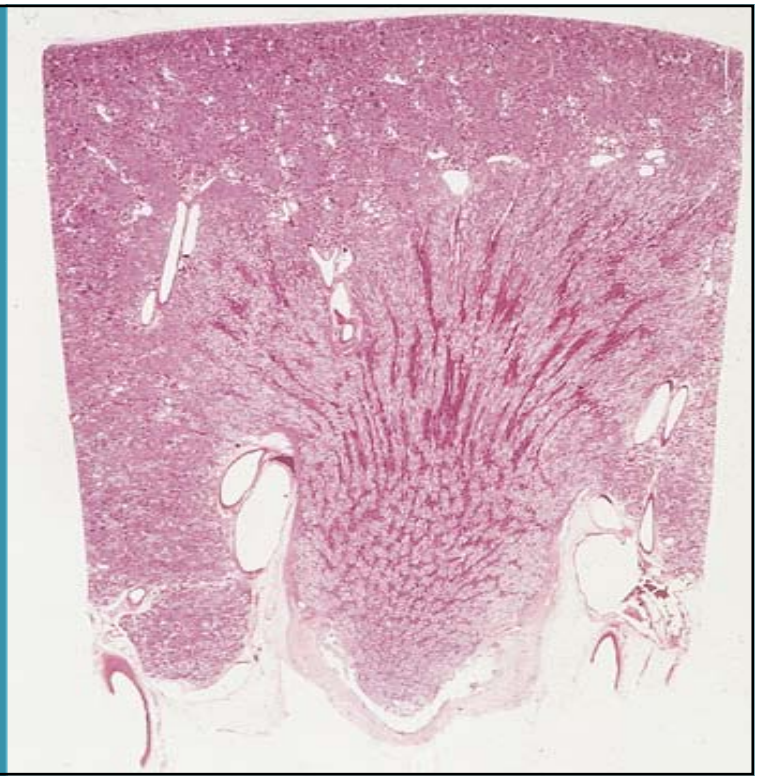
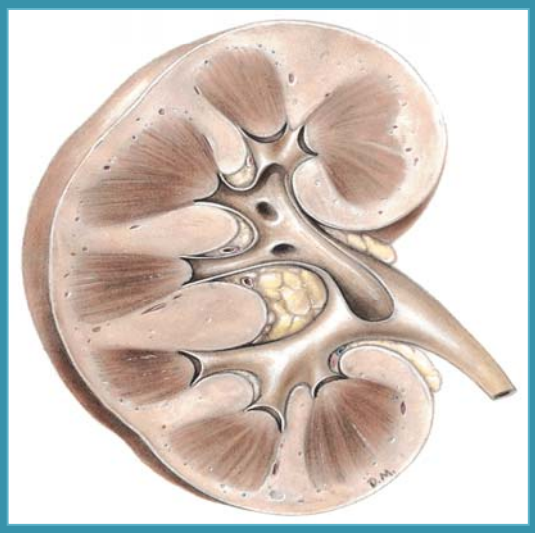
URINARY SYSTEM LECTURE PART 2

D.HAMMOUDI.MD

Cortex

Medulla





Minor calyces

↓

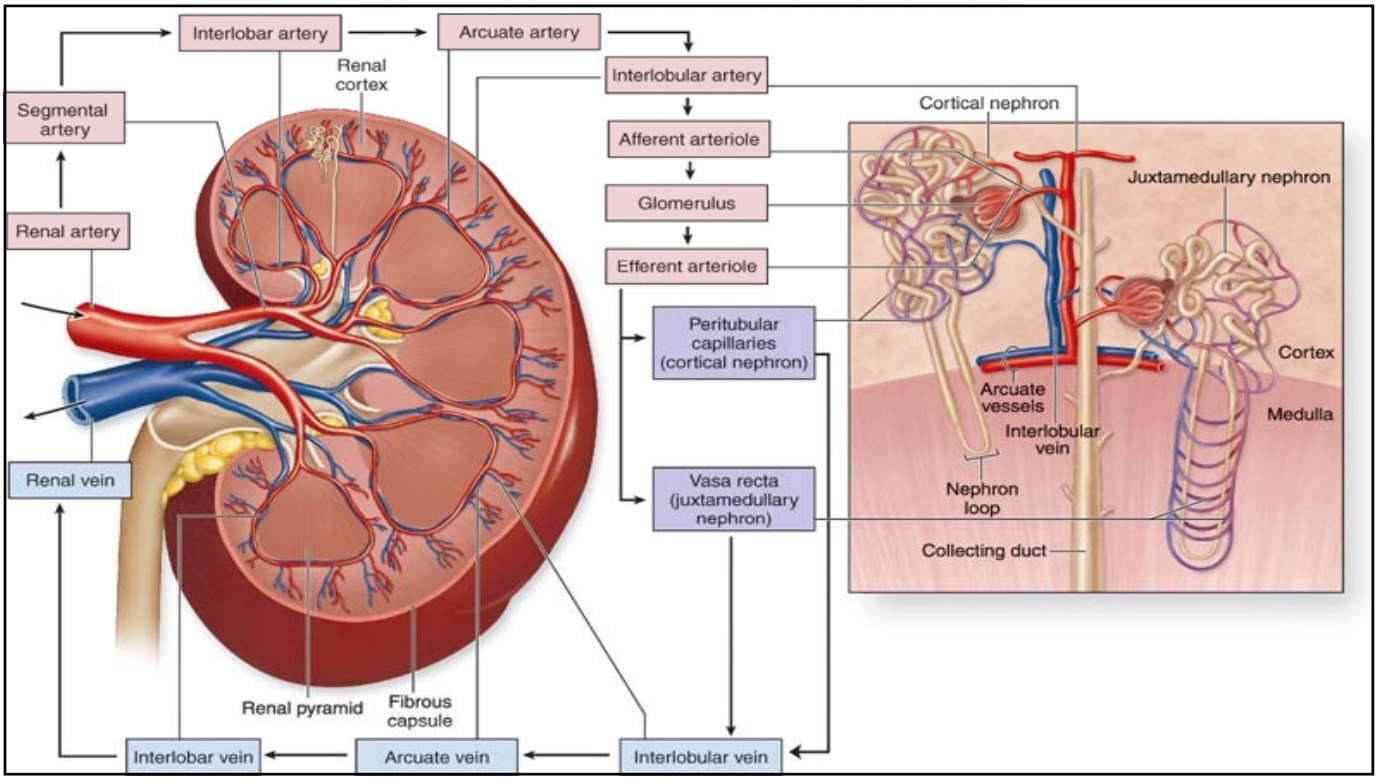
Major calyces

↓

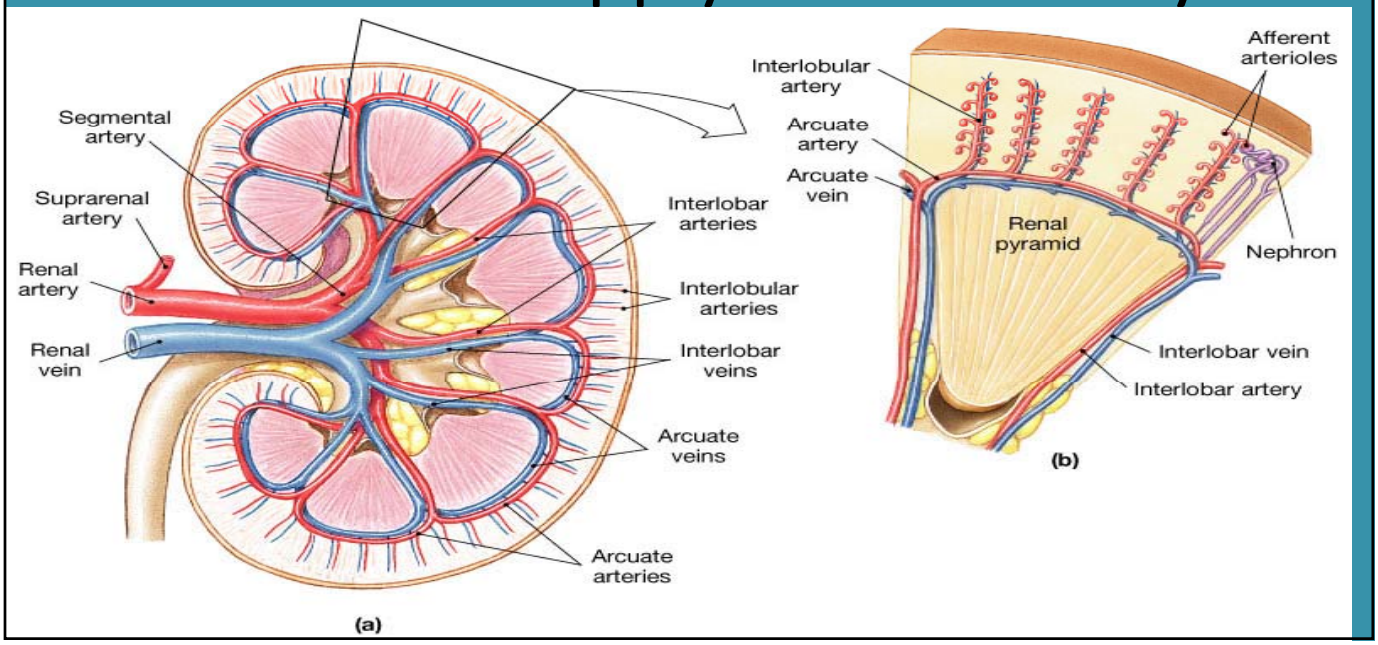
Renal pelvis

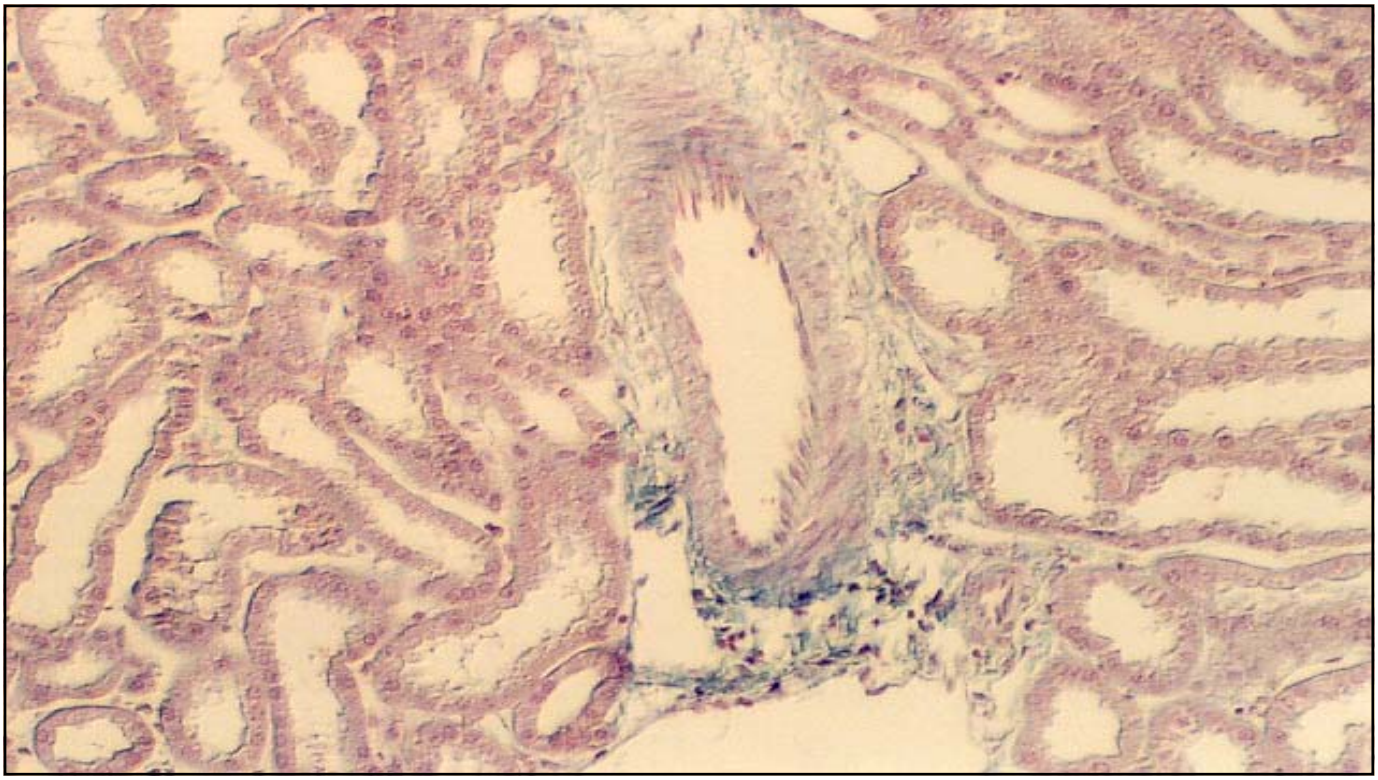
↓

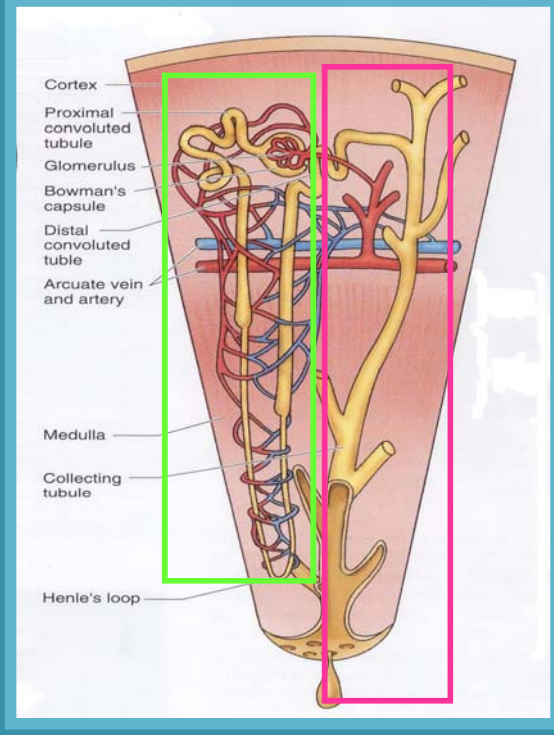
Ureter



The Blood Supply to the Kidneys





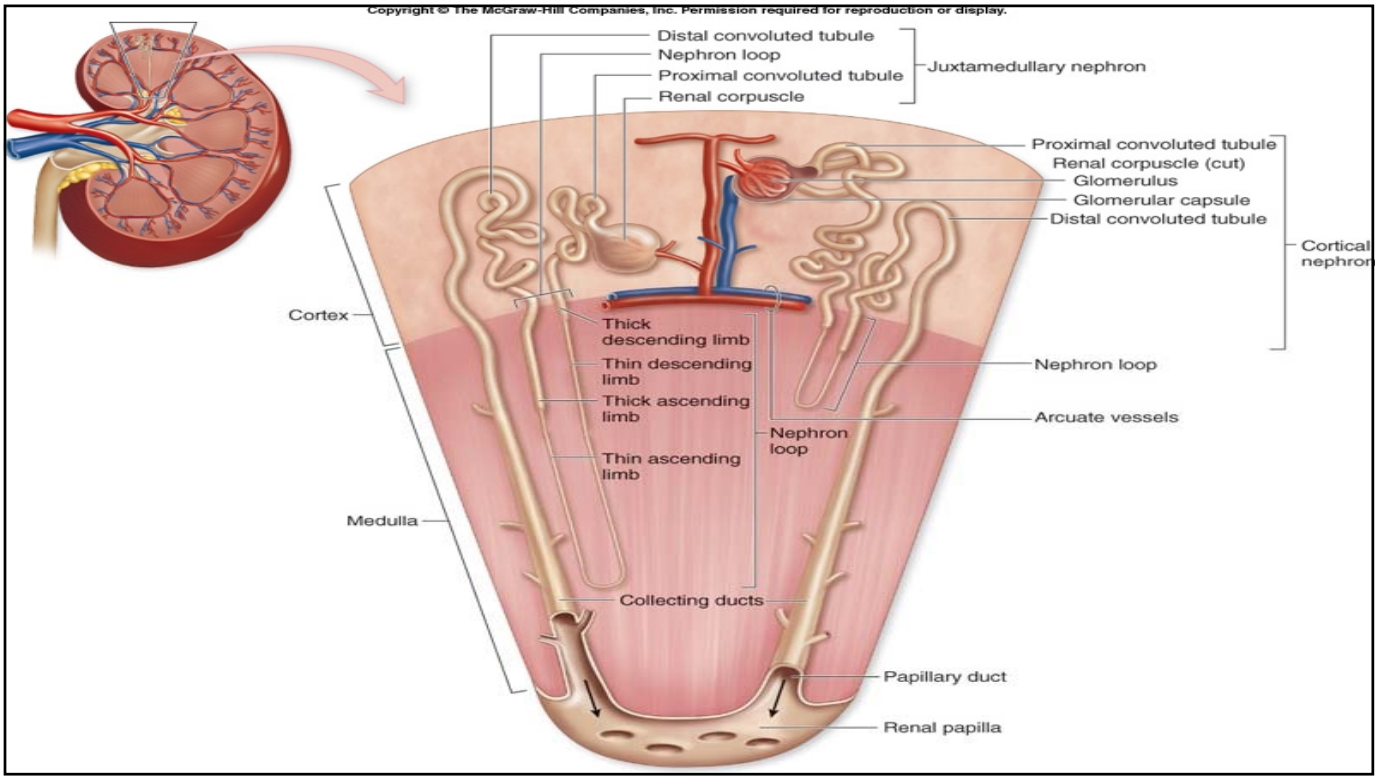


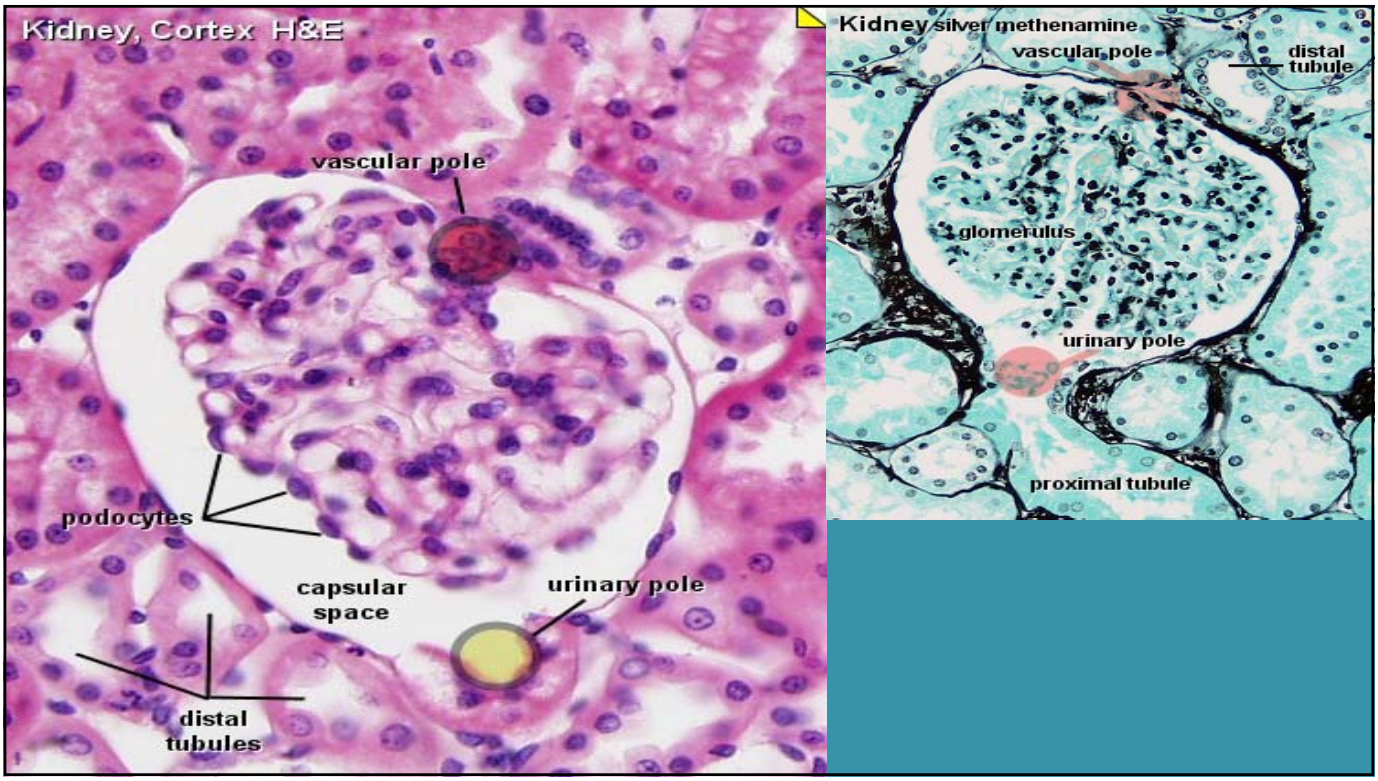
Uriniferous Tubule

Functional unit of the kidney.

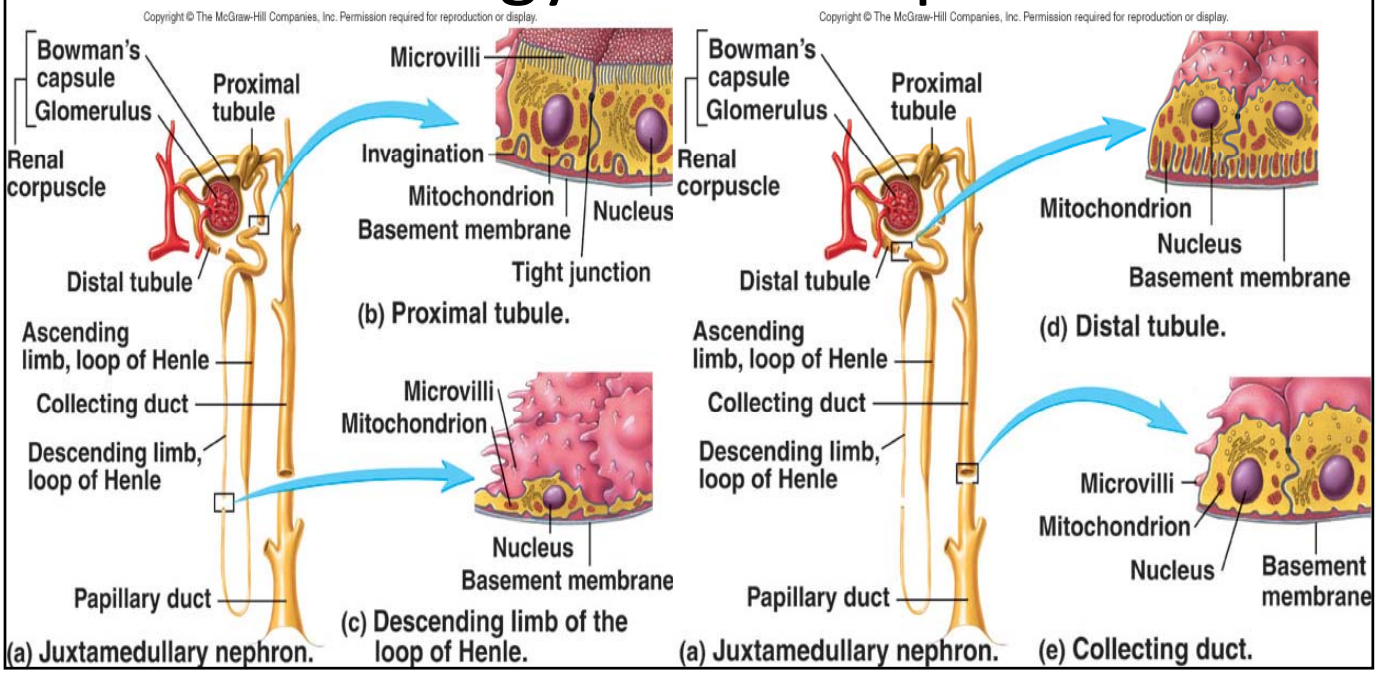
Modify filtrate to form urine.

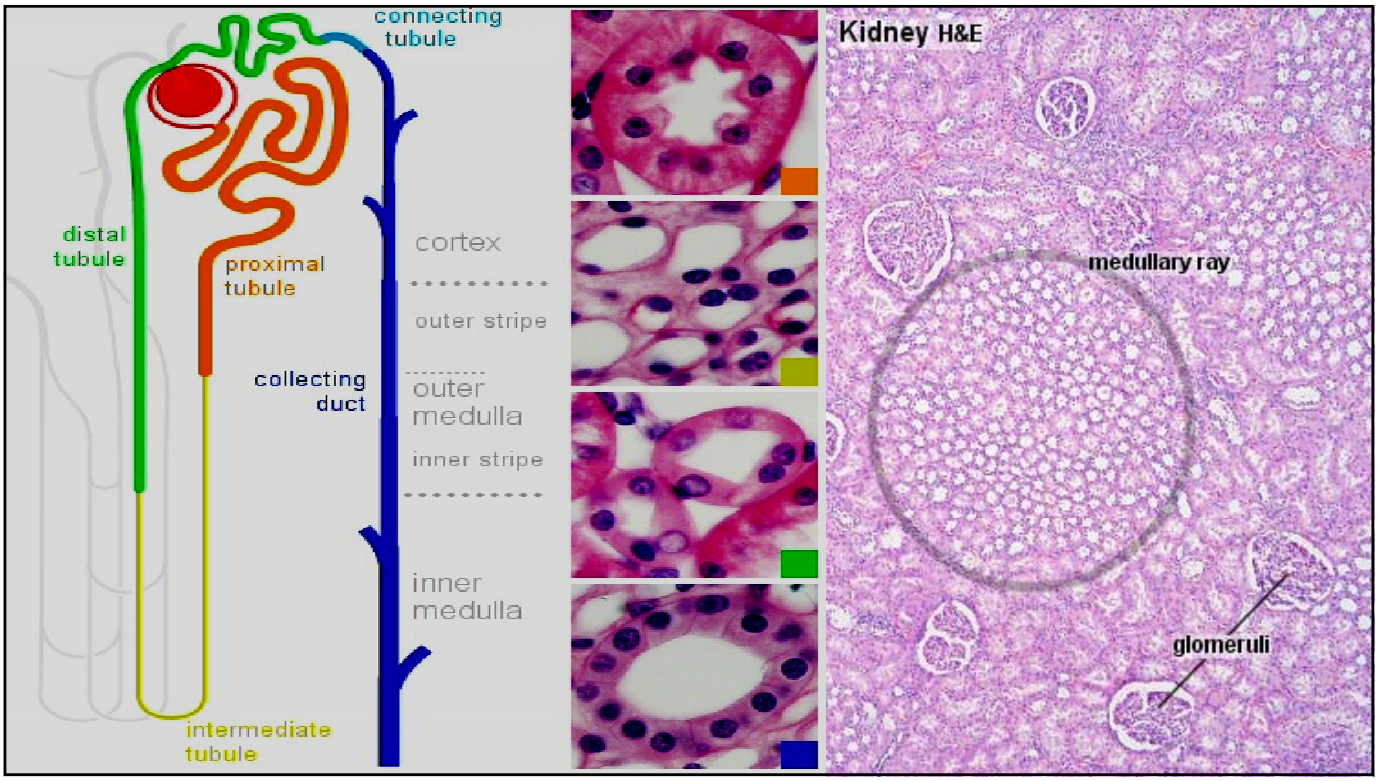
Composed of a nephron & a collecting tubule (embryologically distinct).

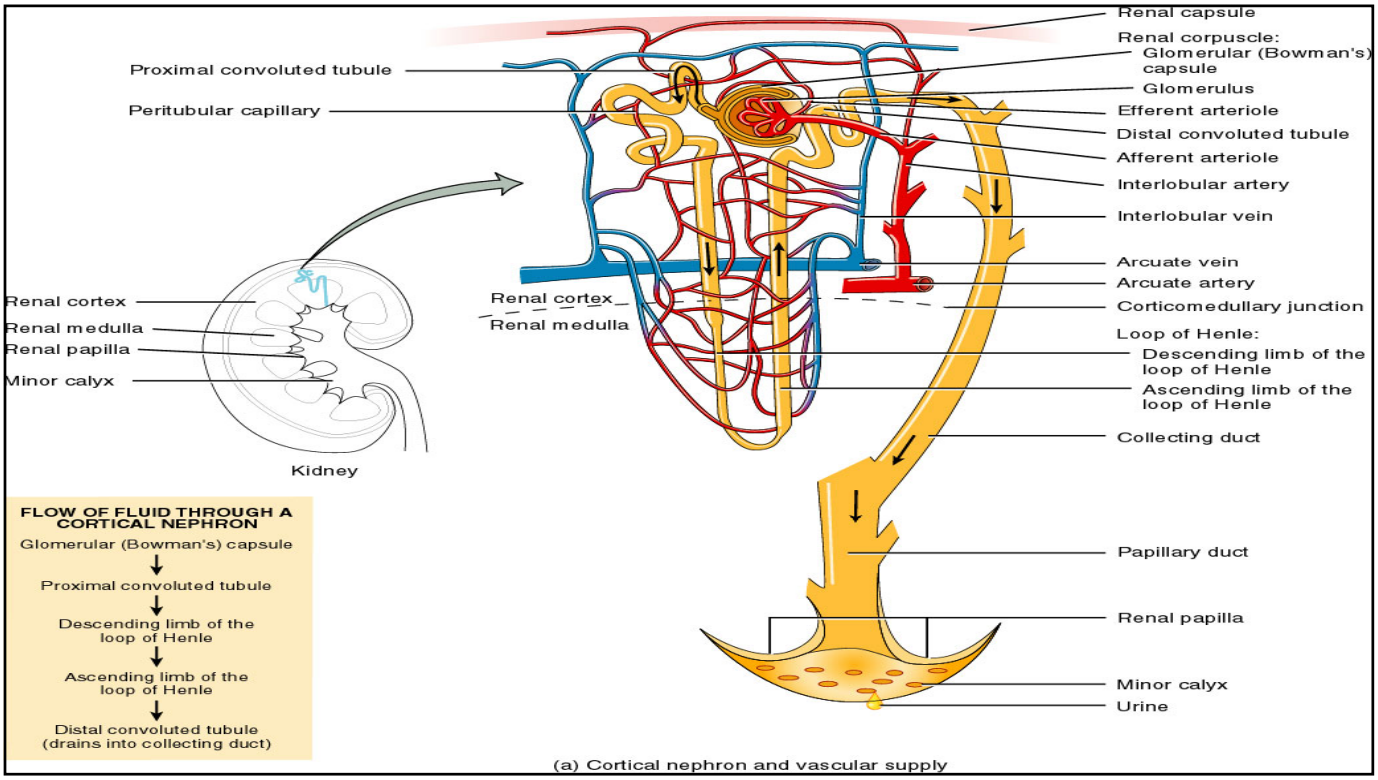


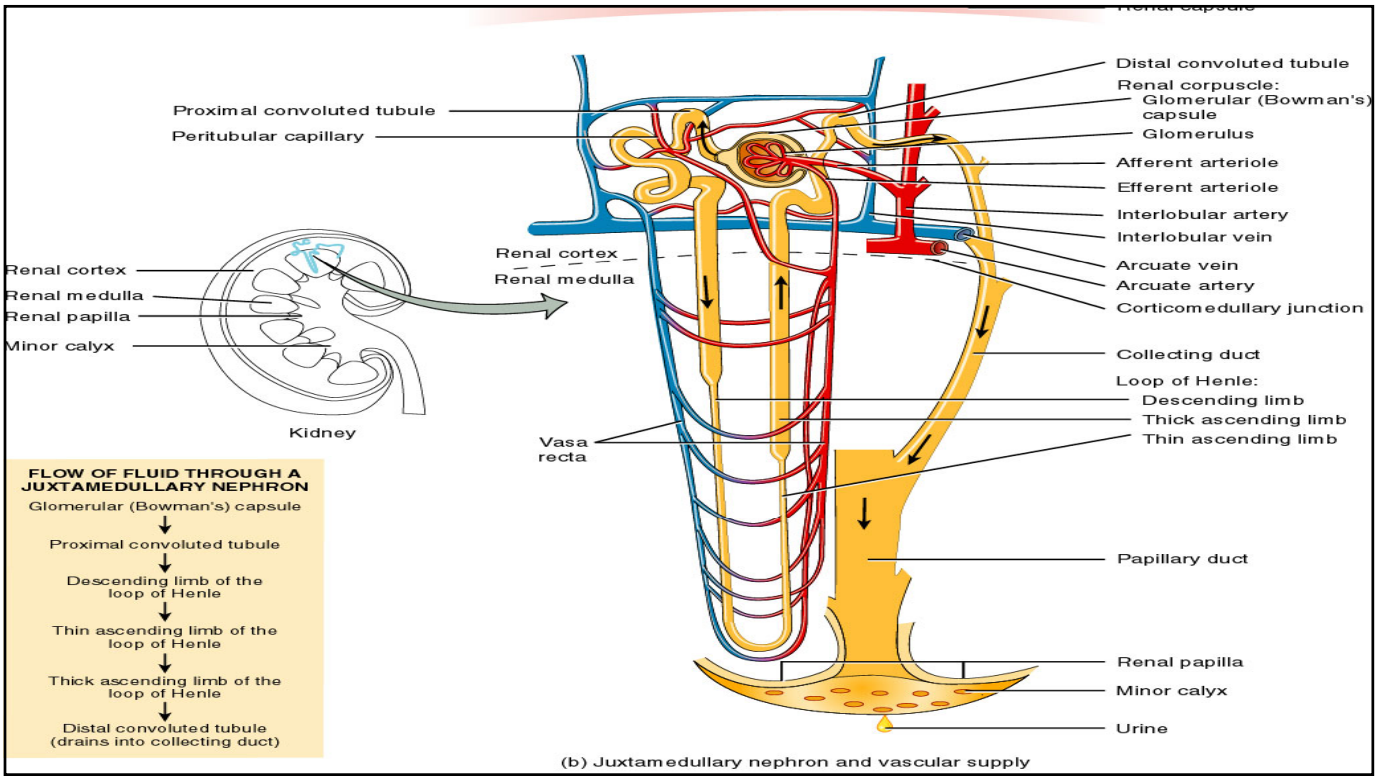


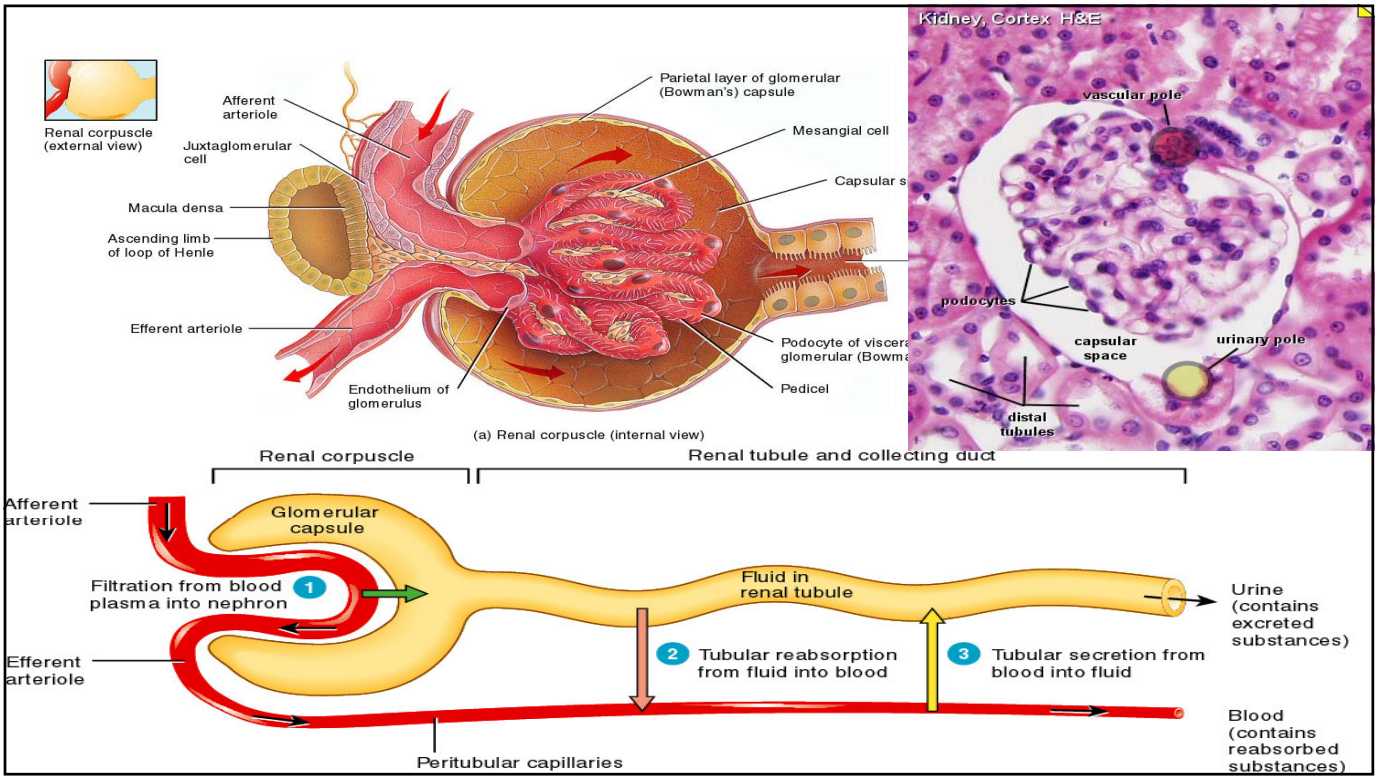
Histology of the Nephron

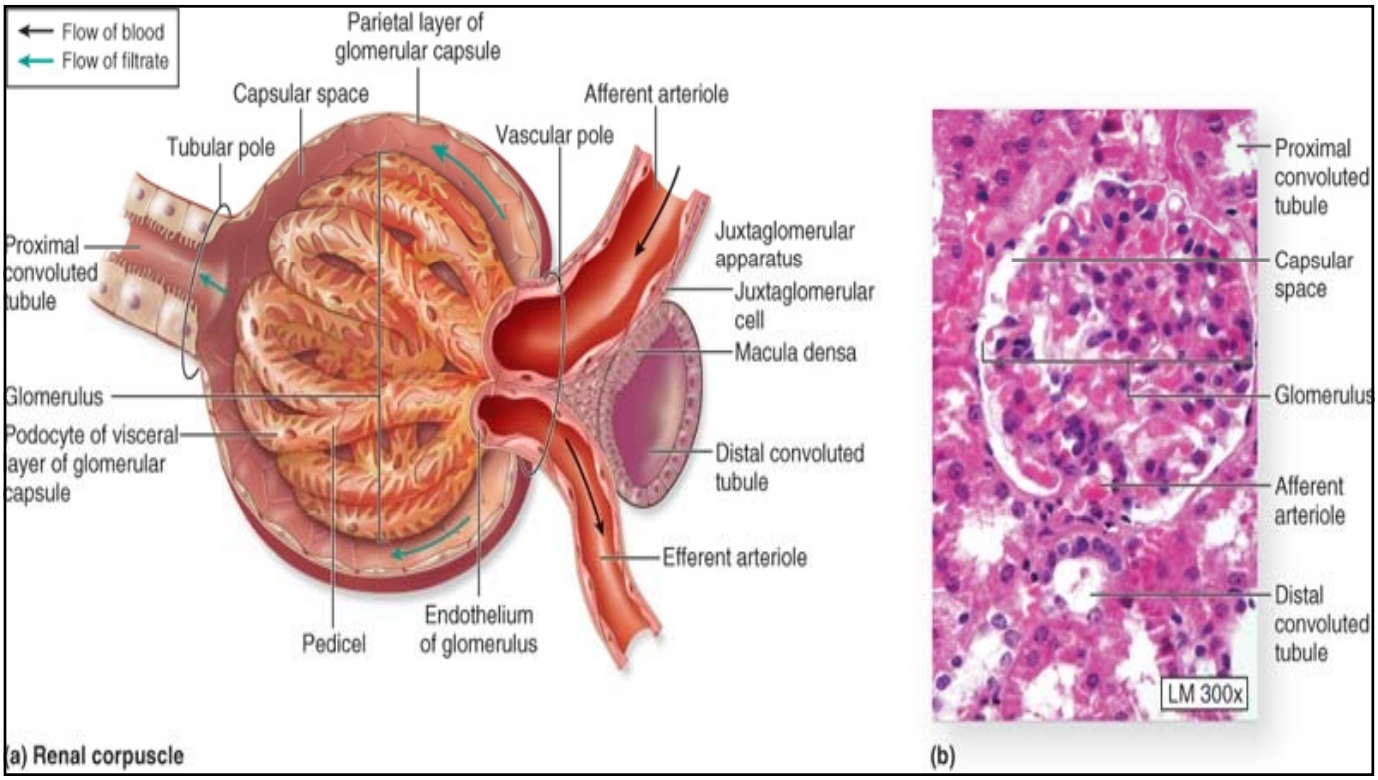


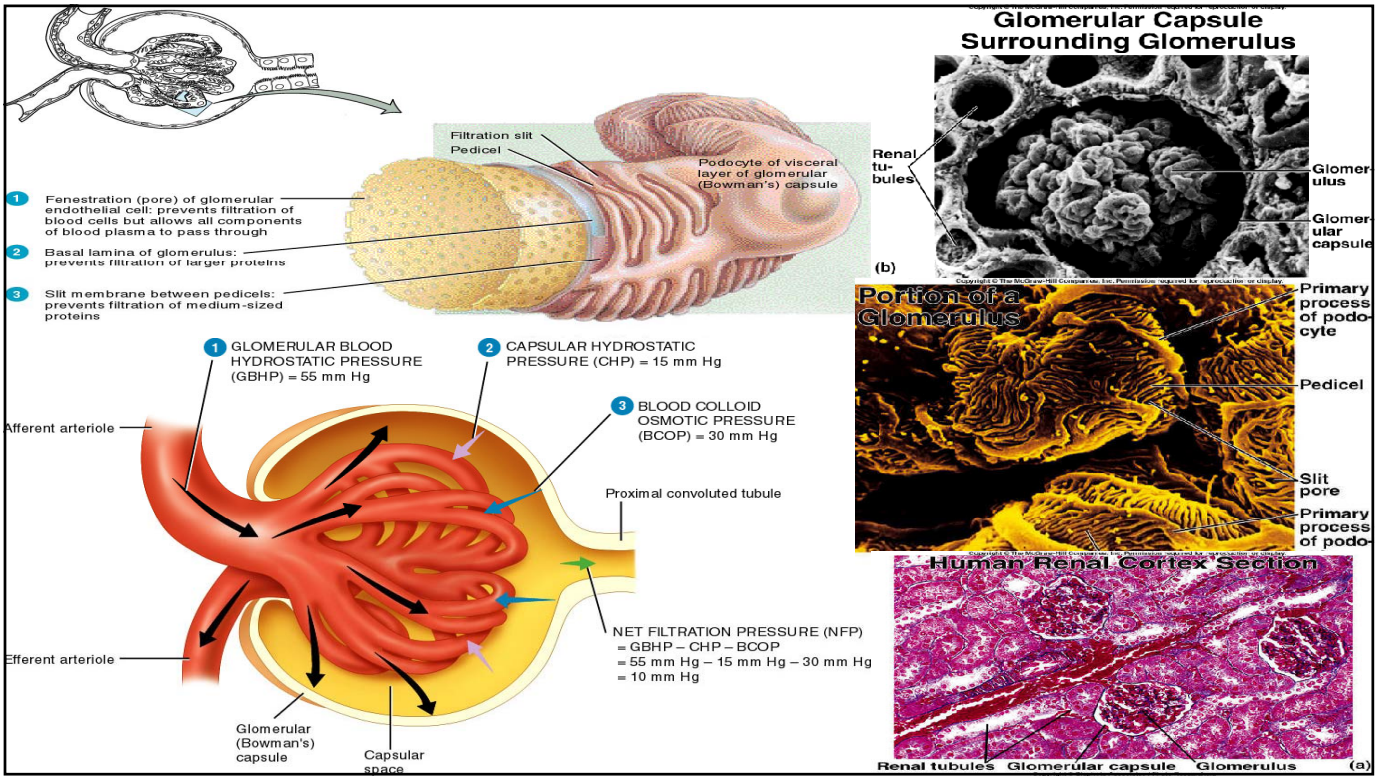

connecting tubule
distal tubule
proximal tubule
collecting duct
intermediate tubule
cortex
outer stripe
outer medulla
inner stripe
inner medulla
Kidney H&E
medullary ray
glomeruli

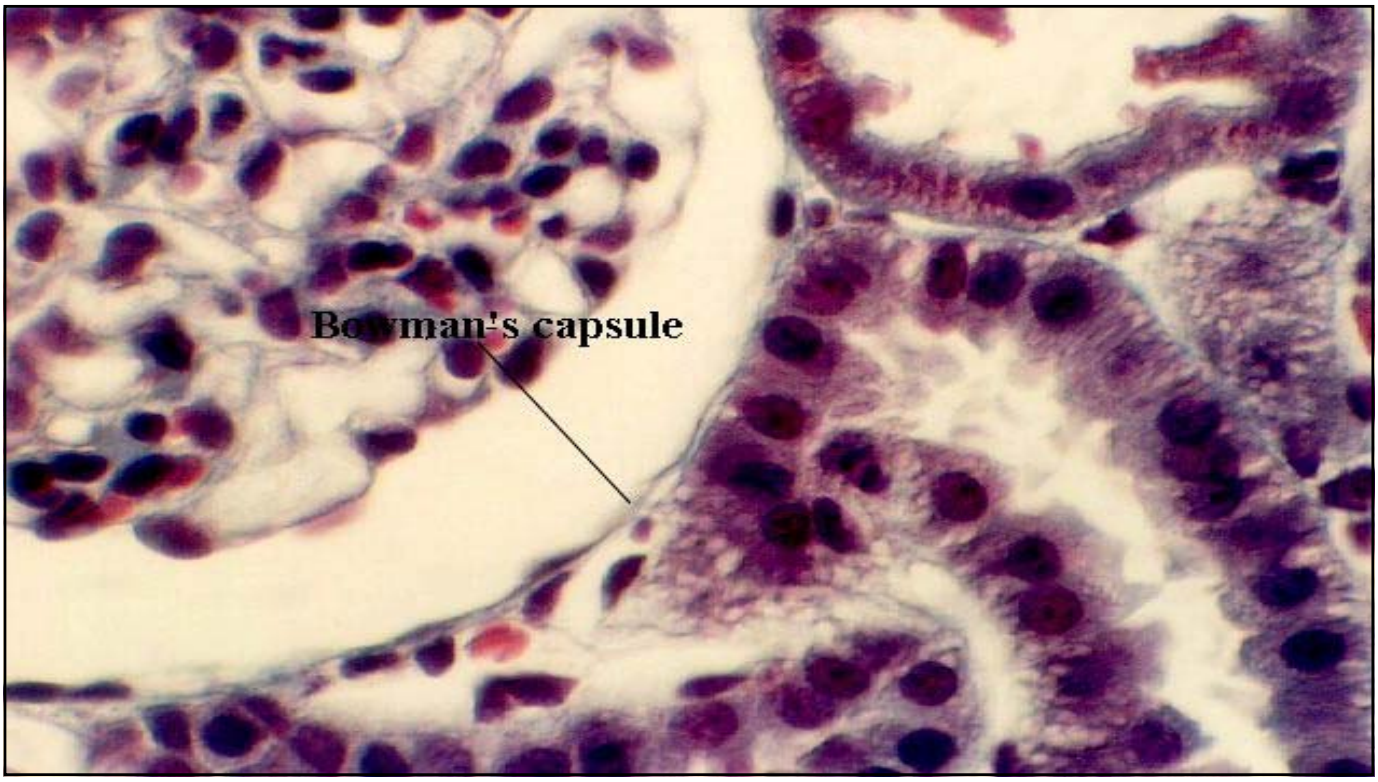

Renal capsule
Renal corpuscle:
Glomerular (Bowman's) capsule
Glomerulus
Efferent arteriole
Distal convoluted tubule
Afferent arteriole
Interlobular artery
Interlobular vein
Arcuate vein
Arcuate artery
Corticomedullary junction
Loop of Henle:
Descending limb of the loop of Henle
Ascending limb of the loop of Henle
Collecting duct
Papillary duct
Renal papilla
Minor calyx
Urine
Proximal convoluted tubule
Peritubular capillary
Renal cortex
Renal medulla
Renal papilla
Minor calyx
Kidney
Renal cortex
Renal medulla
FLOW OF FLUID THROUGH A CORTICAL NEPHRON
Glomerular (Bowman's) capsule
Proximal convoluted tubule
Descending limb of the loop of Henle
Ascending limb of the loop of Henle
Distal convoluted tubule (drains into collecting duct)
(a) Cortical nephron and vascular supply

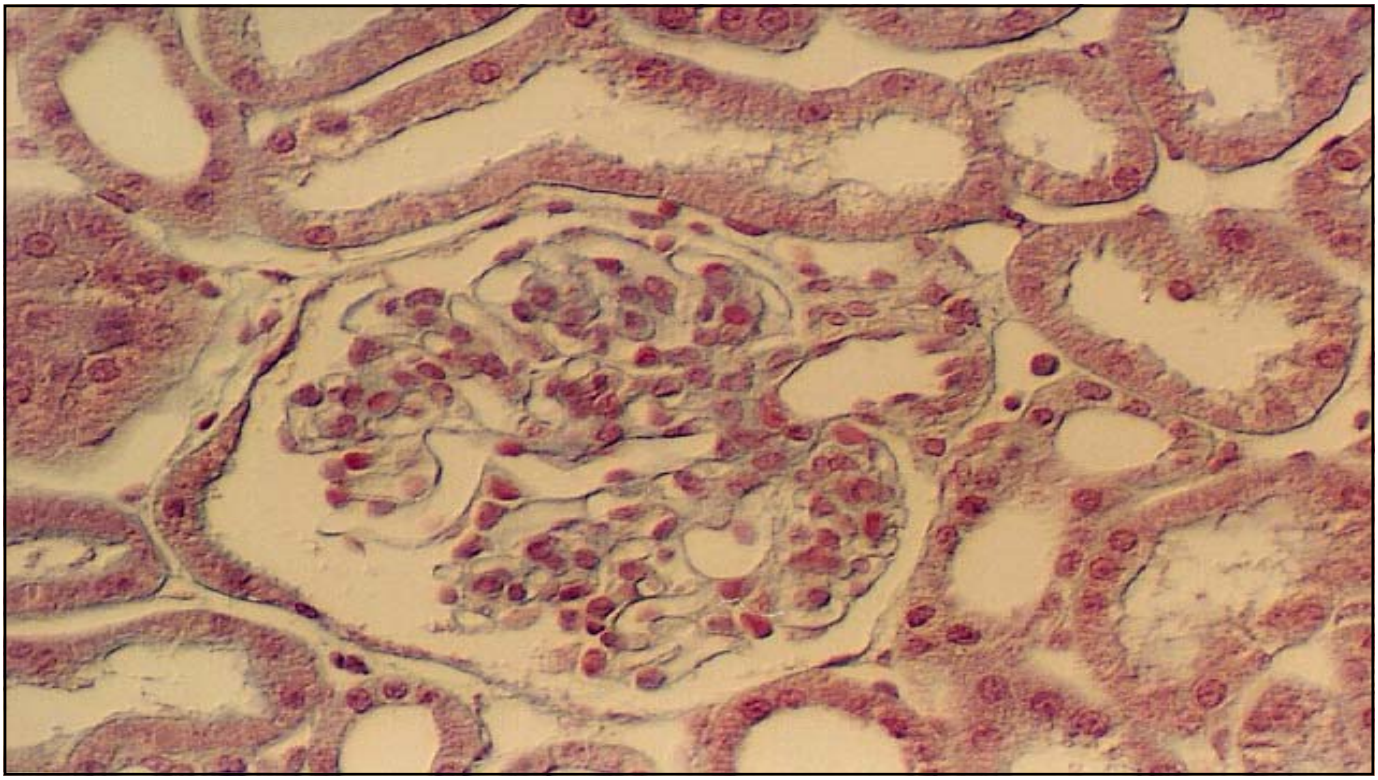

Proximal convoluted tubule
Peritubular capillary
Renal cortex
Renal medulla
Renal papilla
Minor calyx
Kidney
Renal cortex
Renal medulla
Vasa recta
Distal convoluted tubule
Renal corpuscle:
Glomerular (Bowman's) capsule
Glomerulus
Afferent arteriole
Efferent arteriole
Interlobular artery
Interlobular vein
Arcuate vein
Arcuate artery
Corticomedullary junction
Collecting duct
Loop of Henle:
Descending limb
Thick ascending limb
Thin ascending limb
Papillary duct
Renal papilla
Minor calyx
Urine
FLOW OF FLUID THROUGH A JUXTAMEDULLARY NEPHRON
Glomerular (Bowman's) capsule
Proximal convoluted tubule
Descending limb of the loop of Henle
Thin ascending limb of the loop of Henle
Thick ascending limb of the loop of Henle
Distal convoluted tubule (drains into collecting duct)
(b) Juxtamedullary nephron and vascular supply

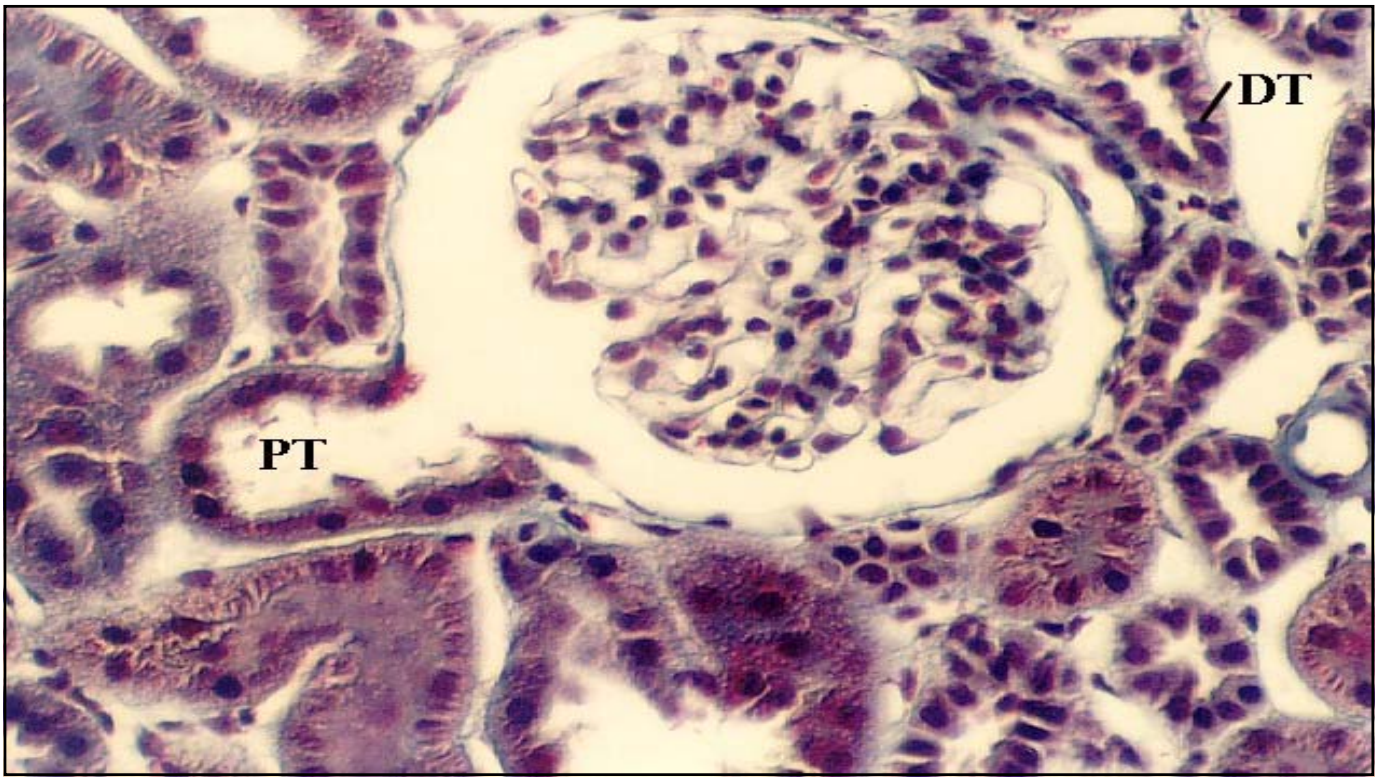

Renal corpuscle (external view)
Afferent arteriole
Juxtaglomerular cell
Macula densa
Ascending limb of loop of Henle
Efferent arteriole
Endothelium of glomerulus
Parietal layer of glomerular (Bowman's) capsule
Mesangial cell
Capsular s
Podocyte of viscera glomerular (Bowma
Pedicel
(a) Renal corpuscle (internal view)
Kidney, Cortex H&E
vascular pole
podocytes
capsular space
urinary pole
distal tubules
Renal corpuscle
Renal tubule and collecting duct
Afferent arteriole
Glomerular capsule
Filtration from blood plasma into nephron
1
Efferent arteriole
Fluid in renal tubule
2
Tubular reabsorption from fluid into blood
3
Tubular secretion from blood into fluid
Urine (contains excreted substances)
Blood (contains reabsorbed substances)
Peritubular capillaries

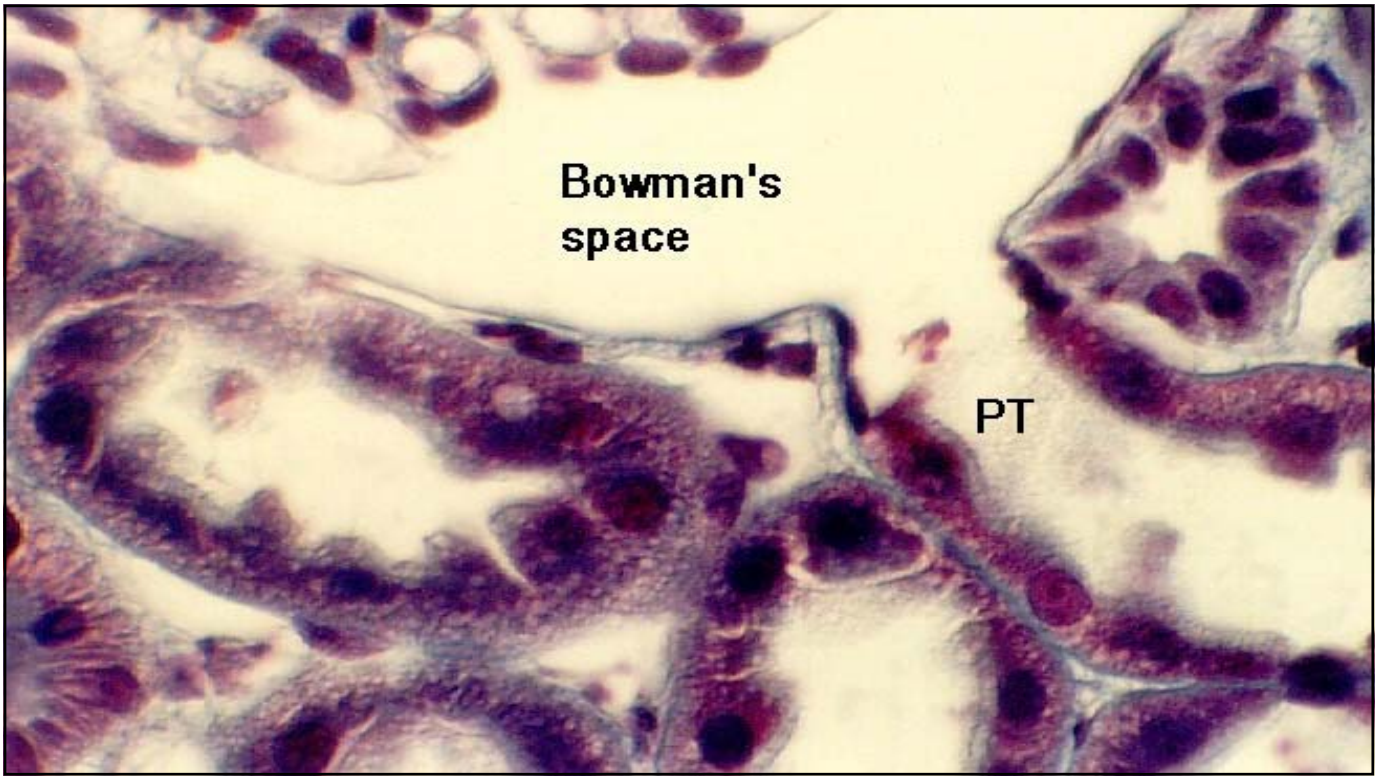

Flow of blood
Flow of filtrate
Parietal layer of glomerular capsule
Capsular space
Afferent arteriole
Tubular pole
Vascular pole
Proximal convoluted tubule
Juxtaglomerular apparatus
Juxtaglomerular cell
Macula densa
Glomerulus
Podocyte of visceral layer of glomerular capsule
Distal convoluted tubule
Efferent arteriole
Pedicel
Endothelium of glomerulus
(a) Renal corpuscle
Proximal convoluted tubule
Capsular space
Glomerulus
Afferent arteriole
Distal convoluted tubule
LM 300x
(b)

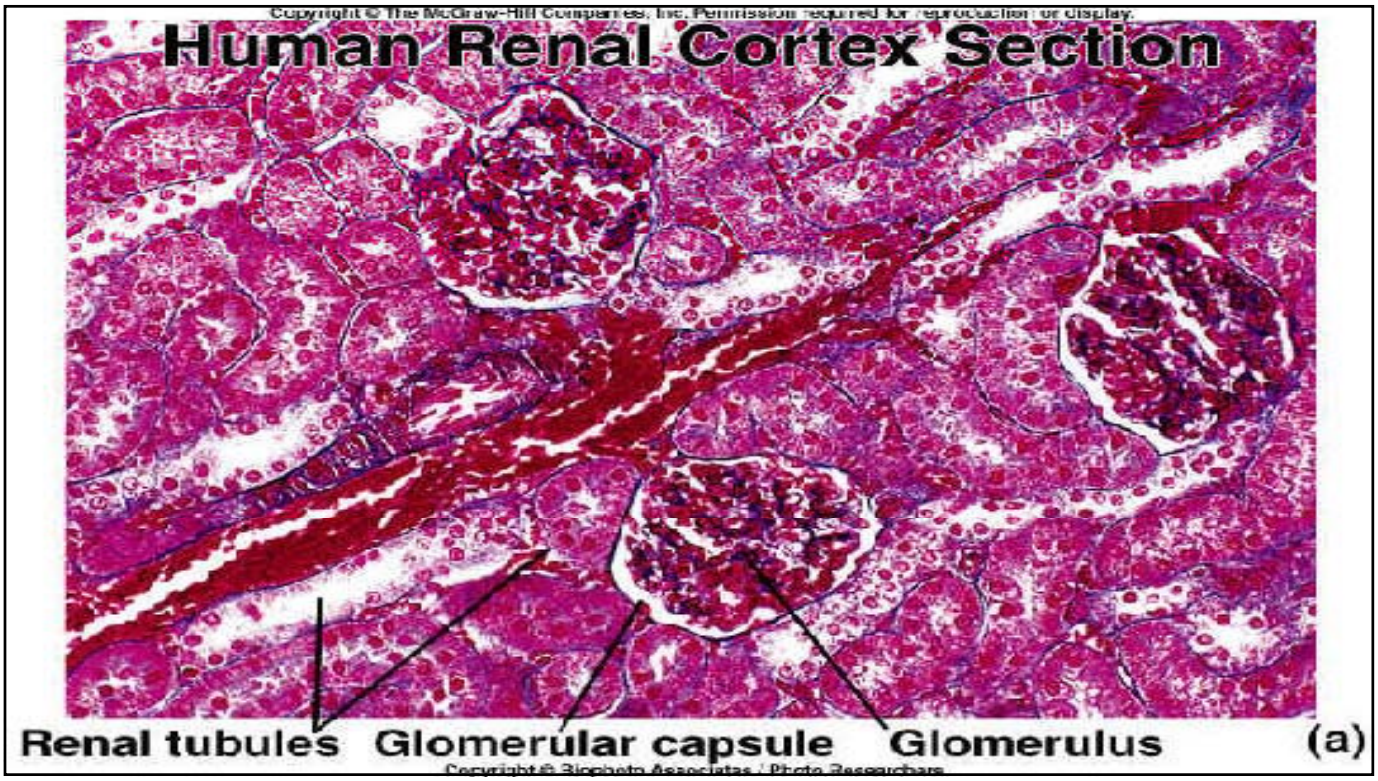

Filtration slit
Pedicel
Podocyte of visceral layer of glomerular (Bowman's) capsule
1 Fenestration (pore) of glomerular endothelial cell: prevents filtration of blood cells but allows all components of blood plasma to pass through
2 Basal lamina of glomerulus: prevents filtration of larger proteins
3 Slit membrane between pedicels: prevents filtration of medium-sized proteins
1 GLOMERULAR BLOOD HYDROSTATIC PRESSURE (GBHP) = 55 mm Hg
2 CAPSULAR HYDROSTATIC PRESSURE (CHP) = 15 mm Hg
3 BLOOD COLLOID OSMOTIC PRESSURE (BCOP) = 30 mm Hg
Afferent arteriole
Proximal convoluted tubule
Efferent arteriole
NET FILTRATION PRESSURE (NFP)
= GBHP – CHP – BCOP
= 55 mm Hg – 15 mm Hg – 30 mm Hg
= 10 mm Hg
Glomerular (Bowman's) capsule
Capsular space
Glomerular Capsule Surrounding Glomerulus
Renal tubules
Glomerulus
Glomerular capsule
(b)
Portion of a Glomerulus
Primary process of podocyte
Pedicel
Slit pore
Primary process of podo-
Human Renal Cortex Section
Renal tubules
Glomerular capsule
Glomerulus
(a)

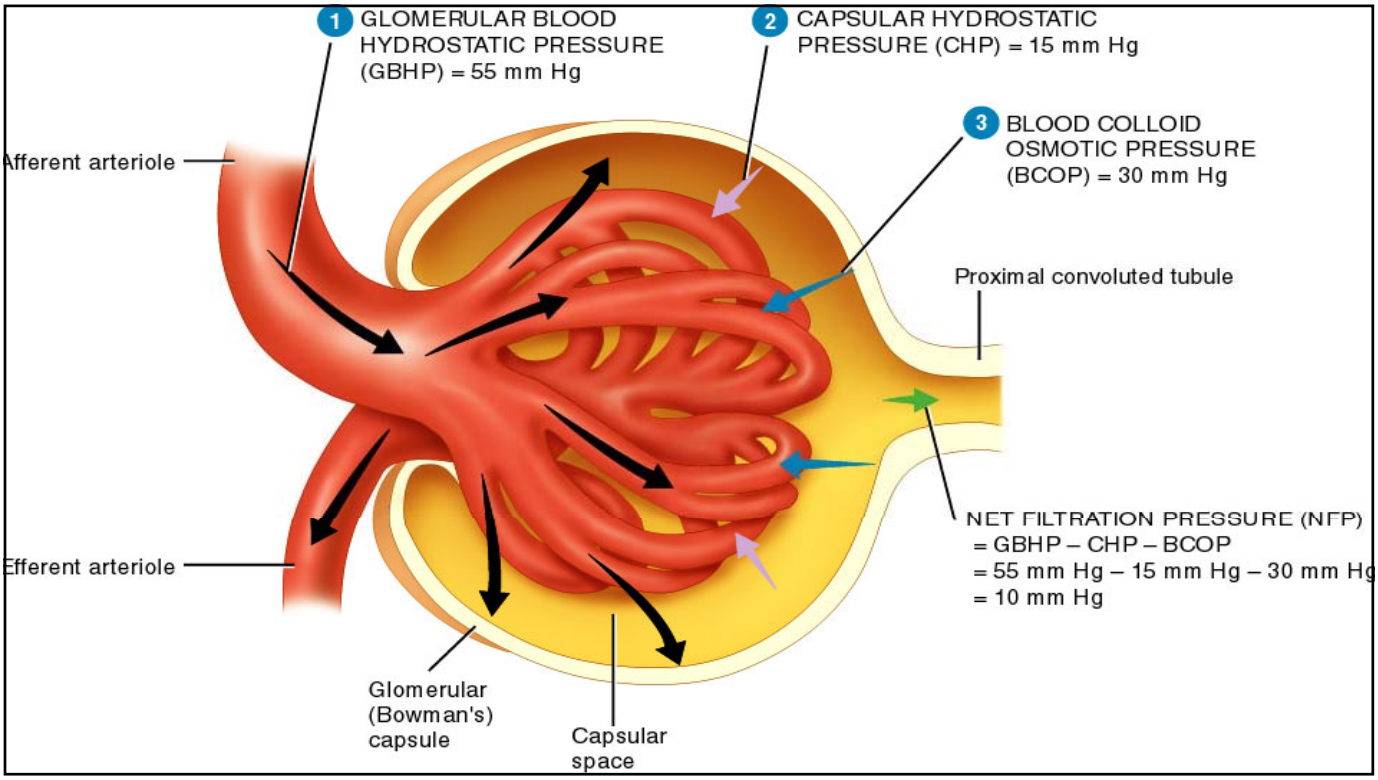

Bowman's capsule




DT
PT

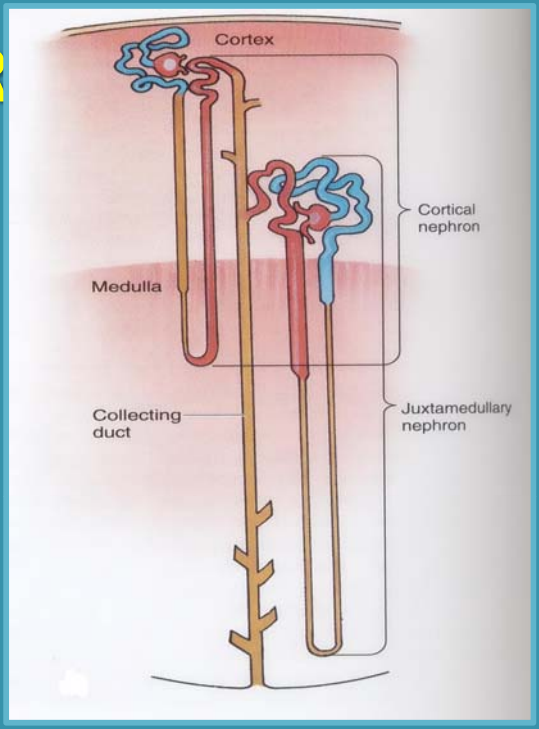

Bowman's
space
PT


Human Renal Cortex Section
Renal tubules
Glomerular capsule
Glomerulus
(a)


1 GLOMERULAR BLOOD HYDROSTATIC PRESSURE (GBHP) = 55 mm Hg
2 CAPSULAR HYDROSTATIC PRESSURE (CHP) = 15 mm Hg
3 BLOOD COLLOID OSMOTIC PRESSURE (BCOP) = 30 mm Hg
Afferent arteriole
Proximal convoluted tubule
NET FILTRATION PRESSURE (NFP)
= GBHP – CHP – BCOP
= 55 mm Hg – 15 mm Hg – 30 mm Hg
= 10 mm Hg
Efferent arteriole
Glomerular (Bowman's) capsule
Capsular space

NEPHR

- Two types depending on location of their Henle loop
- Cortical (short)
- Juxtamedullary (long)



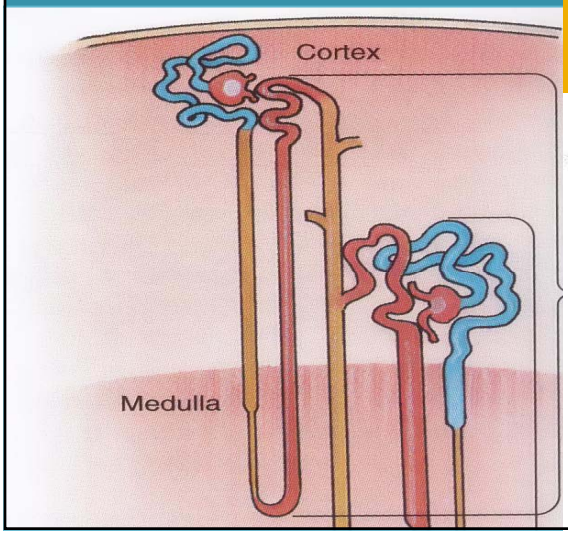
The nephron

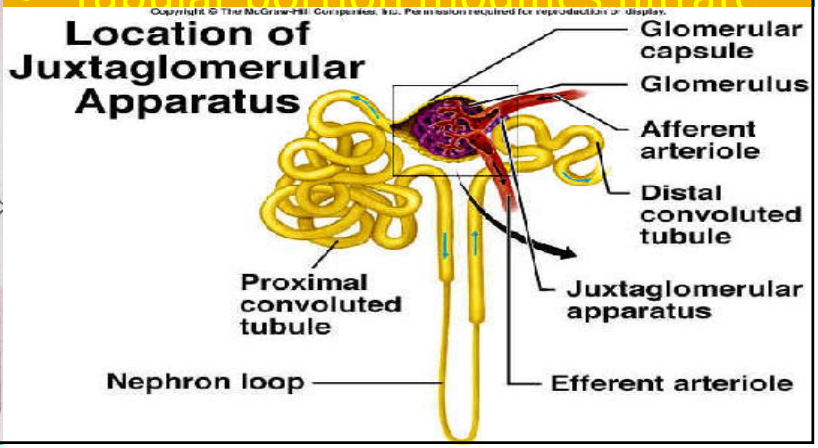
Each nephron consists of:

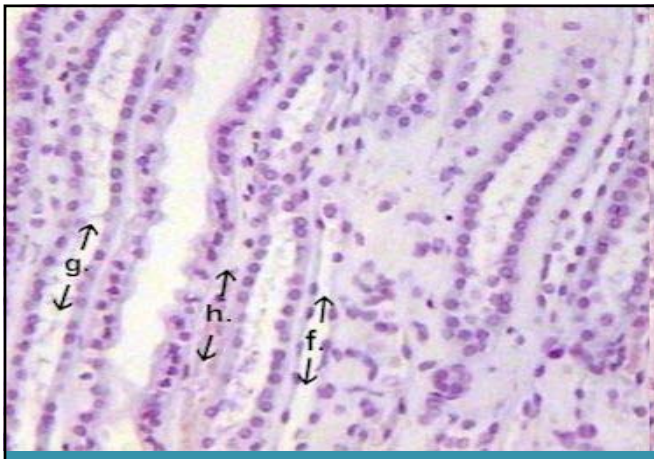
- **Renal corpuscle** (Renal body, Malpighian body)
- **Proximal convoluted tubule**
- **Loop of Henle**
- **Distal convoluted tubule**
- **Collecting duct** (Some authors do not include the collecting duct as a part of the nephron owing to its different embryologic origin).

NE

- Parts are modified for specific physiological functions
- Renal corpuscle filters fluid from blood
- Tubular portion modifies filtrate







a. **Glomerulus with fenestrae** a filtration capillary network covered by podocytes.

b. **Bowman's capsule** collects the filtrate.

c. Parietal **capsule wall** made of simple squamous.

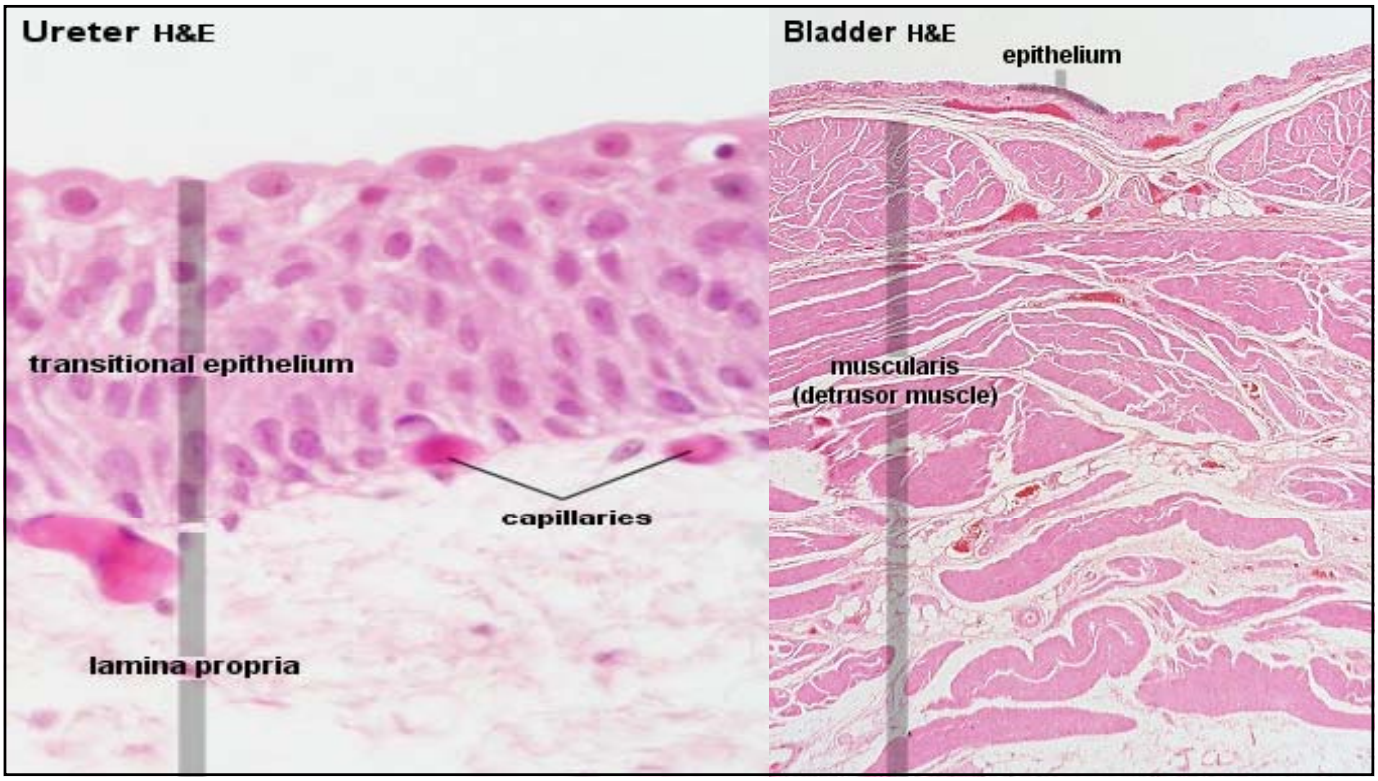
d. **Proximal** convoluted tubule -cuboidal cells with long microvilli

e. **Distal** convoluted tubule - small compact cuboidal cells

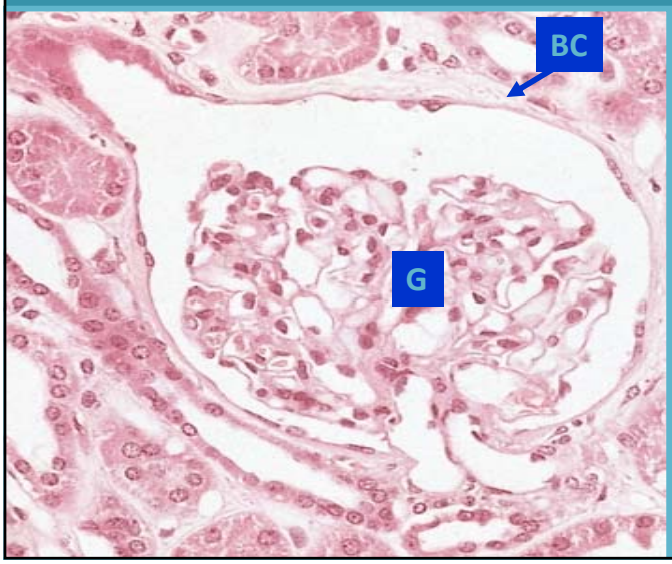
f. **Nephron loop** - thin limb with simple squamous cells

g. **Collecting duct** - lined with cuboidal cells

h. **Peritubular capillary** filled with red blood cells.



Renal Corpuscle

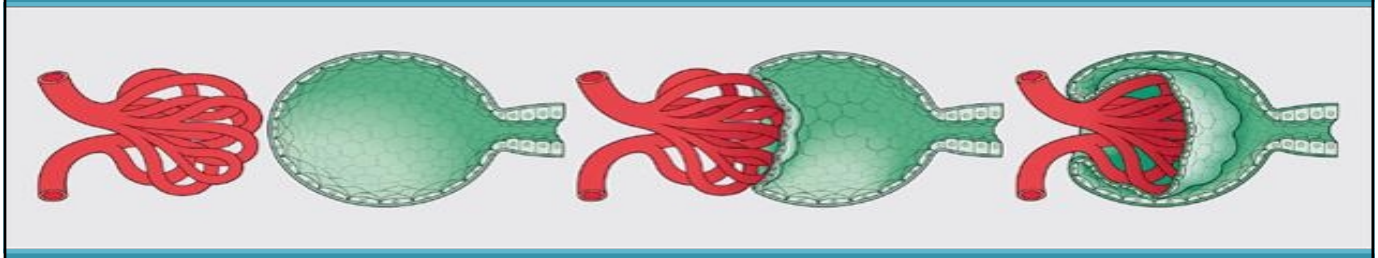


Tuft of fenestrated capillaries - the glomerulus

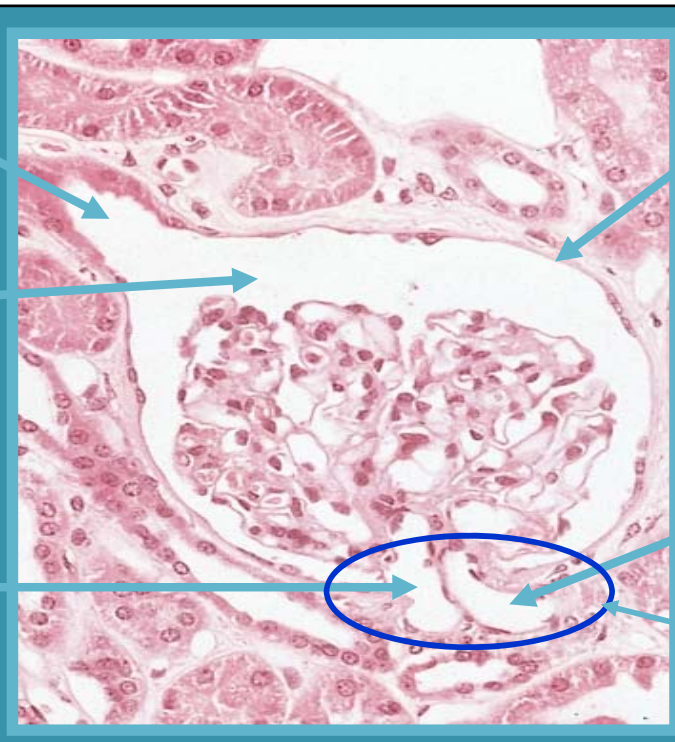
Surrounded by Bowman's capsule

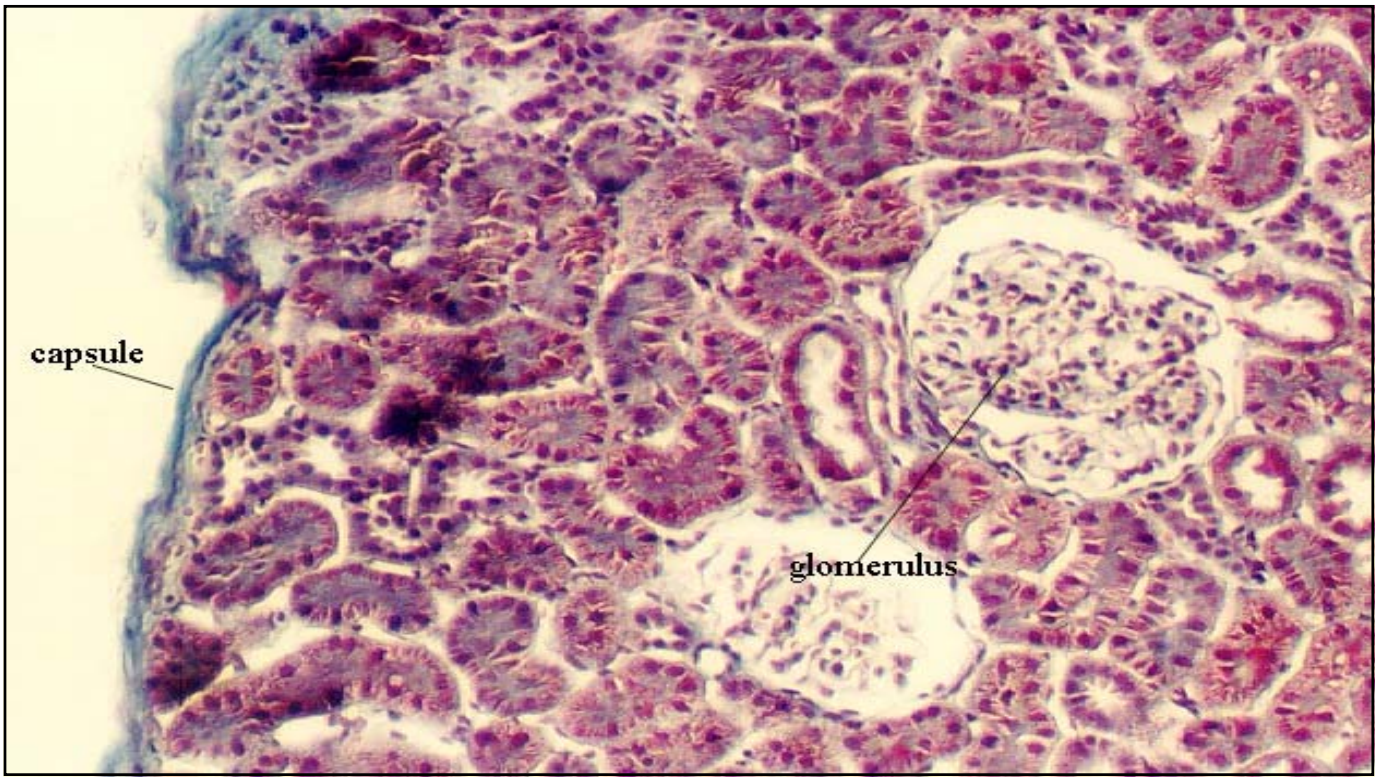
Renal corpuscle

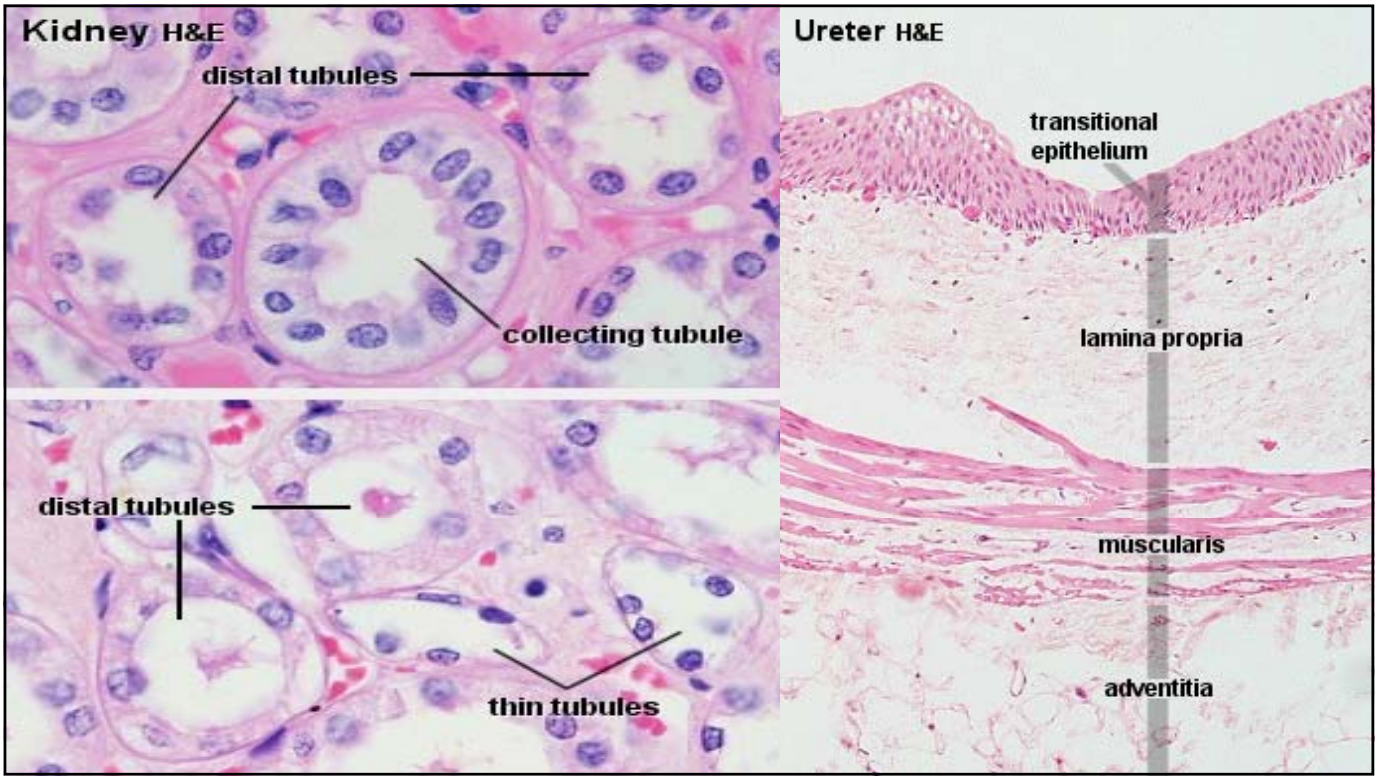
Capillaries invaginate into Bowman's capsule.



Capillaries are in contact with the visceral layer (podocytes).
Parietal layer is simple squamous epithelium.
Separated by the urinary space.



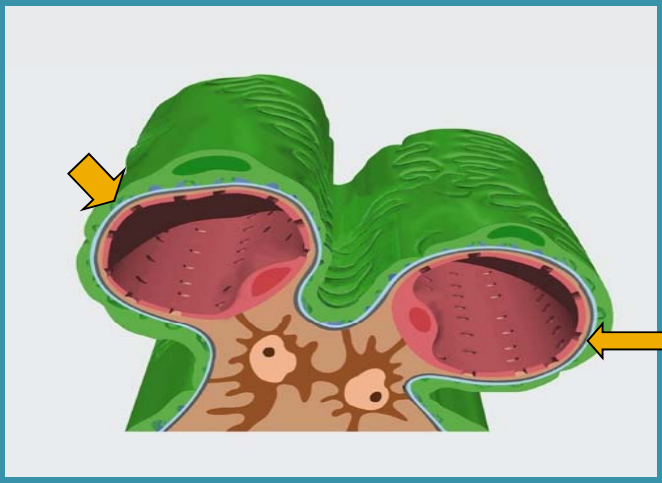

capsule
glomerulus


Kidney H&E
distal tubules
collecting tubule
distal tubules
thin tubules
Ureter H&E
transitional epithelium
lamina propria
muscularis
adventitia

Filtration Barrier

- Fluid from capillaries leaks into the urinary space through a complex filtration barrier
- Capillary endothelium
- Basal lamina
- Podocytes of the visceral layer of Bowman's capsule
- High polyanionic charge on some components of both basal lamina and surface of podocyte processes

Glomerular capillaries



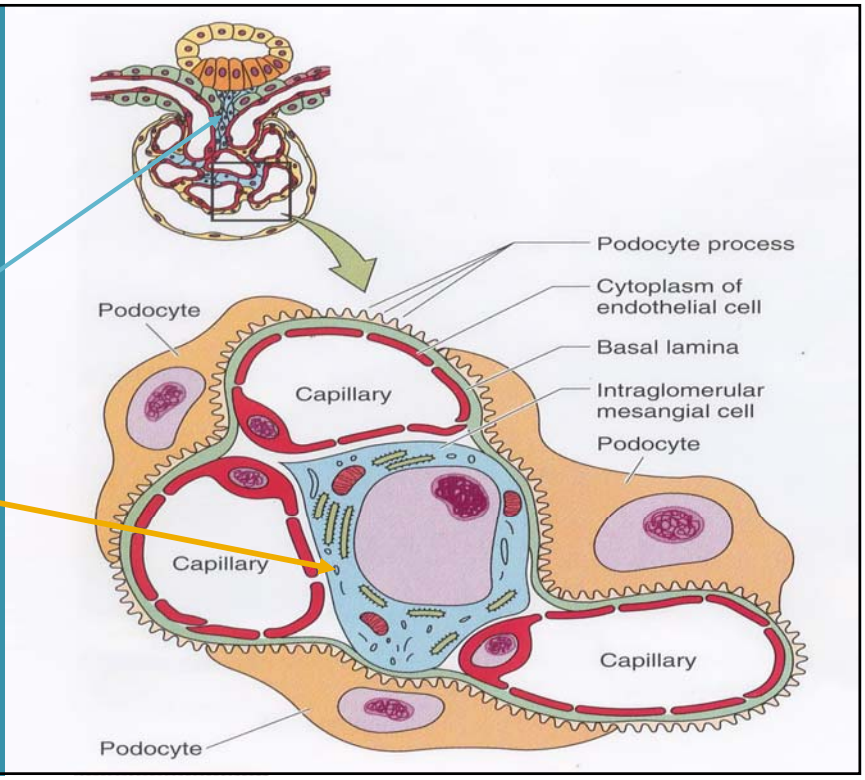
- **Fenestrated**
- **Large pores not covered by a diaphragm**
- **Barrier only to formed elements in blood & large macromolecules**

Mesangial cells

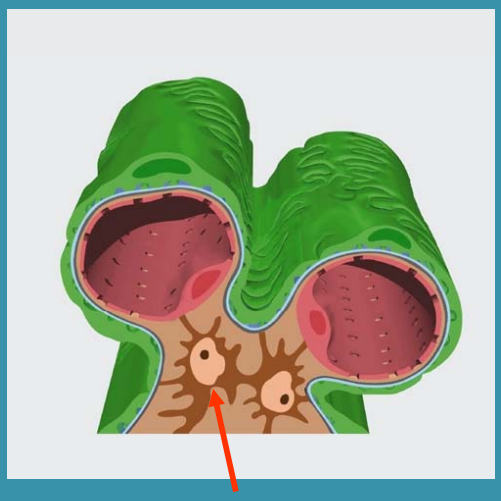
Supporting cells, Modified smooth Muscle

Extraglomerular (vascular pole)

Intraglomerular

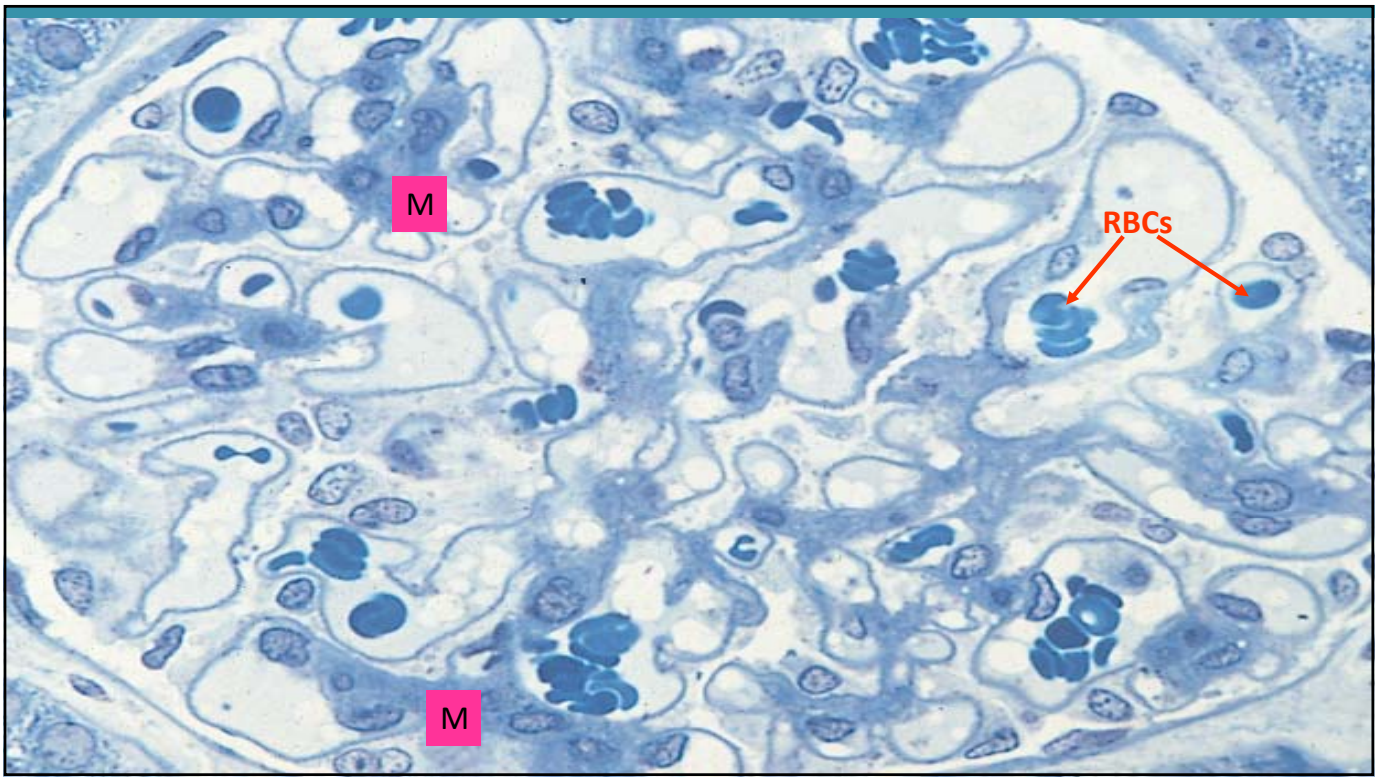


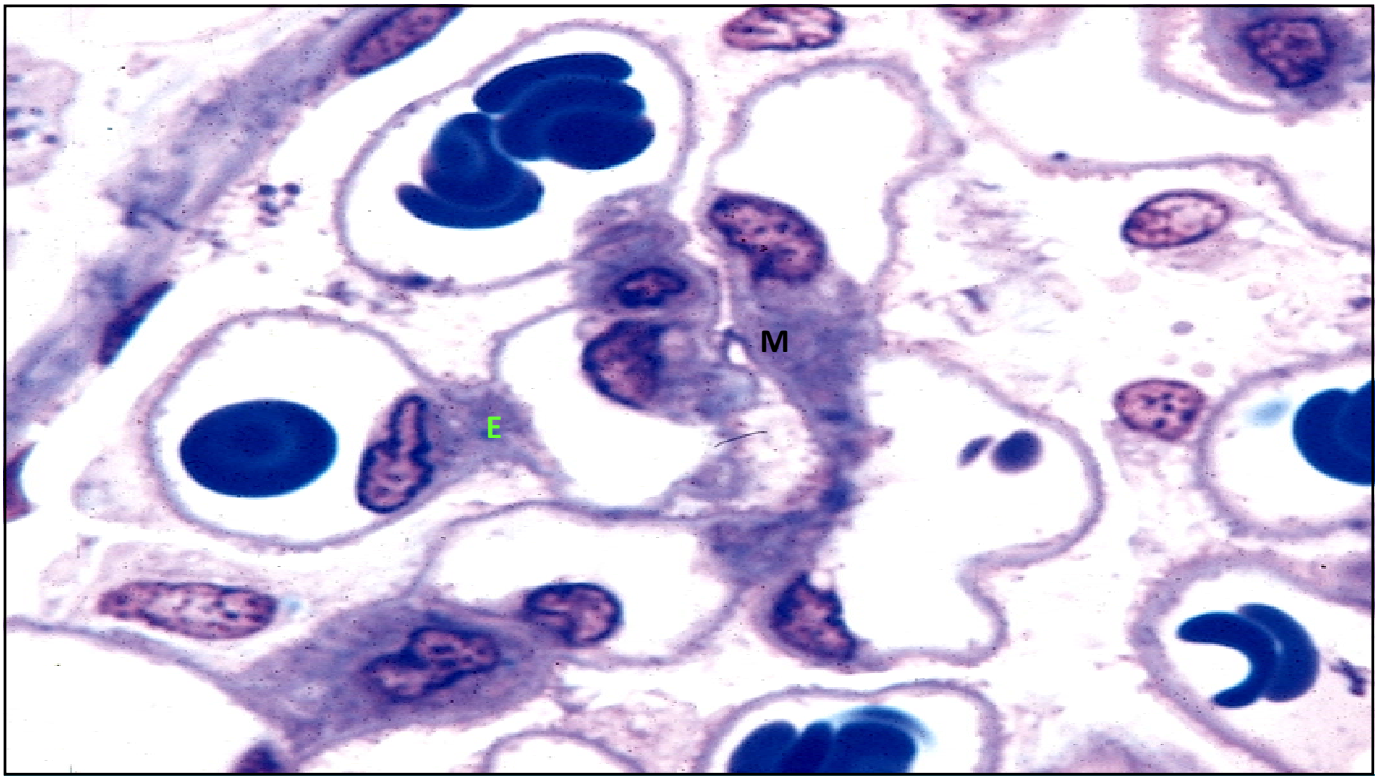
Functions of Mesangial Cells

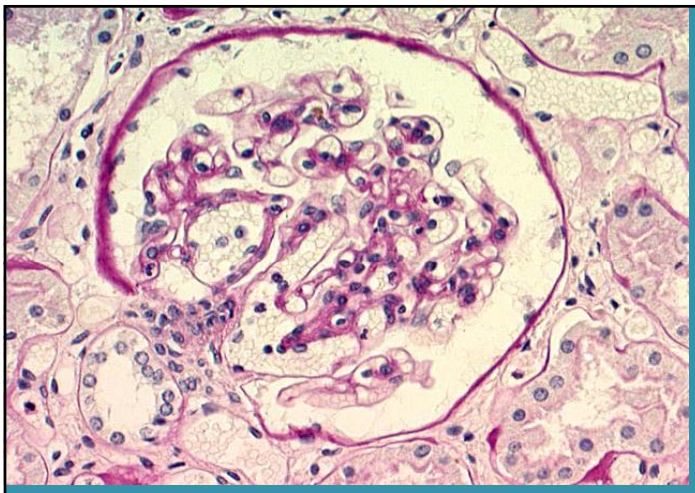


Intraglomerular mesangial cells

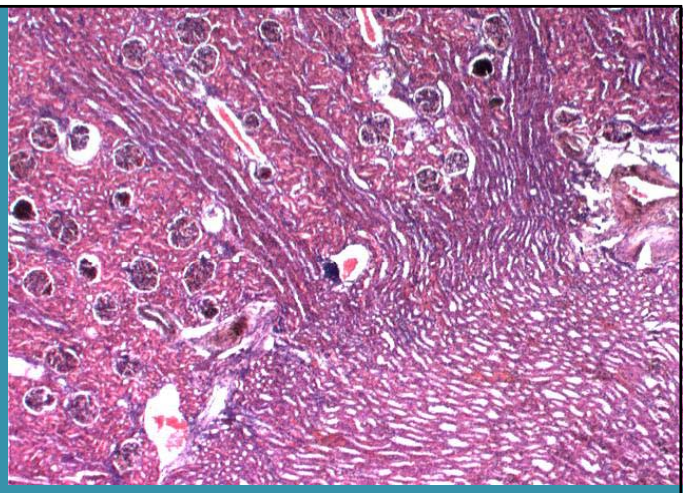
- Contractile - reduce blood flow through capillaries
- Supportive in area where the visceral layer of the renal corpuscle is absent
- Phagocytic – resorption & maintenance of the basal lamina


M
RBCs
M

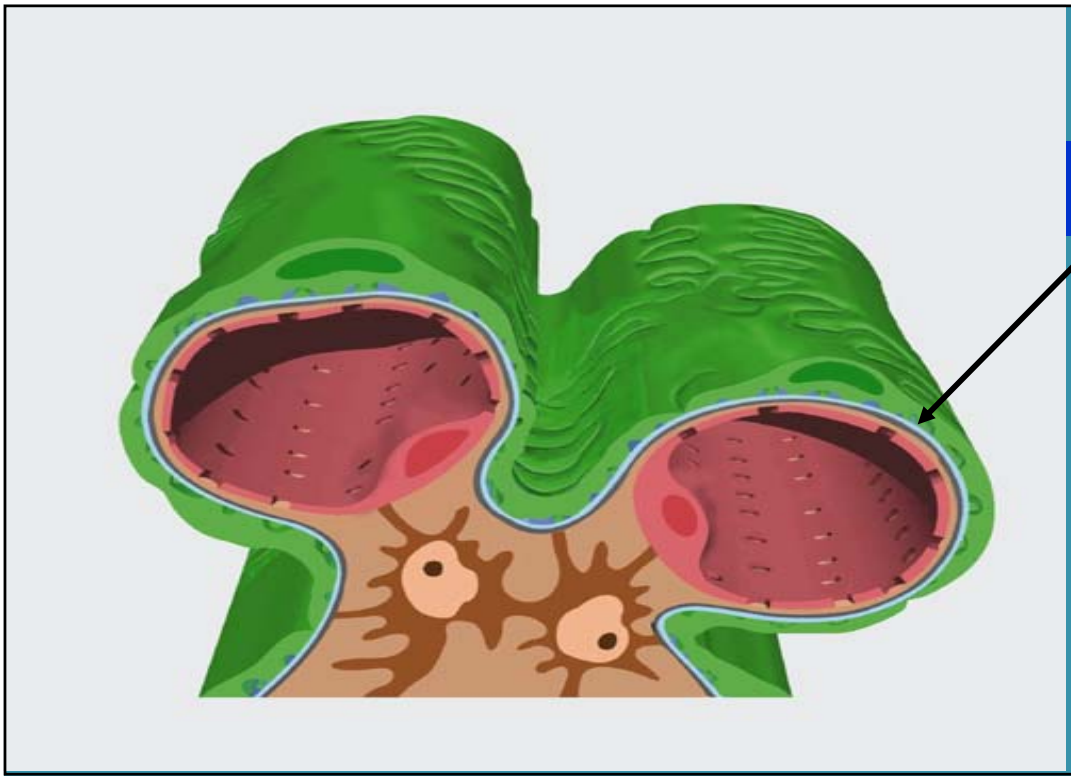

M
E



A Renal Corpuscle



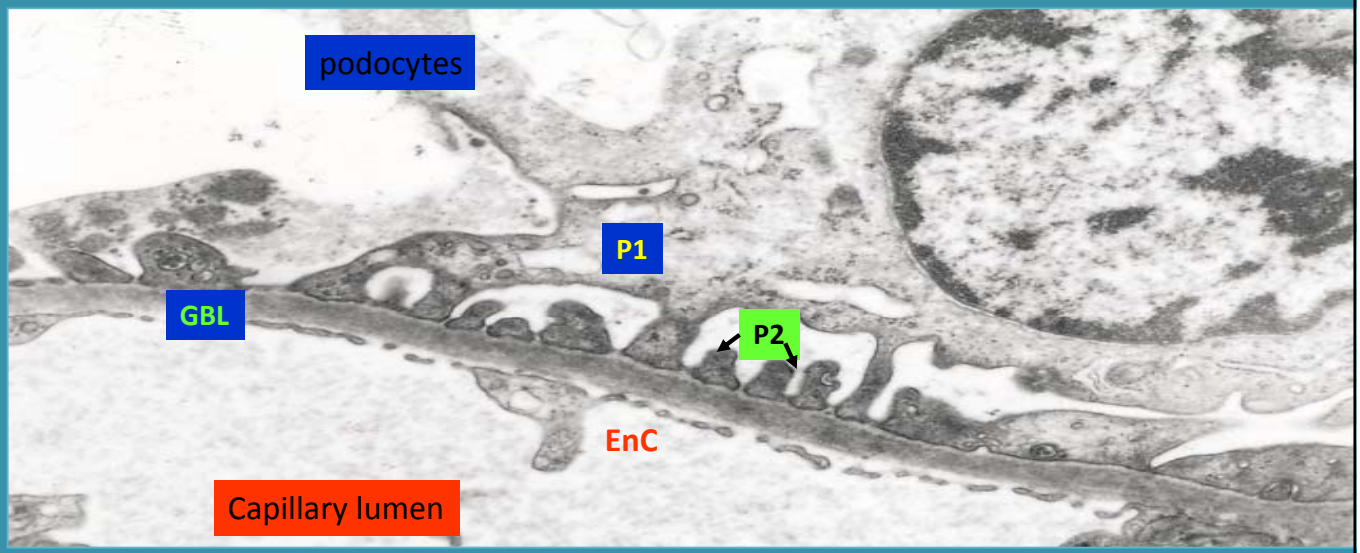
Medulla vs. Cortex

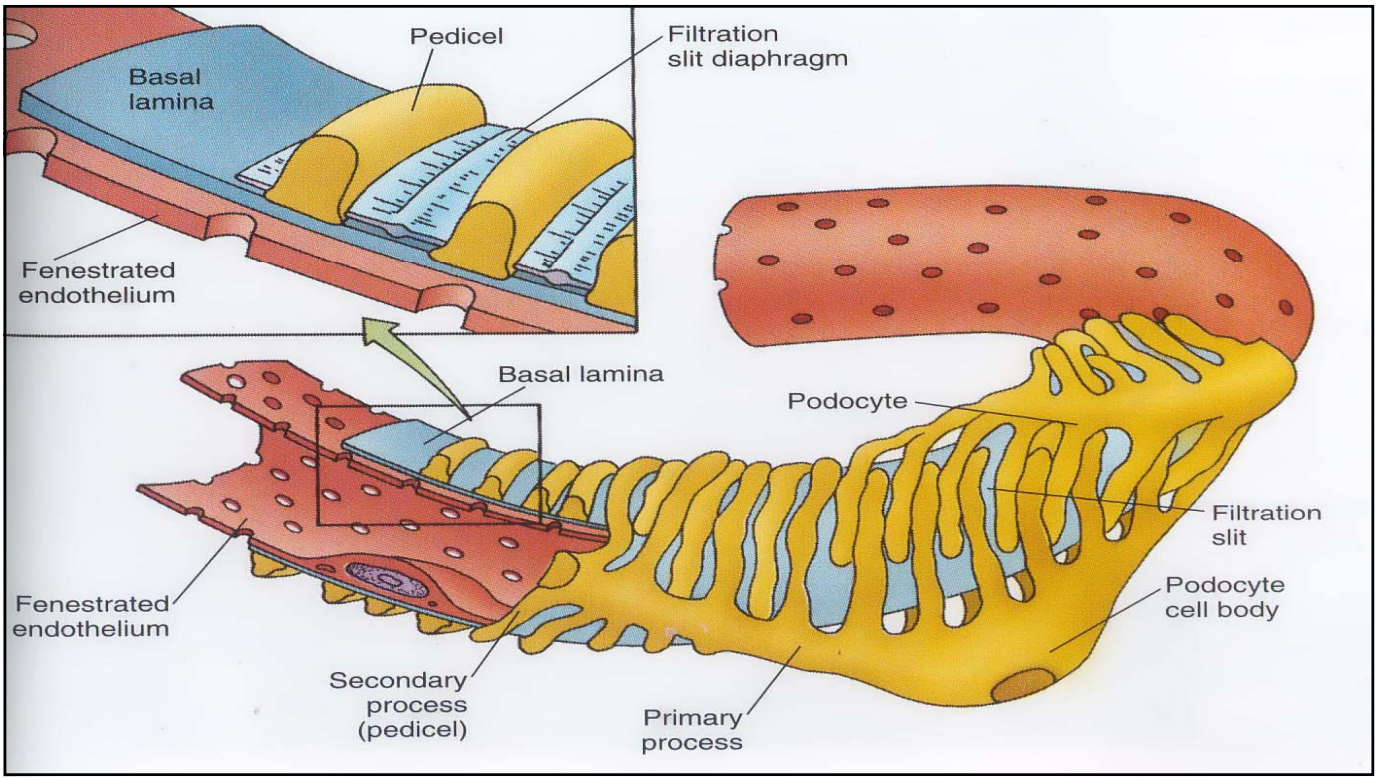


Basal Lamina

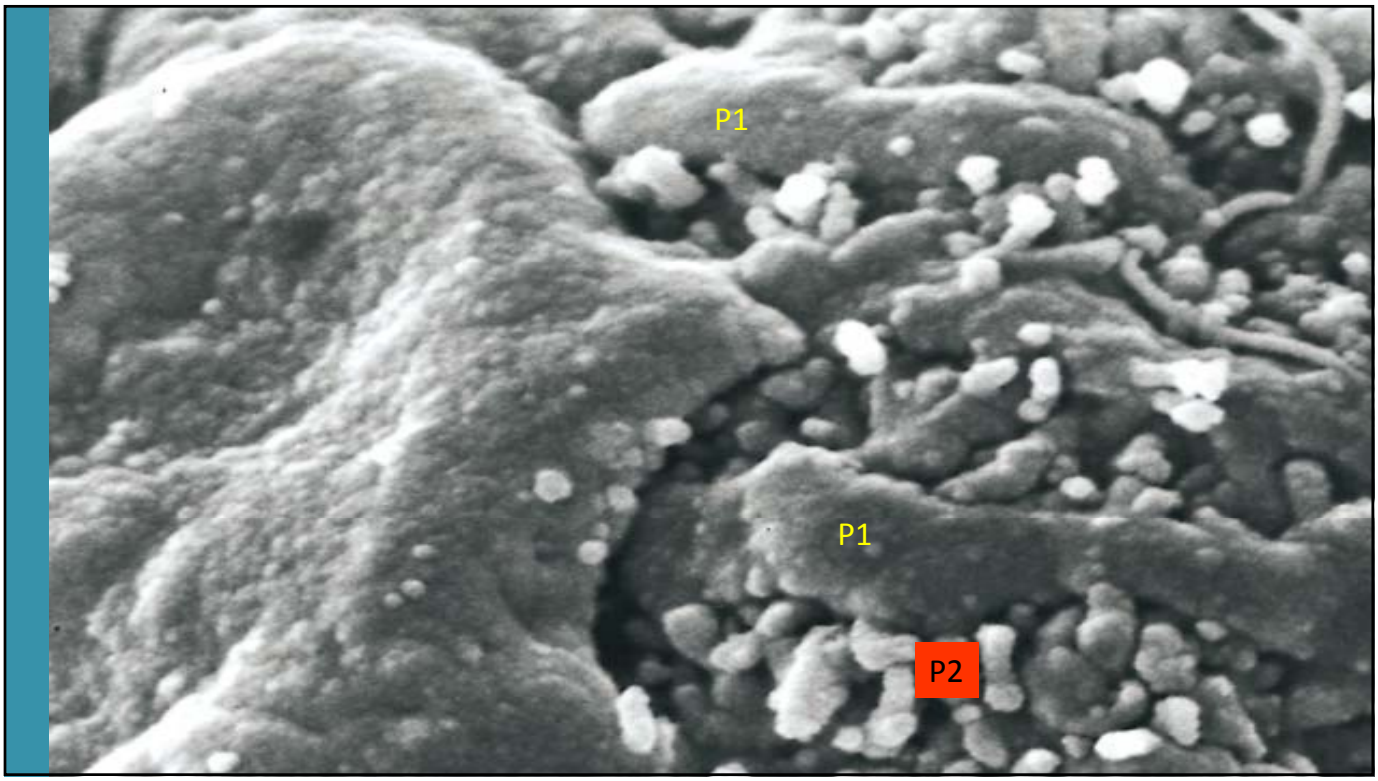
Lamina rarae contain:
Laminin
Fibronectin
Negatively-charged proteoglycans

Visceral Layer of Bowman's Capsule

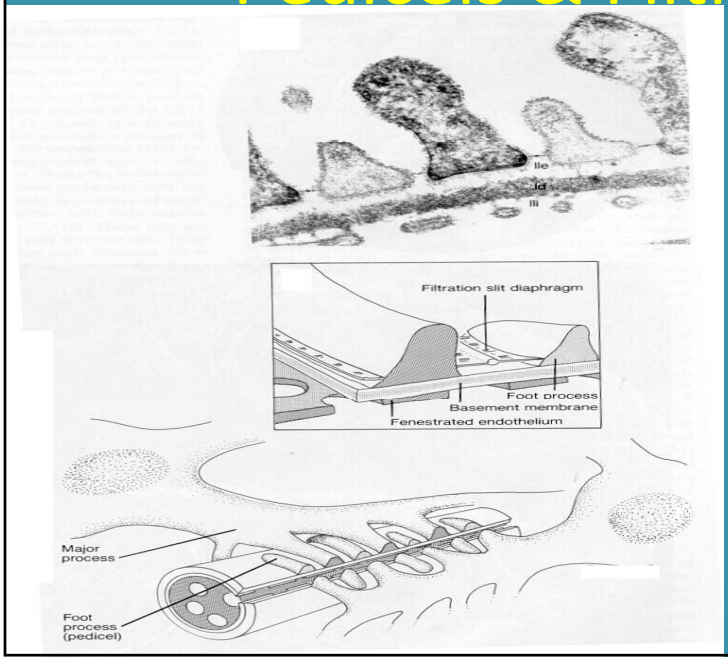



Pedicel
Filtration slit diaphragm
Basal lamina
Fenestrated endothelium
Basal lamina
Podocyte
Filtration slit
Podocyte cell body
Fenestrated endothelium
Secondary process (pedicel)
Primary process


P



Pedicels & Filtration slits



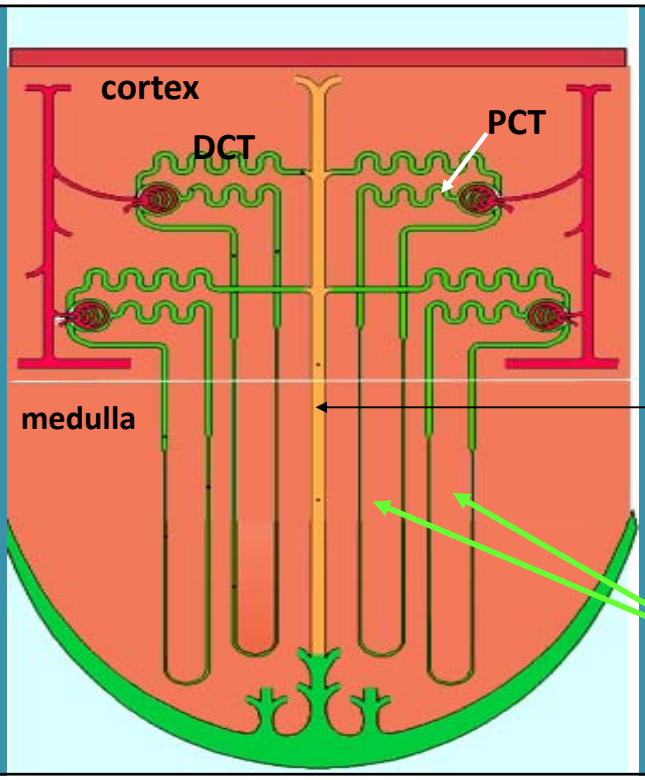
- Each pedicel has a glycocalyx of negatively-charged podocalyxin
- Separated by clefts – filtration slits
- Covered by a porous slit diaphragm

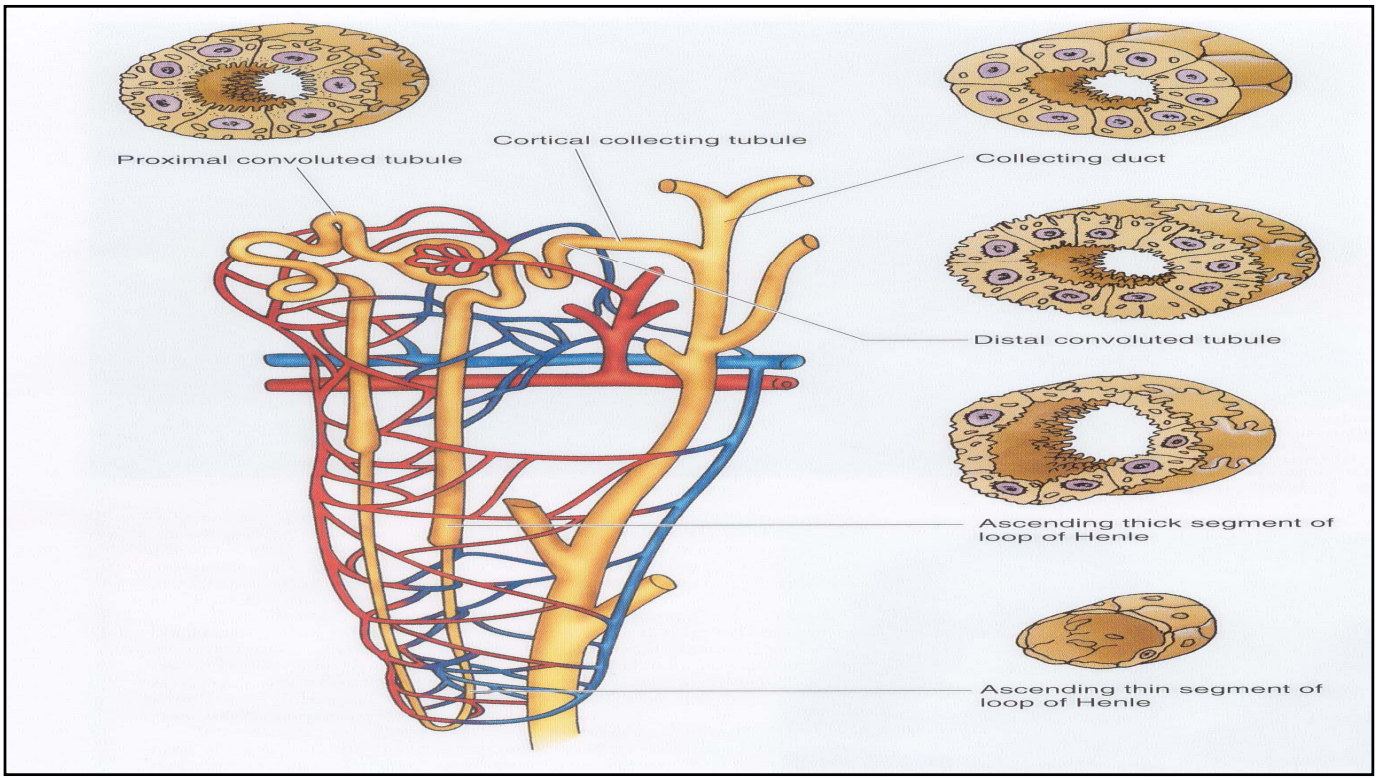
Filtration Process

- Blood enters glomerulus via afferent arteriole
- Arteriole pressure forces fluid through fenestrae of capillary endothelium
- Large molecules are trapped by the basal lamina
- Negatively charged molecules are stopped by the basal lamina & podocytes
- Fluid passes though pores in slit diaphragm to enter the urinary space.

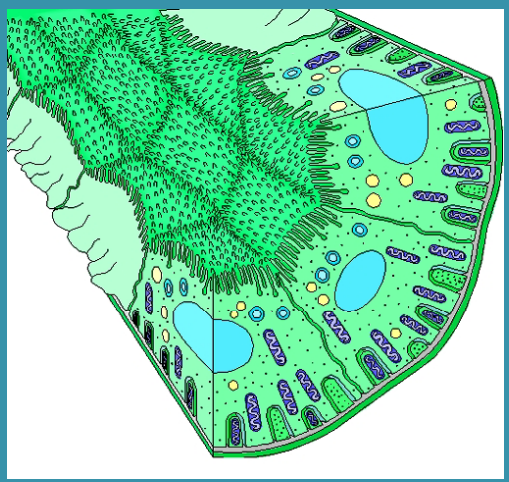
Tubular and Collecting System

Glomerular ultrafiltrate leaves urinary space and enters tubule which modifies its composition

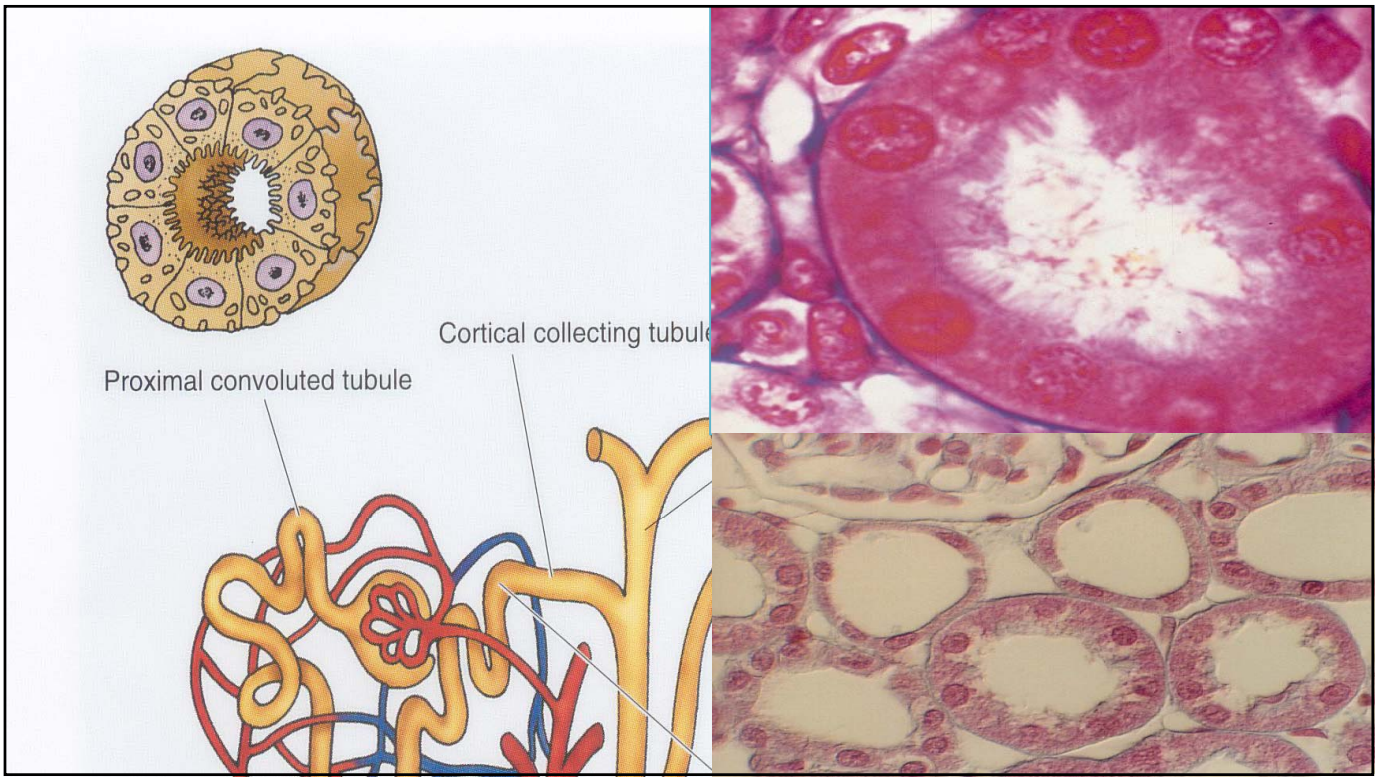


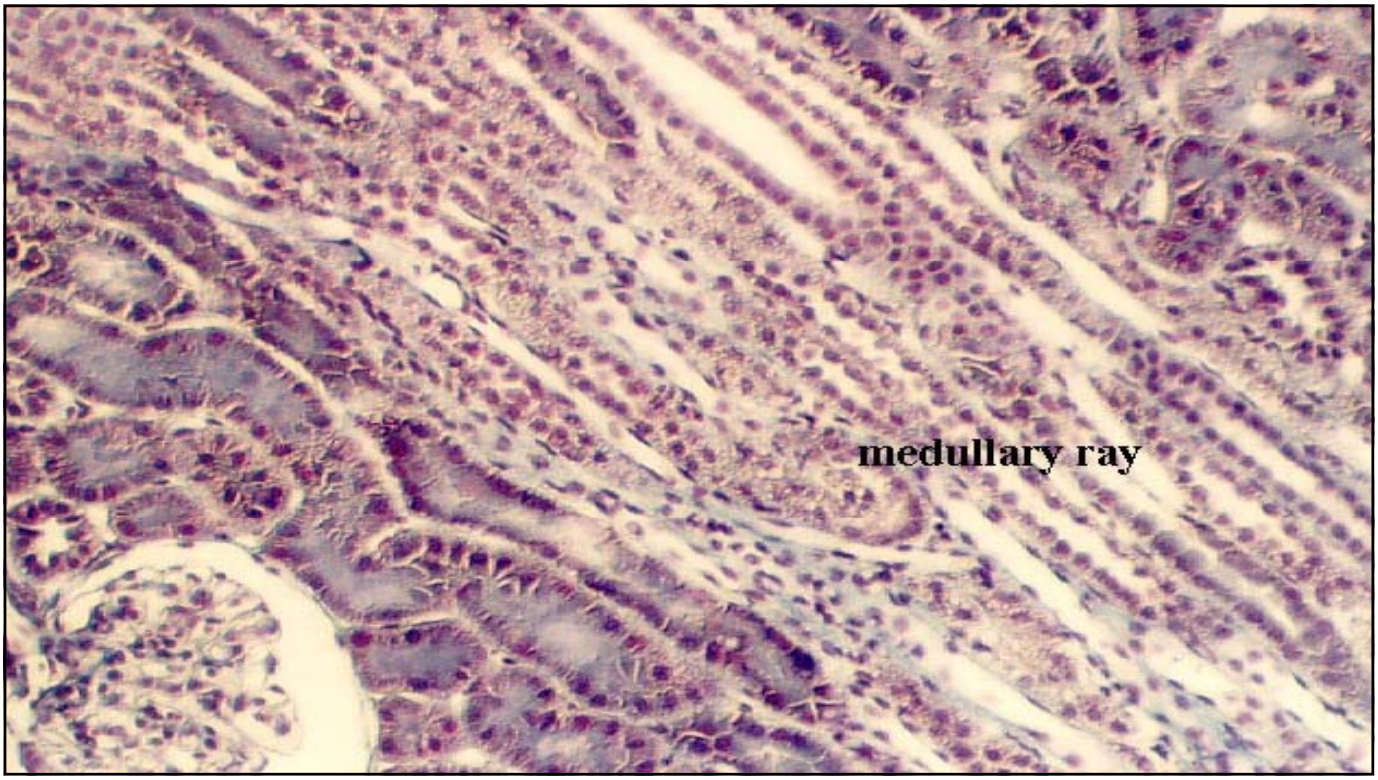


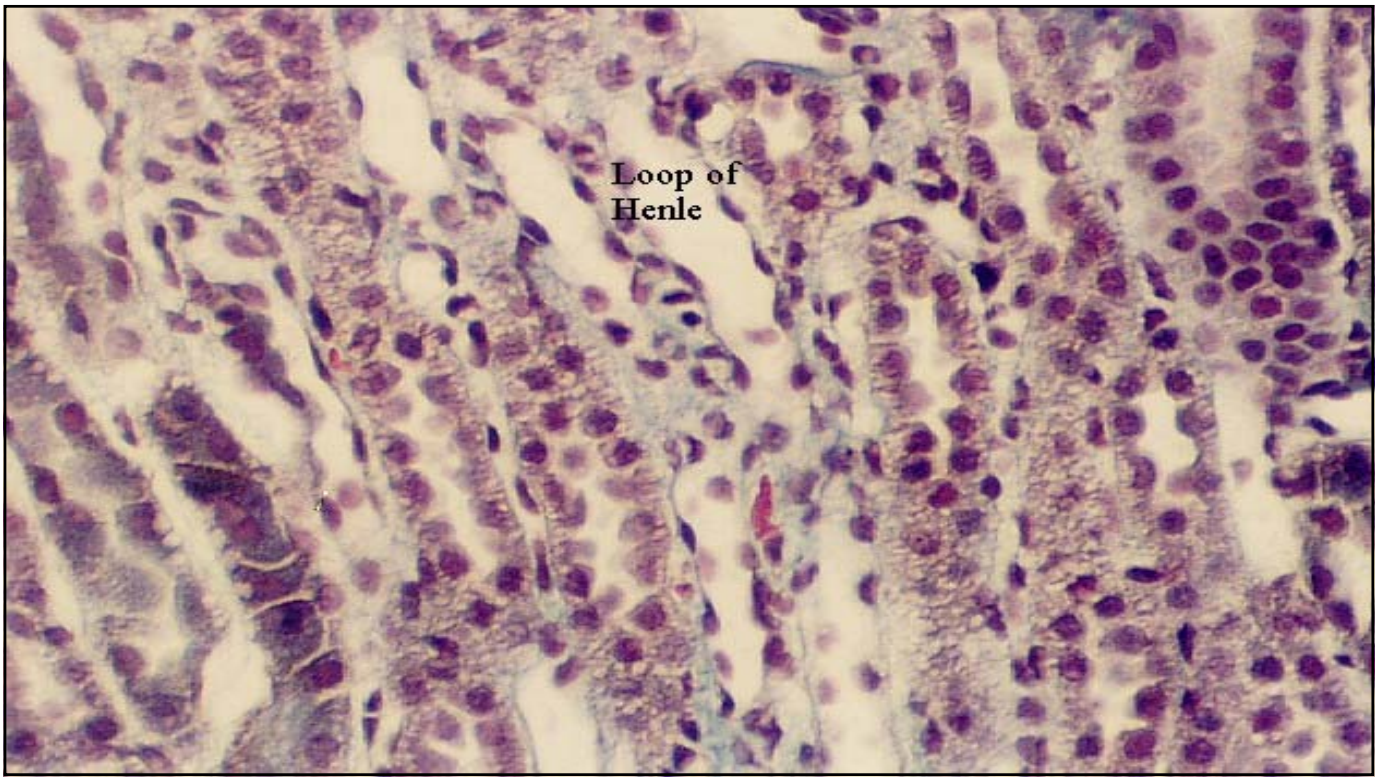
Proximal Tubule



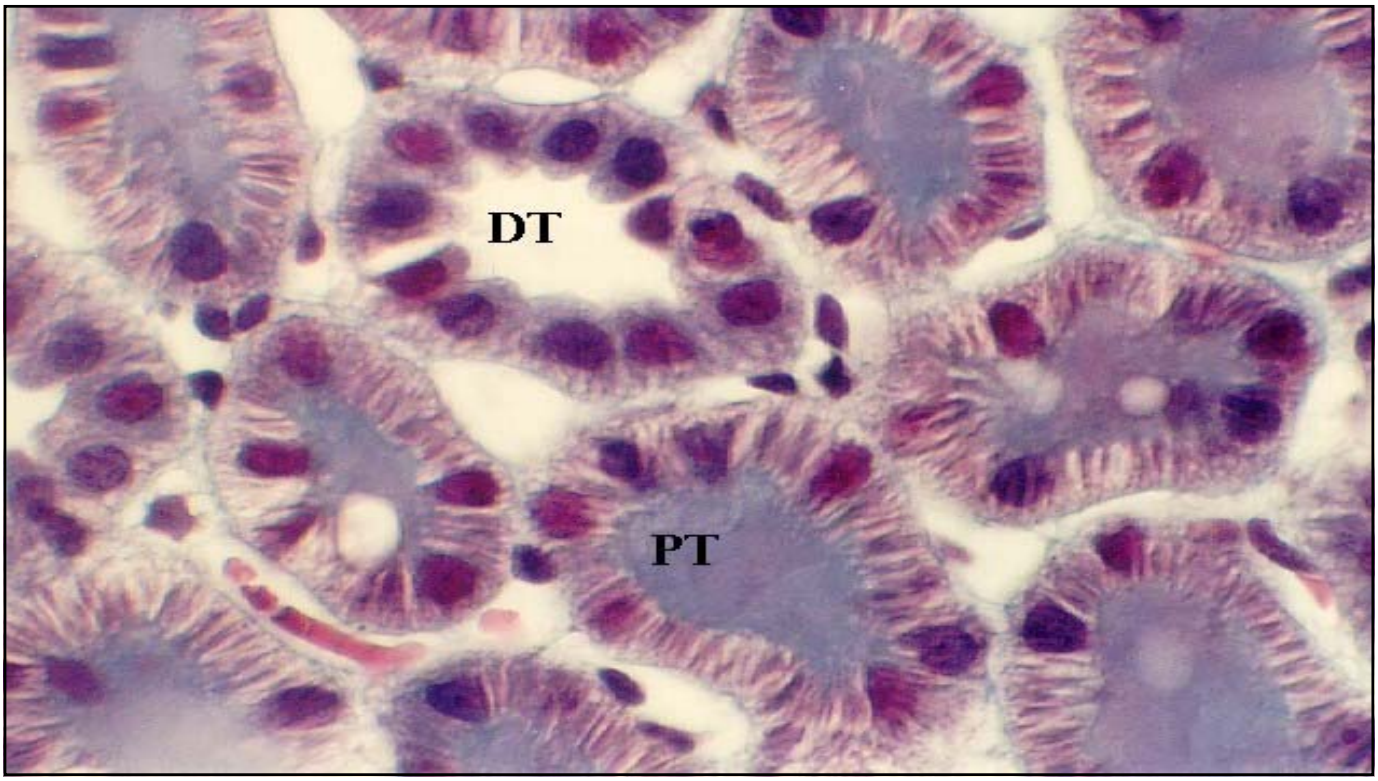
- Begins at urinary pole
- Lined by eosinophilic cuboidal/ low columnar epithelium
- Centrally placed nucleus
- Microvilli & well-defined brush border
- Lateral border indistinct due to interdigitations


Cortical collecting tubule
Proximal convoluted tubule


medullary ray


Loop of
Henle


medulla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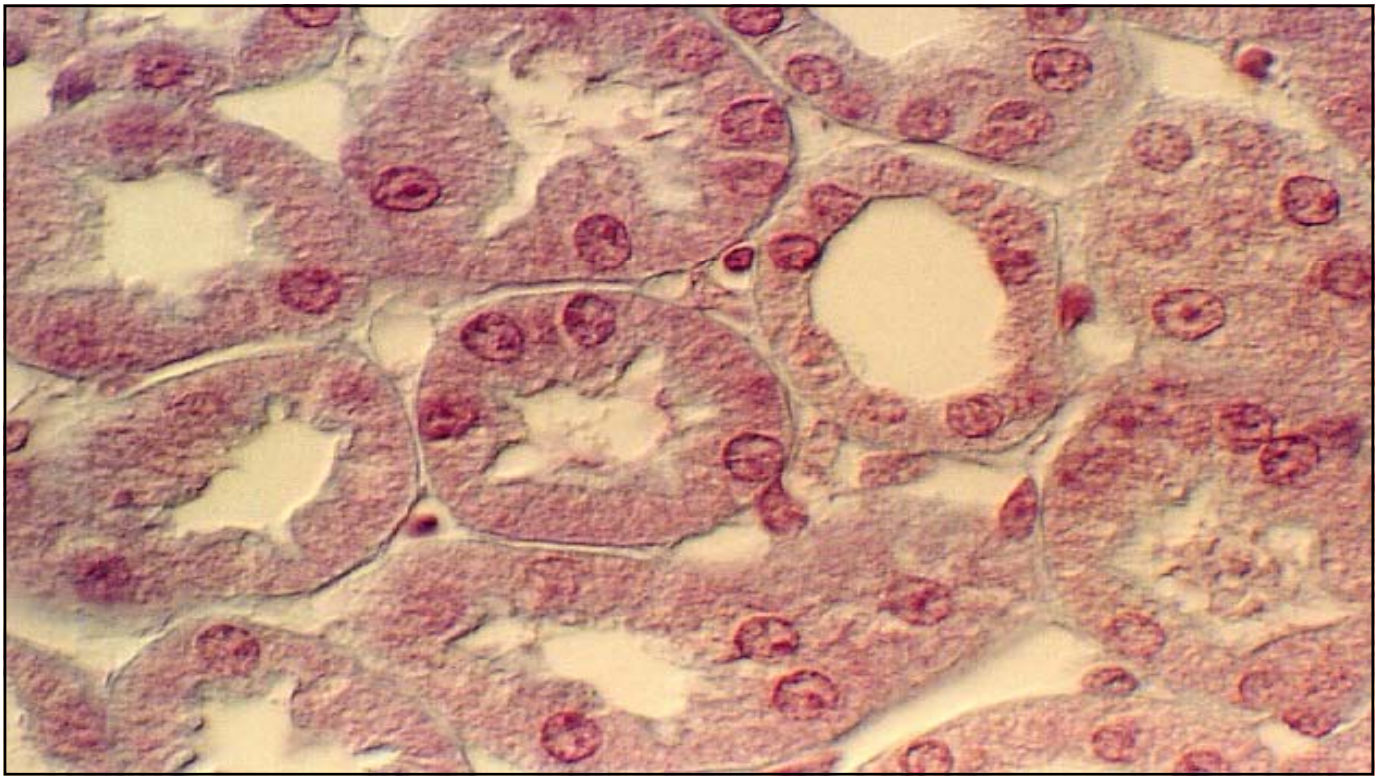
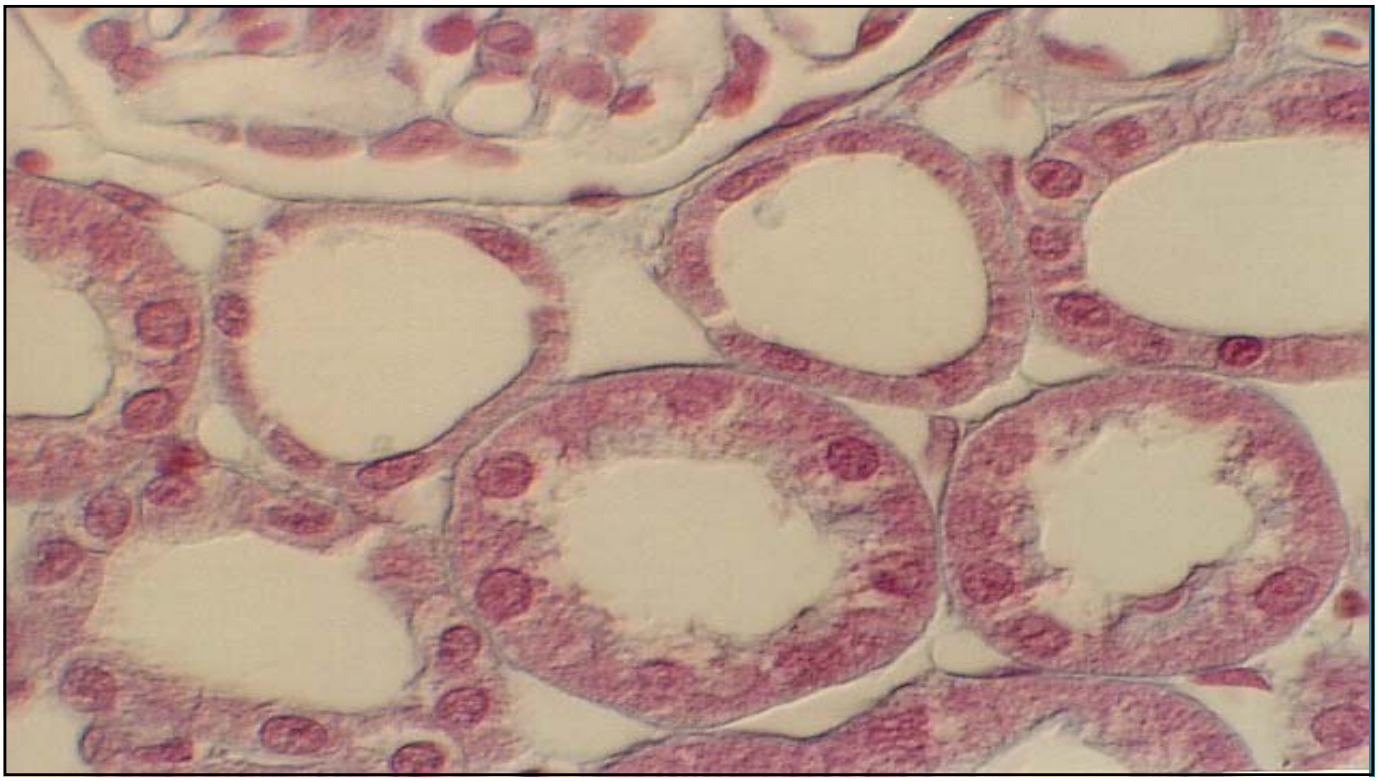


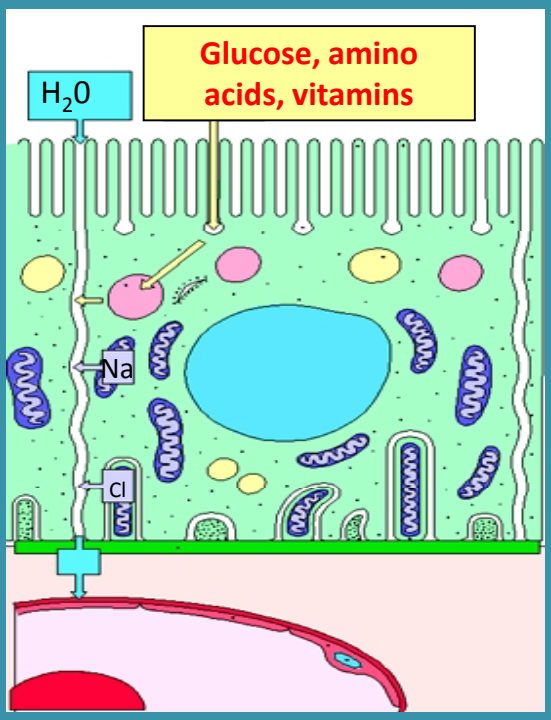


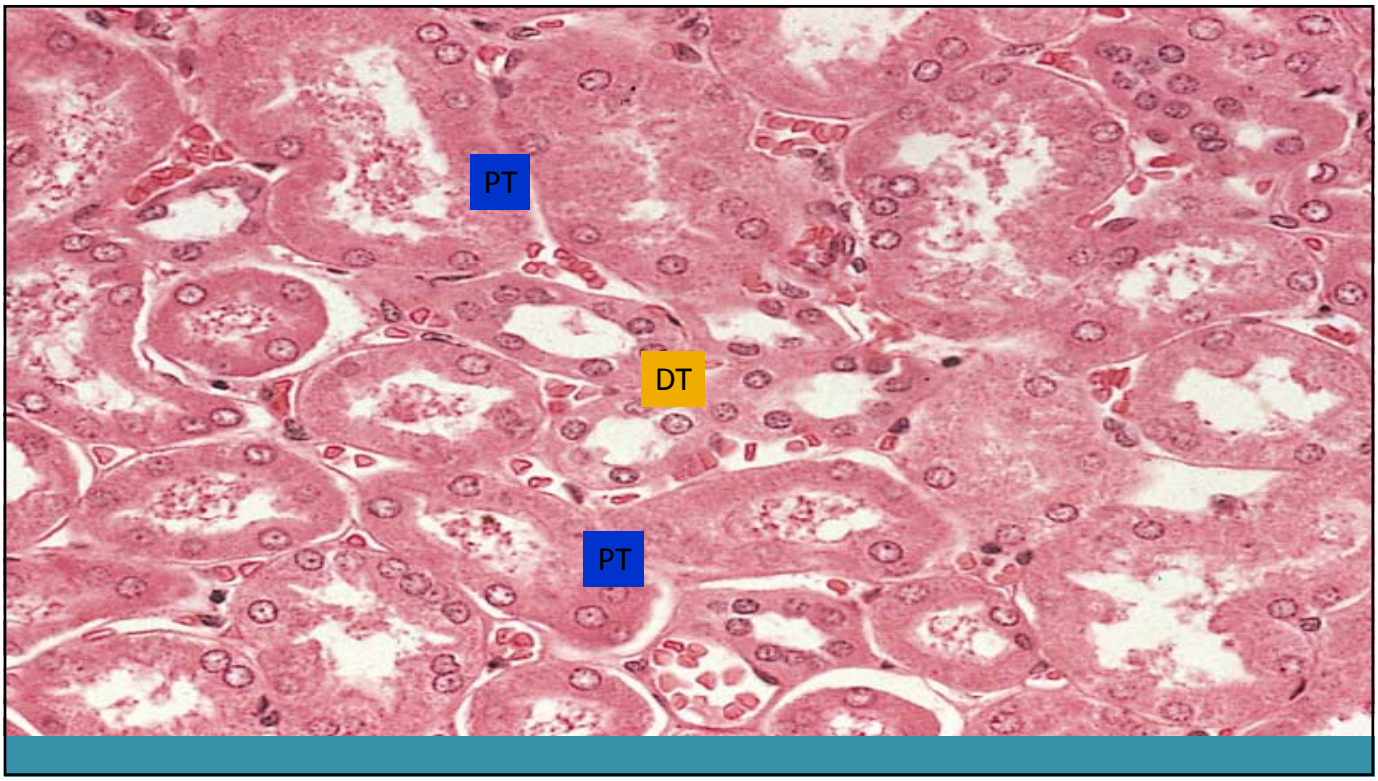
Proximal Tubule

- Extensive reabsorption of glomerular filtrate (microvilli).

- NA^+ (active transport)
- Cl^- (passive diffusion)
- H_20

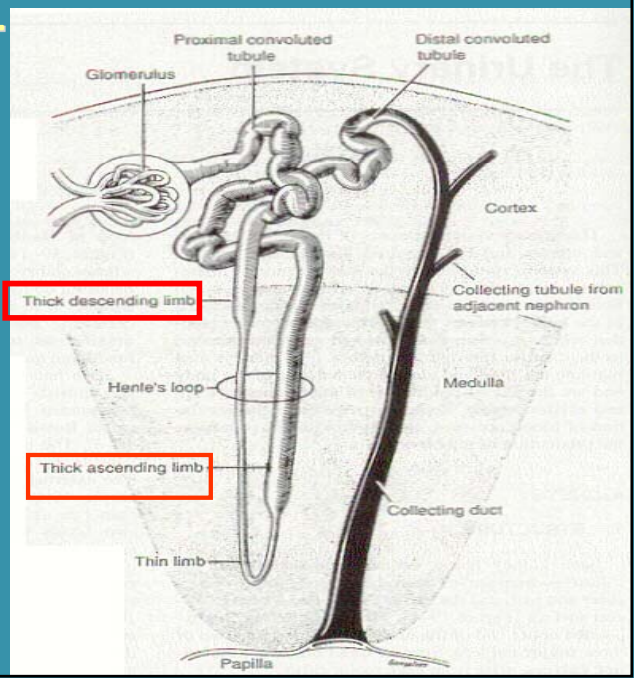
Reduction in fluid volume





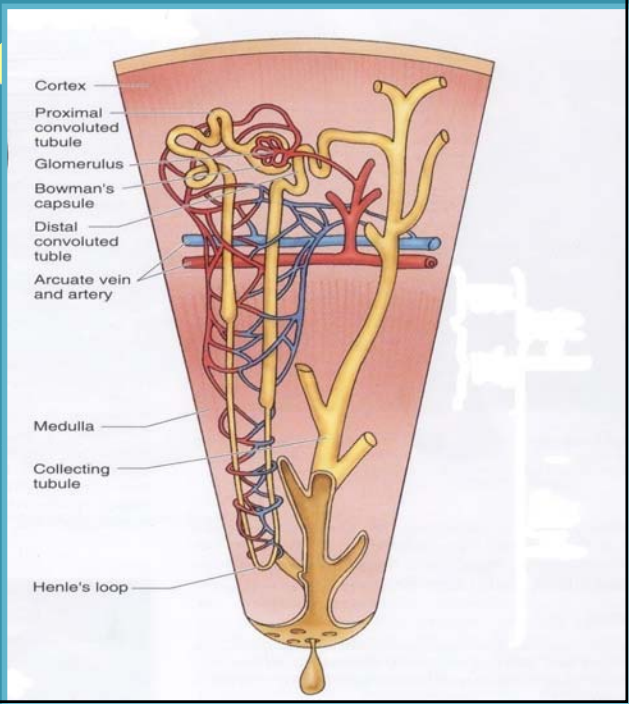
LOOP OF HENLE: STRUCT

- U-shaped epithelial tube
- Consists of a thick & thin descending limb and a thick & thin ascending limb
- Thick & thin denote and epithelial change (cuboidal to squamous) in both the descending and ascending limbs



LOOP OF HENLE: STRU

- Continuous with PT in cortex
- Travels into the medulla, then back to the cortex
- Empties into the distal convoluted tubule (DCT)



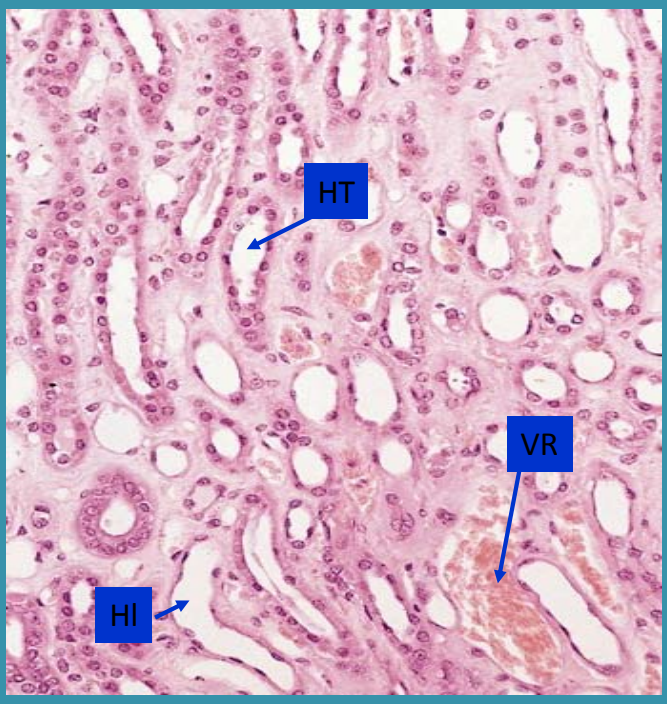
Sectional anatomy of the kidneys

- Superficial outer cortex and inner medulla
  - The medulla consists of 6-18 renal pyramids
  - The cortex is composed of roughly 1.25 million nephrons
- Major and minor calyces along with the pelvis drain urine to the ureters

Thick portions are similar in histological appearance to both PT and DCT.

Thin portions of Henle's loop have moderate cytoplasm and bulging nuclei.

They may resemble capillaries except for the presence of RBCs.



LOOP OF HENLE

- **Function – to assist in forming hypertonic urine by establishing an osmotic gradient in the interstitial fluid of the medulla.**

LOOP OF HENLE: DESCENDING PORTION

- Permeable to both water and salt
- As filtrate (isotonic) in the lumen passes deeper into the medulla (hypertonic), it loses water to the interstitium
- Filtrate becomes more hypertonic
- Filtrate volume also decreases with loss of water

LOOP OF HENLE: ASCENDING PORTION

- Plays a more active role in setting up the osmotic gradient required to make the interstitium hypertonic
- Contains a Na+/K+/Cl- Pump (symporter)
- Constantly pumps these ions from the filtrate into the interstitium

LOOP OF HENLE: ASCENDING PORTION

- Impermeable to water (water cannot follow salt into interstitium)
- Loss of salt, but not water, causes the filtrate in Henle's loop to become isotonic or even hypotonic
- Filtrate ascends toward the DCT in the cortex

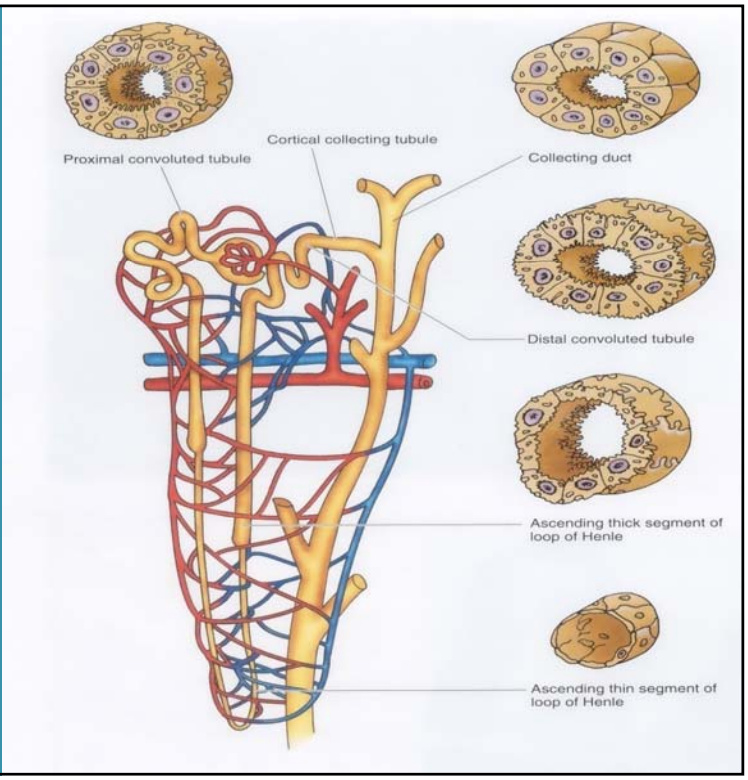
Distal Convoluted Tubule

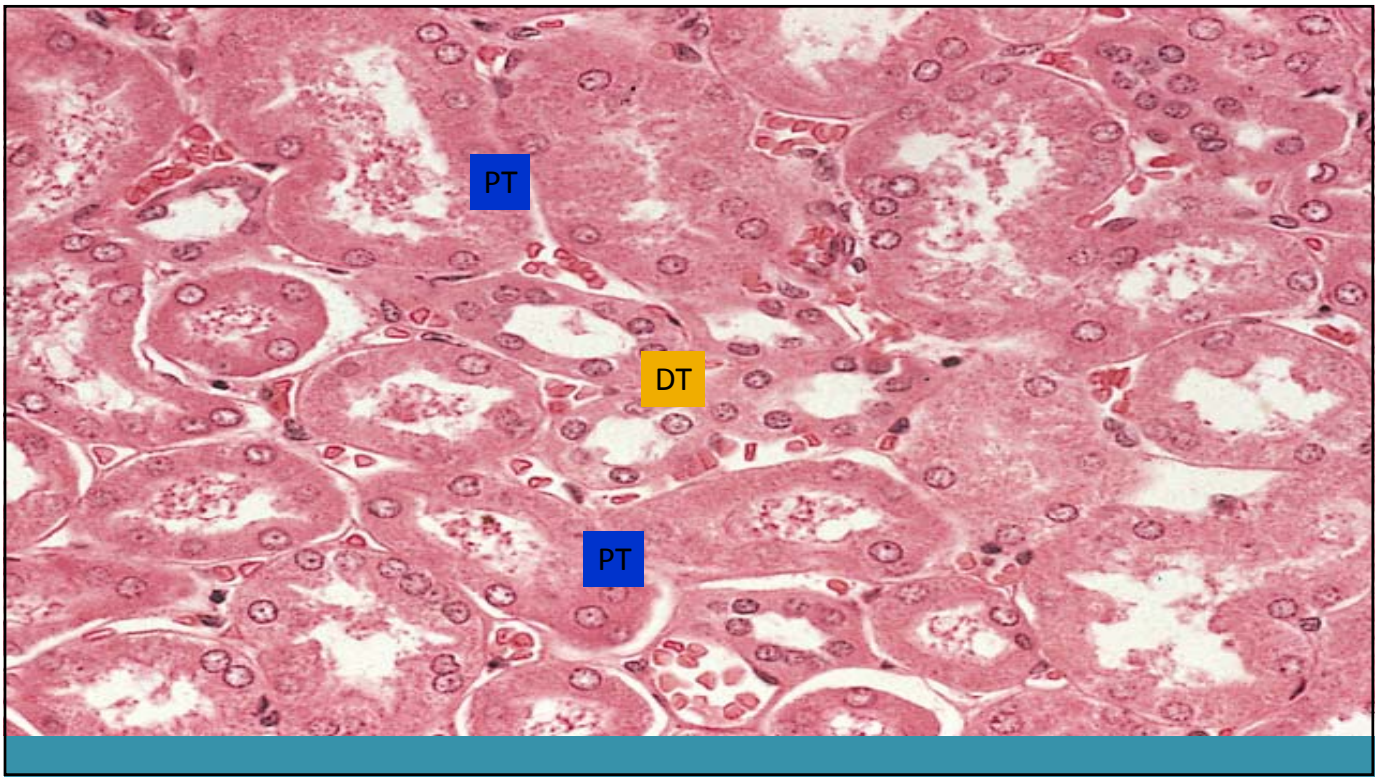
•Lined by pale-staining, low cuboidal epithelium

•Nuclei are round/oval apically laced

•Fewer microvilli in comparison to PT (lumen looks larger)

•Extensive basal and lateral interdigitations

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