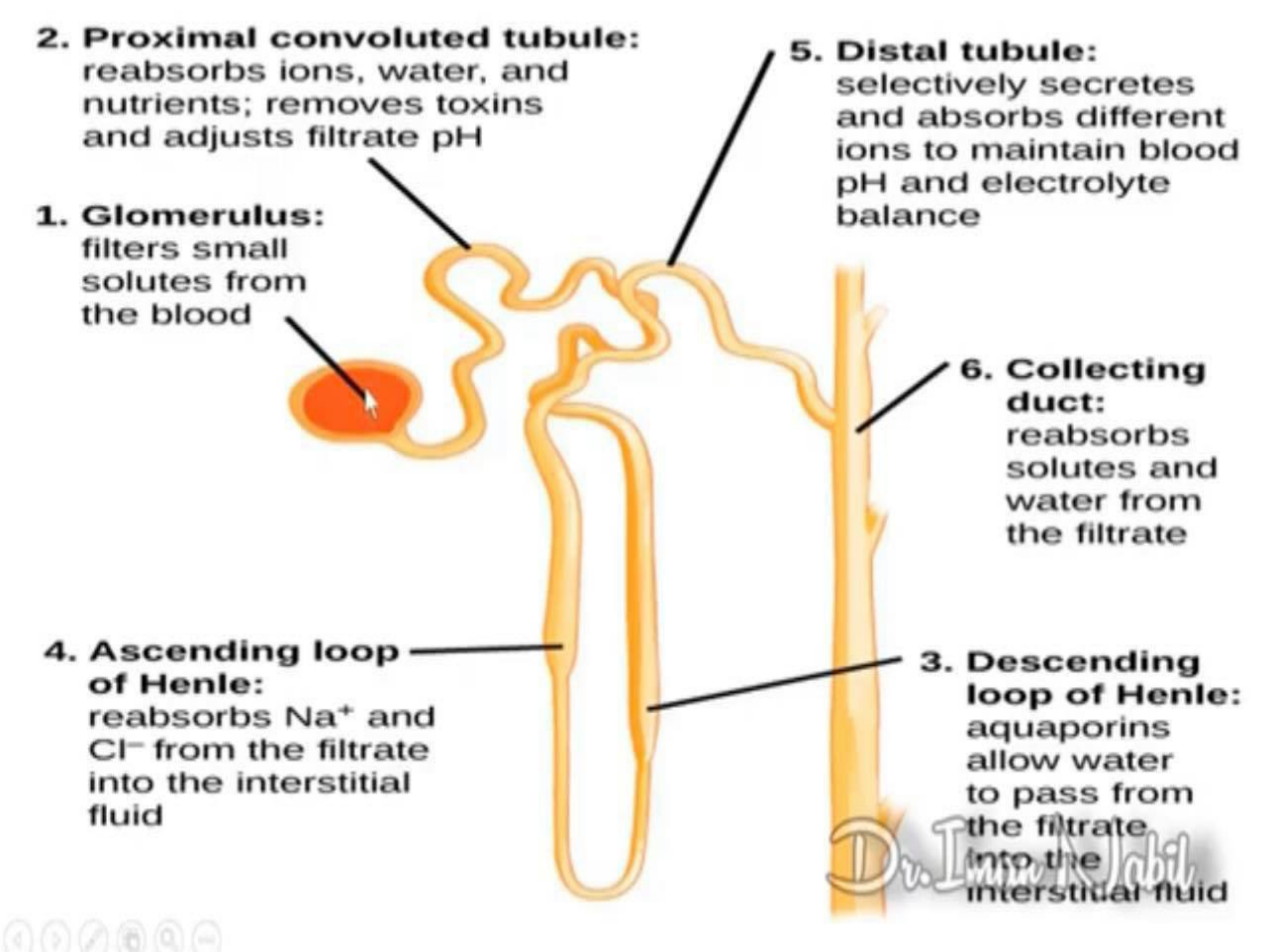
Active ion transport





Less reabsorption

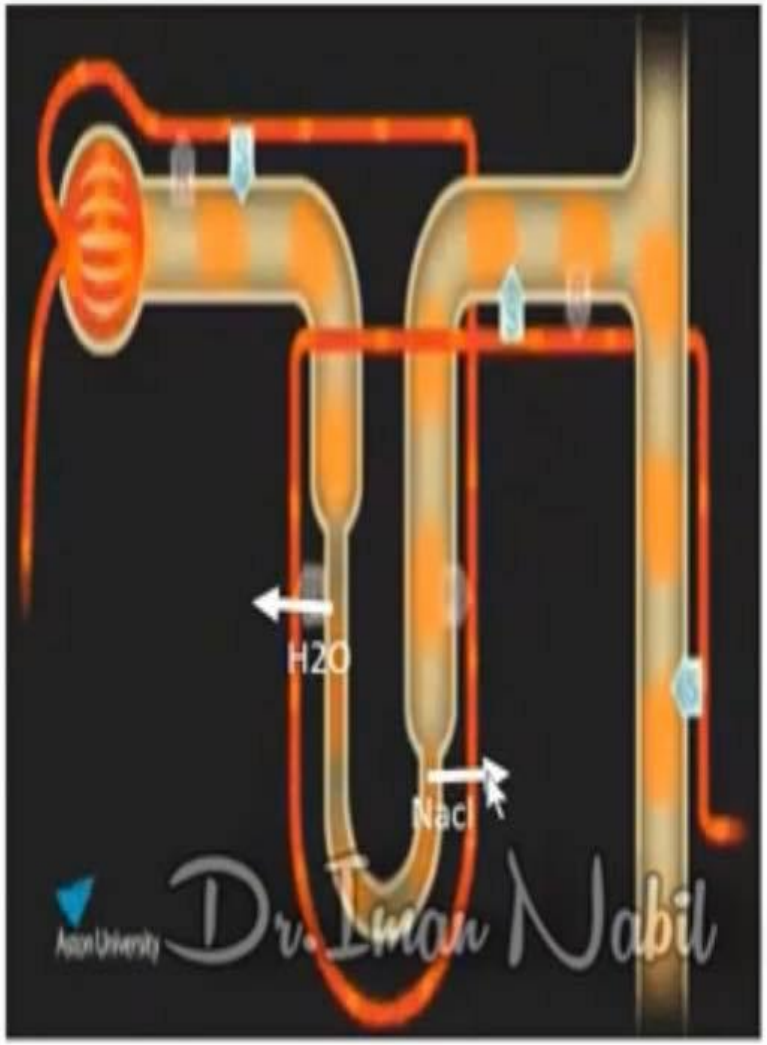
Active ion transport


2. Proximal convoluted tubule: reabsorbs ions, water, and nutrients; removes toxins and adjusts filtrate pH
5. Distal tubule: selectively secretes and absorbs different ions to maintain blood pH and electrolyte balance
1. Glomerulus: filters small solutes from the blood
6. Collecting duct: reabsorbs solutes and water from the filtrate
4. Ascending loop of Henle: reabsorbs Na^+ and Cl^- from the filtrate into the interstitial fluid
3. Descending loop of Henle: aquaporins allow water to pass from the filtrate into the interstitial fluid

III-Loop of Henle

- **Function:** urine concentration in coordination with the vasa recta& renal interstitium.

It requires minimum level of metabolic activity (without expenditure of energy).



3- Juxtaglomerular Complex

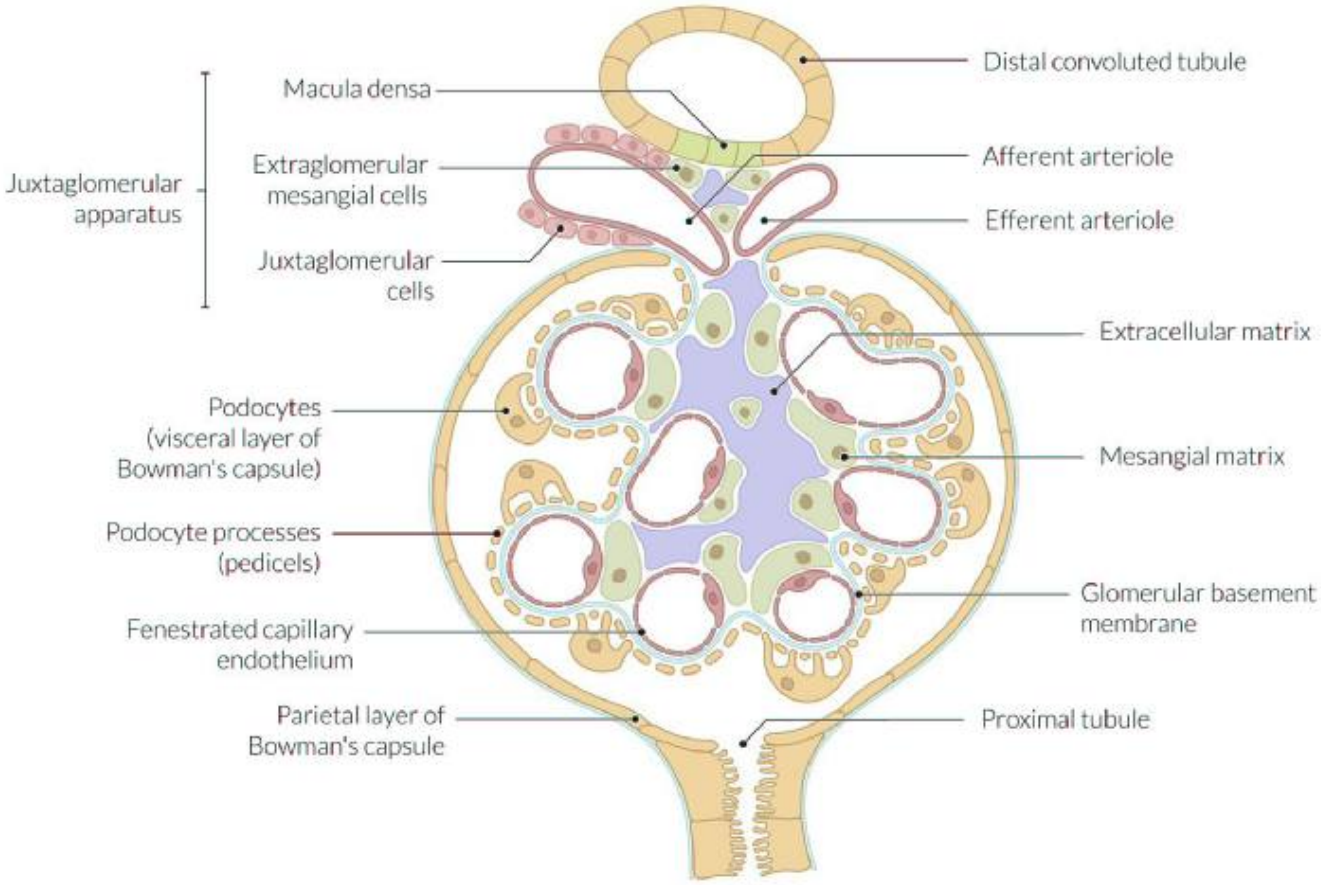
Definition

A specialized structure within the nephron

Located between the distal convoluted tubule (DCT) and the afferent arteriole of the nephron

Maintains the GFR by regulating the renin-angiotensin-aldosterone system (RAAS)

Components


Distal convoluted tubule
Macula densa
Afferent arteriole
Juxtaglomerular apparatus
Extraglomerular mesangial cells
Efferent arteriole
Juxtaglomerular cells
Extracellular matrix
Podocytes (visceral layer of Bowman's capsule)
Mesangial matrix
Podocyte processes (pedicels)
Glomerular basement membrane
Fenestrated capillary endothelium
Parietal layer of Bowman's capsule
Proximal tubule

Juxtaglomerular cells

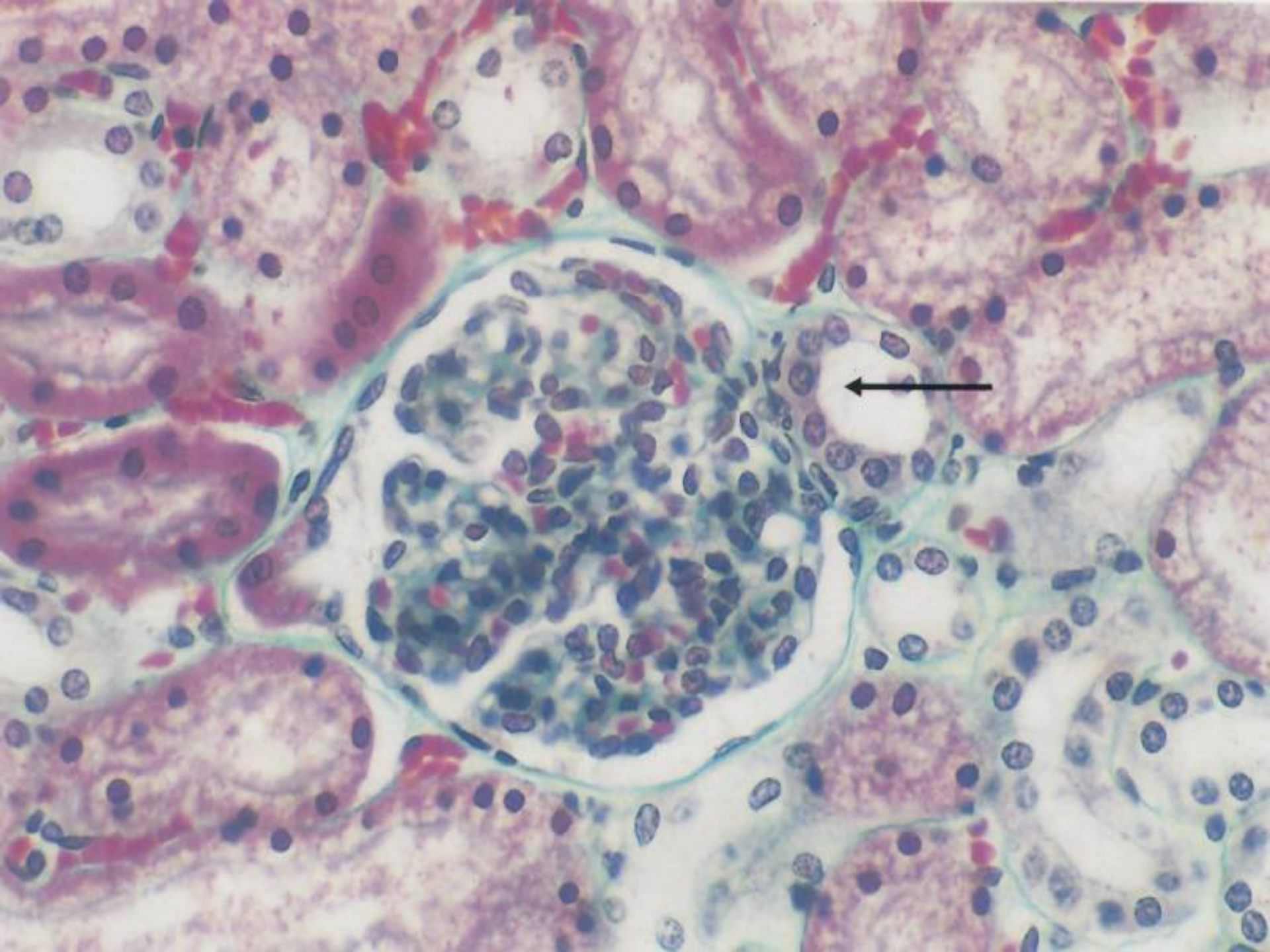
- Modified smooth muscle cells located in the afferent arterioles
- Function: renin synthesis

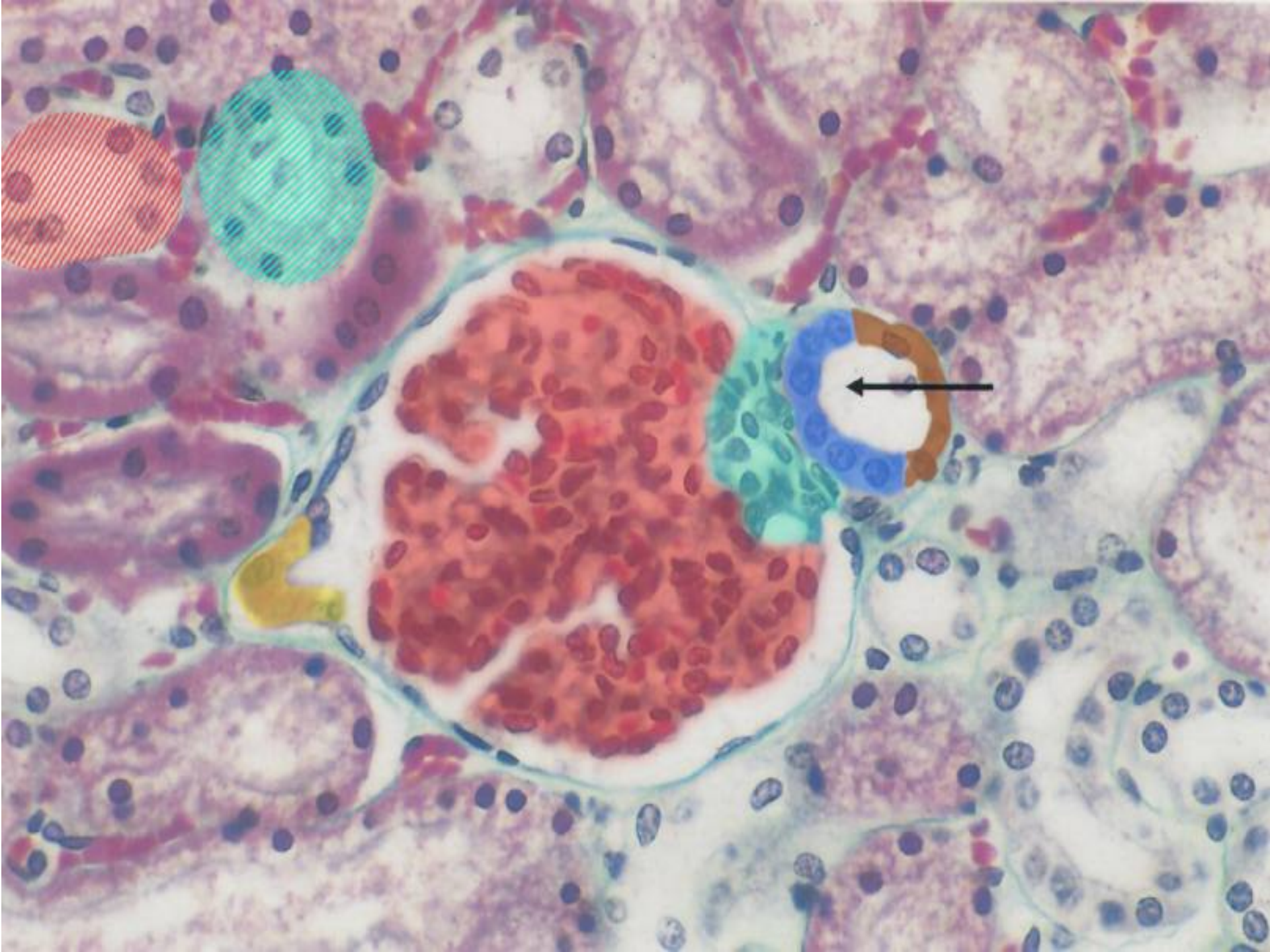
Macula densa

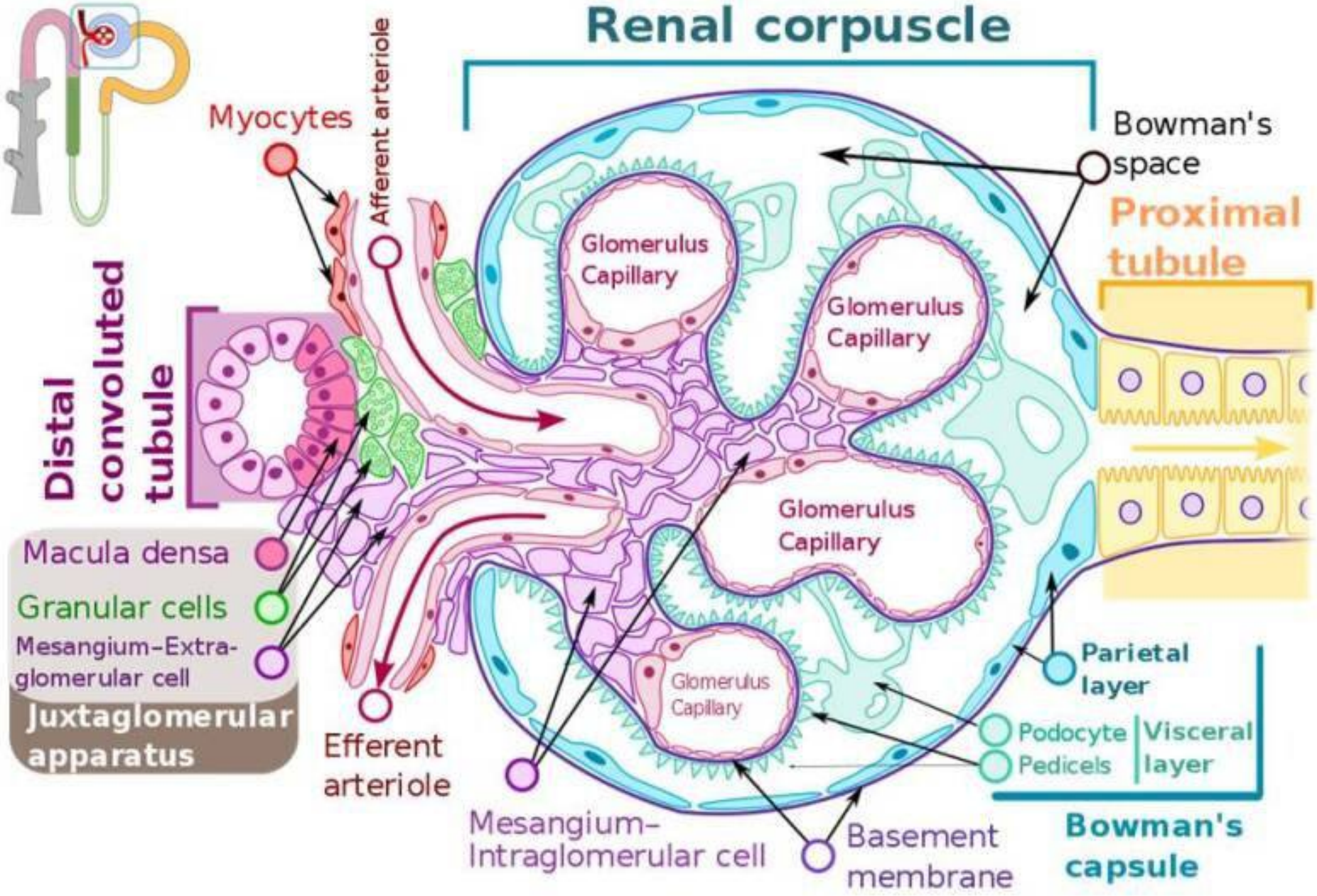
- Composed of tall cuboidal cells located at the distal end of the thick ascending loop of Henle –OSMORECEPTORS
- Monitors the NaCl concentration within the lumen of the DCT
  - Hypoosmolar urine triggers the release of renin → vasoconstriction of the efferent arteriole → increase in GFR
  - Hyperosmolar urine triggers the release of adenosine → vasoconstriction of the afferent arteriole → decrease in GFR

Extra glomerular mesangial cells (Lacis cells)

- Play a role in autoregulation of blood flow to the kidney (exact functioning is not entirely understood)
- Form a network of cells, connecting the sensory cells of the macula densa with juxtaglomerular effector cells
- May also signal to contractile glomerular mesangial cells and, thereby, directly affect vasoconstriction






Renal corpuscle
Myocytes
Afferent arteriole
Bowman's space
Proximal tubule
Glomerulus Capillary
Glomerulus Capillary
Glomerulus Capillary
Glomerulus Capillary
Distal convoluted tubule
Macula densa
Granular cells
Mesangium–Extra-glomerular cell
Juxtaglomerular apparatus
Efferent arteriole
Mesangium–Intraglomerular cell
Basement membrane
Parietal layer
Podocyte Pedicels
Visceral layer
Bowman's capsule

3- Urinary Passages

They include calyces, renal pelvis, ureters, urinary bladder and urethra.

Each has the same histological structure: a mucosa consisting of Uroepithelium (transitional epithelium) and lamina propria of fibroelastic C.T., musculosa and adventitia.

Ureters

Retroperitoneal, hollow tubes that extend from the renal medulla (renal pelvis) to the urinary bladder

Contain smooth muscles that contract and relax in a wave-like manner (peristalsis) to propel urine forward towards the bladder

Microscopic anatomy

1- Mucosa:

Shows prominent longitudinal folds giving the lumen a stellate appearance.

Formed of uroepithelium (transitional epithelium) and underlying C.T. corium.

Uroepithelium is formed of 3 layers:

1. Basal layer: one layer of small basal cells resting on a very thin basement membrane.

2. Intermediate layer: one to several layers of polyhedral cells.

3. Superficial layer: "umbrella cells" large dome shaped cells, may be binucleated.

N.B.: Both transitional epithelium and extensive longitudinal folds allow distention of the ureter, so small stones can be voided in urine.

2- Musculosa:

The upper two thirds of the ureter has an inner longitudinal and an outer circular layer of smooth muscles.

The lower third has an additional outer longitudinal layer.

Contraction of these muscle layers produces peristaltic waves which propel urine along it towards urinary bladder.

3- Adventitia: Formed of fibroelastic C.T. containing blood vessels, nerves and lymphatics.

Urinary Bladder

Hollow, triangular-shaped organ

Located **extraperitoneally** , behind the pubic symphysis, within the pelvis, and beneath the peritoneum

Can hold ~ 500–1,000 ml of urine

Sensation of bladder fullness is felt at ~ 300–500 mL .

Contains **smooth muscle** (the **detrusor muscle** of the bladder) that contracts during micturition.

Microscopic anatomy

1- Mucosa:

a. Epithelium: formed of uroepithelium in which umbrella cells are well developed and have extensive intercellular junctional complex forming a unique apical membrane as contact with urine is greatest.

- In empty bladder: uroepithelium is 5-6 layers thick. Superficial cells "umbrella cells" are dome shaped .
- In full bladder: uroepithelium is 3-4 layers thick. Superficial cells become squamous.

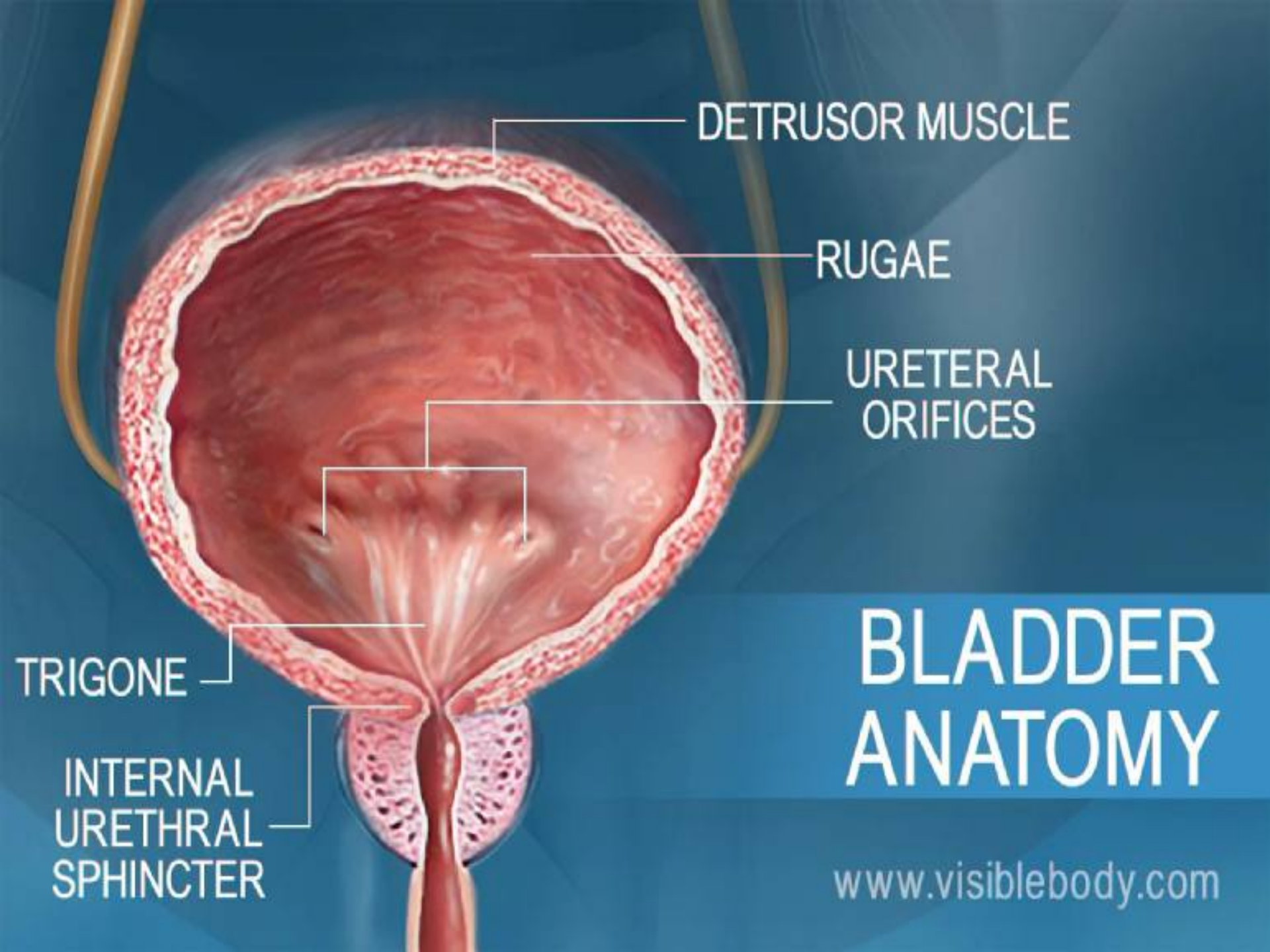
b. C.T. corium (lamina propria): formed of fibroelastic C.T

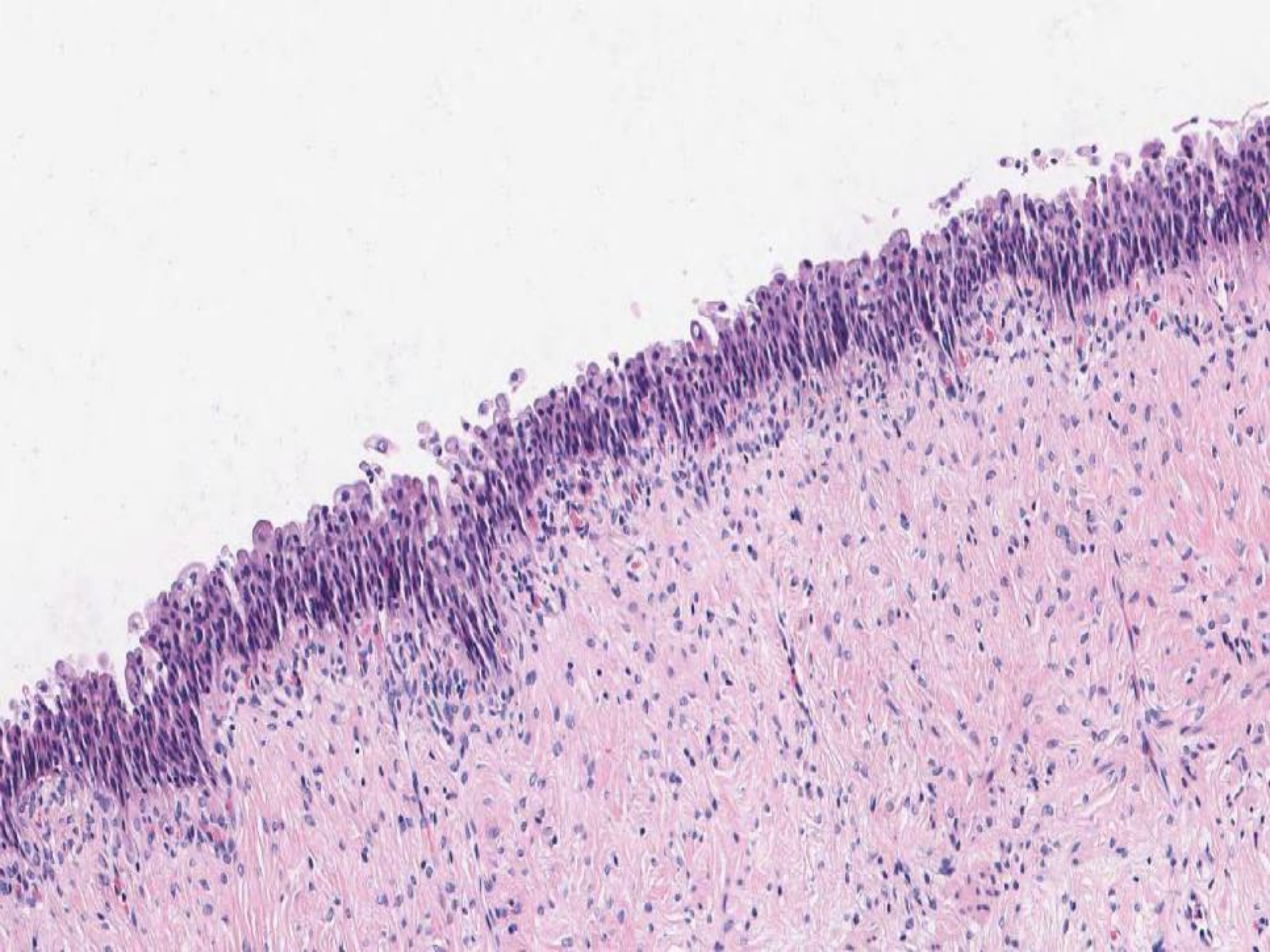
2- Musculosa:

- Formed of: inner longitudinal, middle circular and outer longitudinal smooth muscle.

Distal to the bladder neck, the inner longitudinal layer becomes circular to form the internal urethral sphincter.

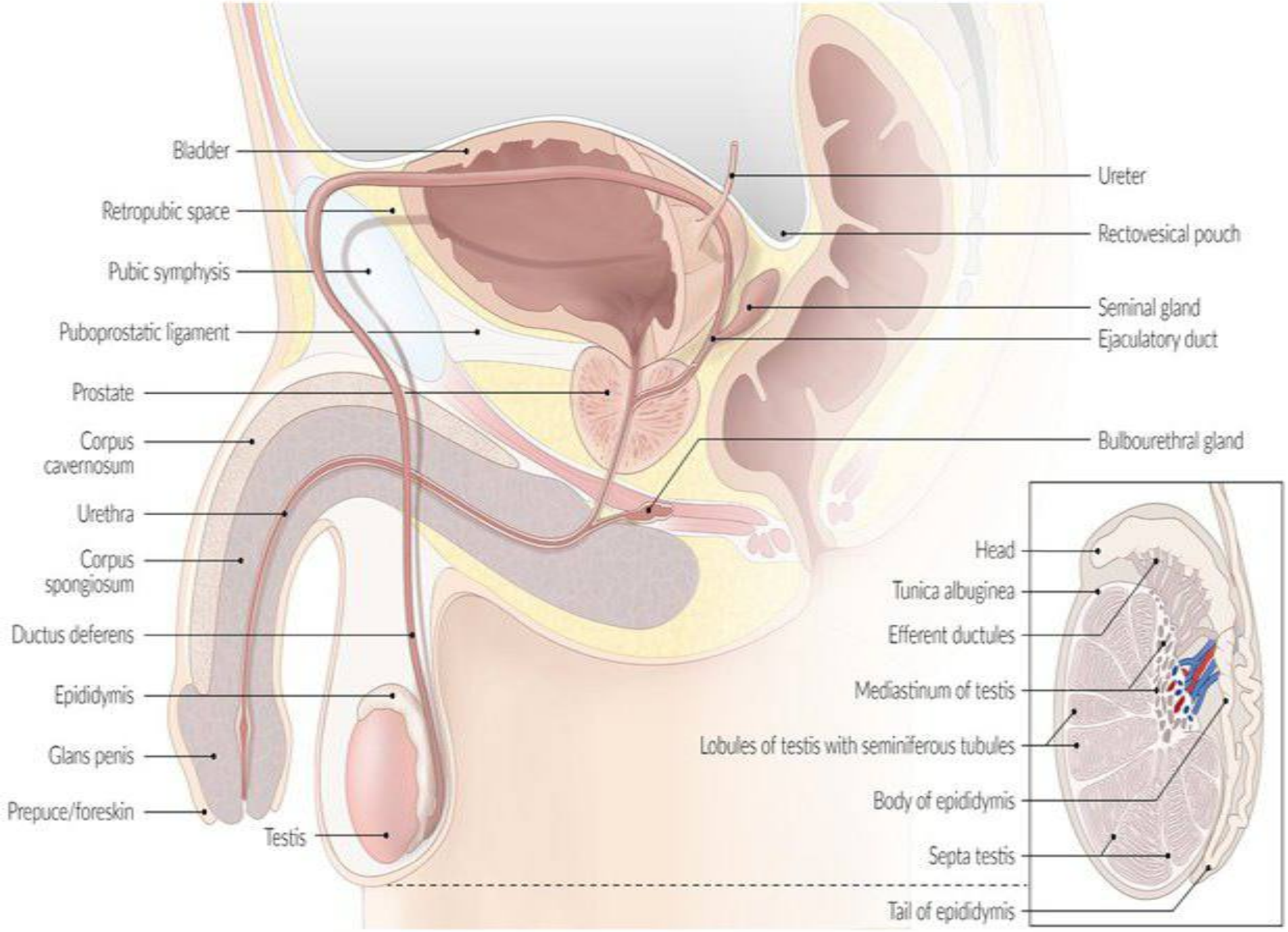
3- Adventitia: the urinary bladder is covered by fibroelastic C.T. except the superior part which is covered by serosa (peritoneum).


DETRUSOR MUSCLE
RUGAE
URETERAL ORIFICES
TRIGONE
INTERNAL URETHRAL SPHINCTER
BLADDER ANATOMY
www.visiblebody.com



Urethra

Transports urine from the urinary bladder to the exterior of the body under control of the urethral sphincter


Bladder
Retropubic space
Pubic symphysis
Puboprostatic ligament
Prostate
Corpus cavernosum
Urethra
Corpus spongiosum
Ductus deferens
Epididymis
Glans penis
Prepuce/foreskin
Testis
Ureter
Rectovesical pouch
Seminal gland
Ejaculatory duct
Bulbourethral gland
Head
Tunica albuginea
Efferent ductules
Mediastinum of testis
Lobules of testis with seminiferous tubules
Body of epididymis
Septa testis
Tail of epididymis

Male urethra:

A curved tube about 20 cm in length. Also, serves as a pathway for semen during ejaculation. It is divided into:

1- Prostatic urethra:

The initial part of urethra that passes through the prostate.

Lined with transitional epithelium.

It is surrounded by internal urethral sphincter

2- Membranous urethra:

A short part that passes through the urogenital diaphragm.

Lined with stratified or pseudo-stratified columnar epithelium.

It is surrounded by skeletal muscles of the pelvis forming external urethral sphincter

3- Penile (cavernous) urethra:

Located in corpus spongiosum of penis.

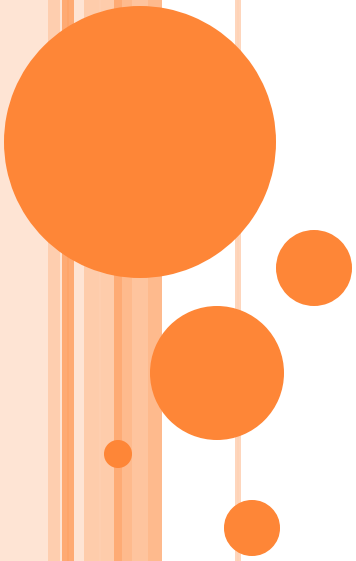
Lined with stratified columnar epithelium, which changes to stratified squamous in its distal dilated part

Open into it the ducts of glands of Littré.

Female urethra:

It is a short straight tube.

Lined with transitional, stratified or pseudostratified columnar then stratified squamous epithelium at its distal end.



Thank you