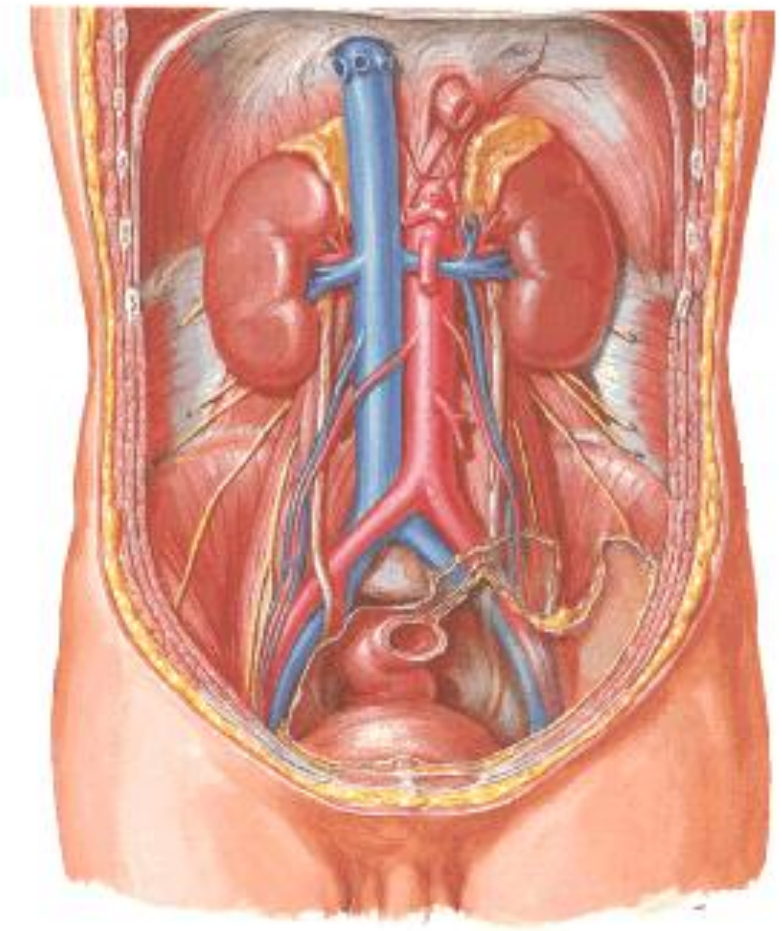
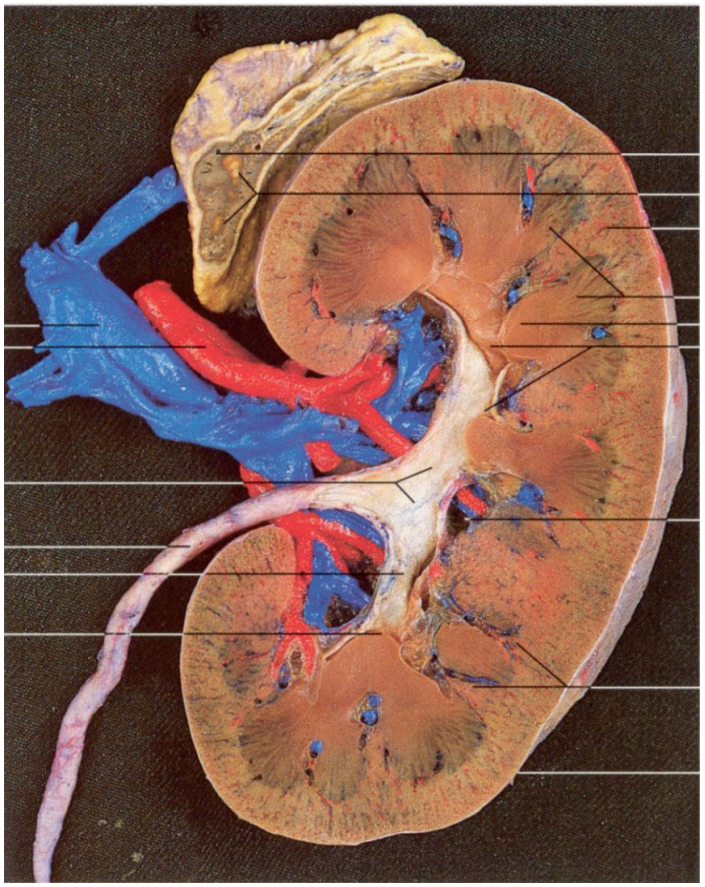
Urinary System

- Kidneys
- Uriniferous tubule
- Ureters, bladder and urethra



Urinary System Functions

1) Excretion
    1) Waste products of metabolism
    2) Foreign substances
2) Homeostasis
    1) Regulate total body water & extracellular fluid volume
    2) Electrolyte balance (Na+)
    3) Acid-base balance
3) Endocrine function
    1) Erythropoietin
    2) Enzyme renin >>> regulate aldosterone secretion
    3) Vitamin D activation

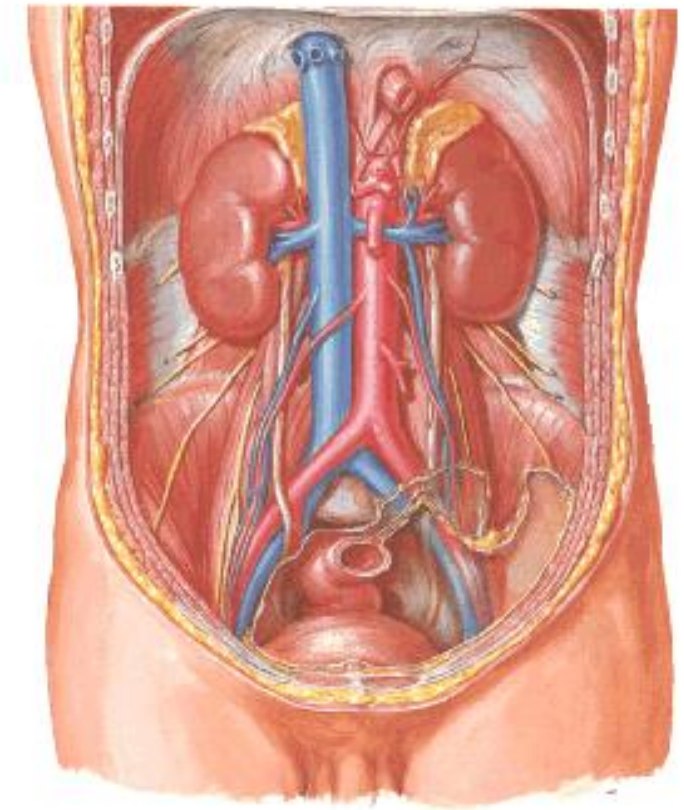


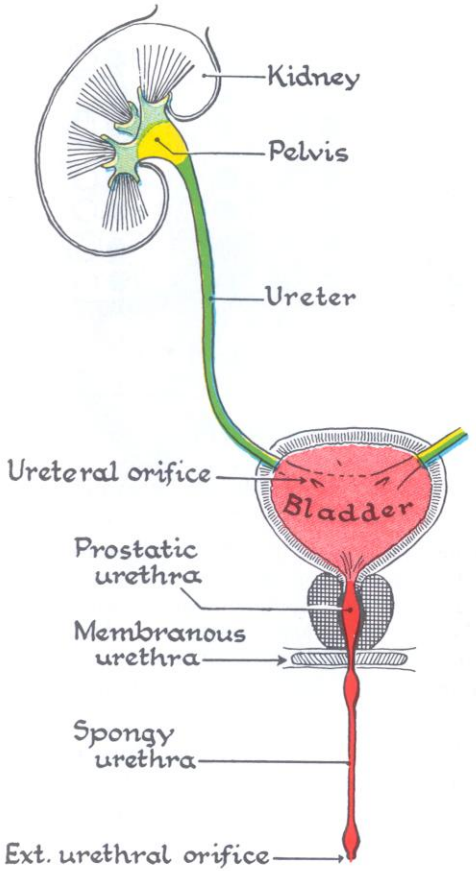
Organs

2 kidneys – produce urine

2 ureters
1 bladder
1 urethra

} transport, store, excrete urine





Kidneys

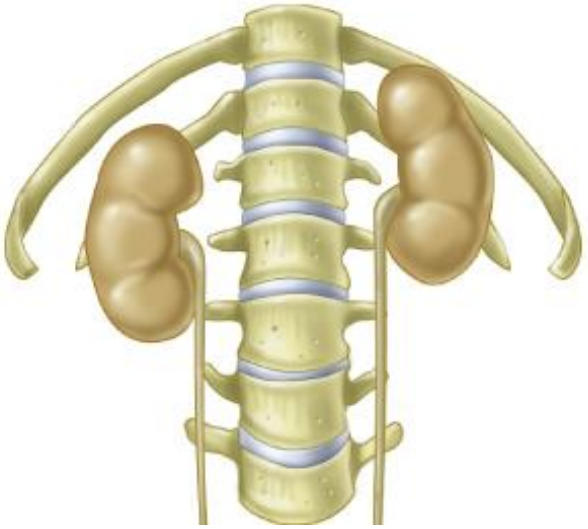
300 gm; 10 to 12 cm by 3 to 4 cm

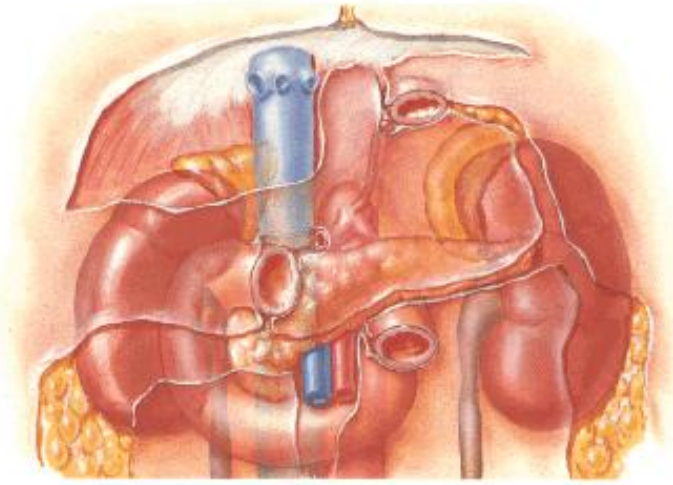
Level T12 to L3

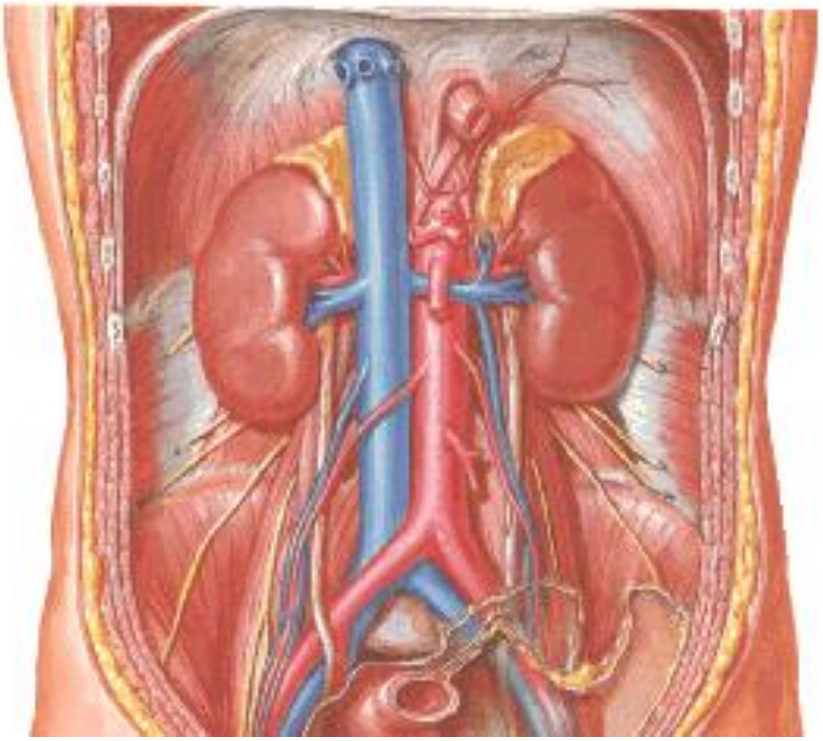
Left kidney slightly higher due to liver on right

Just anterior to psoas and quadratus lumborum mm.

Retroperitoneal

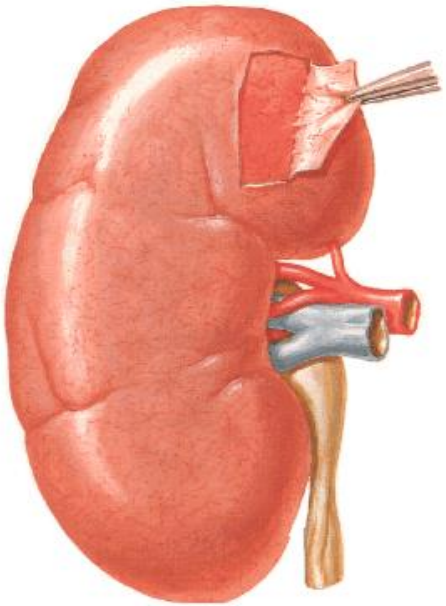


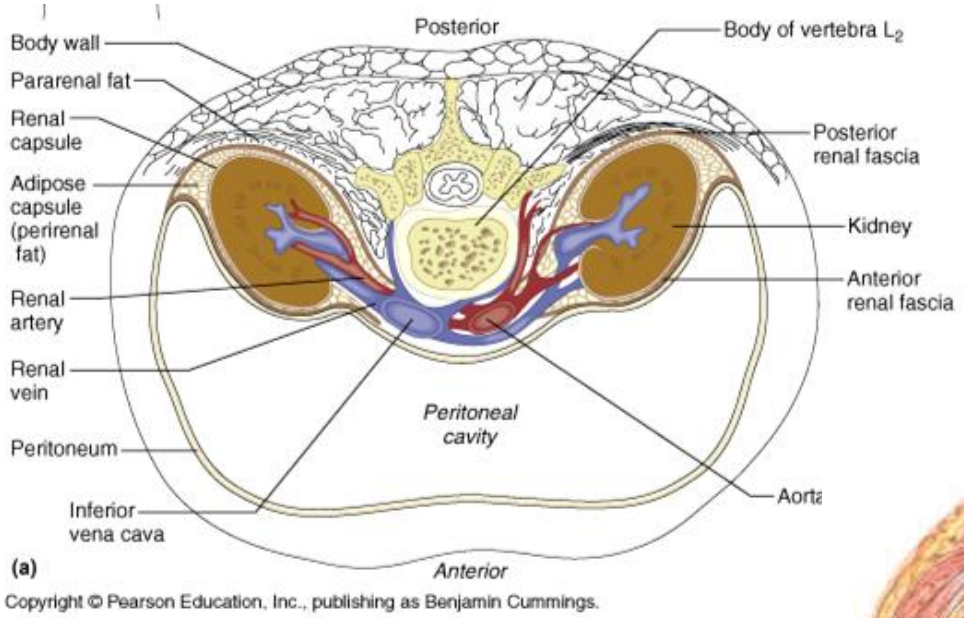


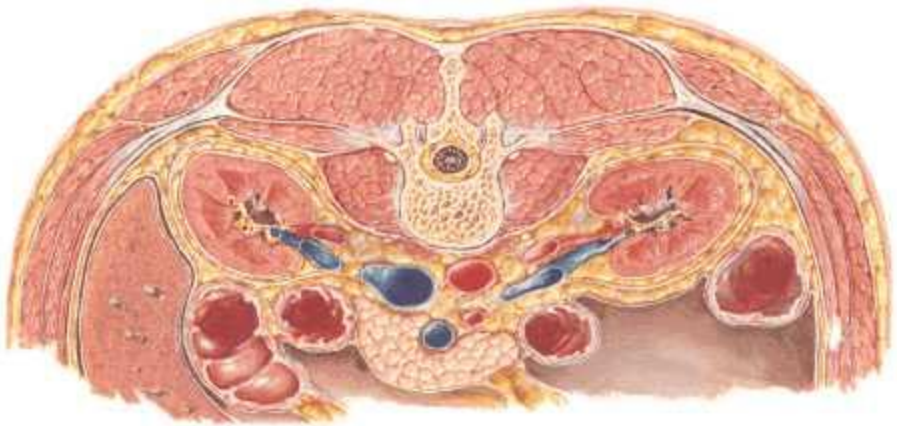


3 capsules

1) True = fibrous CT
2) Adipose capsule = perirenal fat
3) Renal fascia = subserous fascia







Hilus

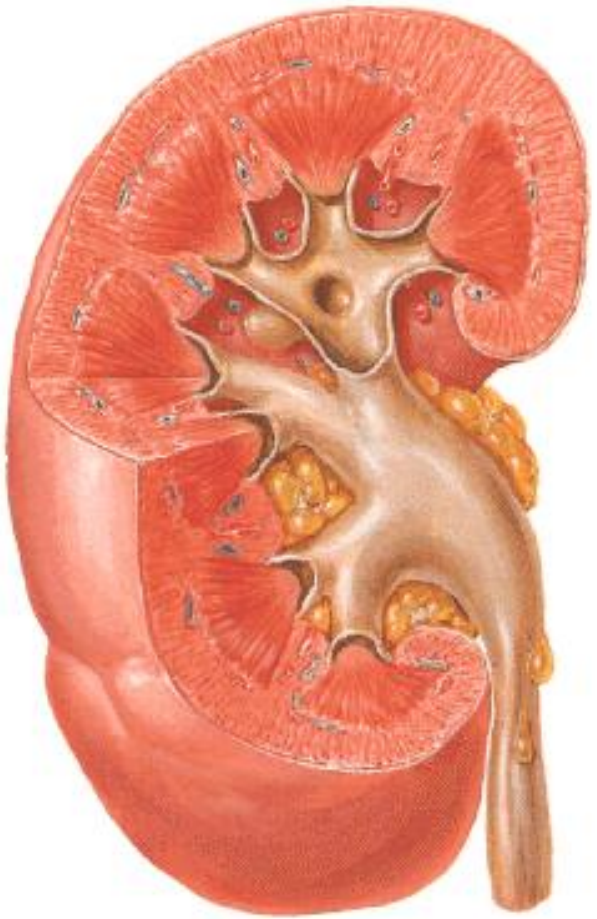
- Medial indentation
- Vessels and nerves enter and exit

Sinus

- Thin concave slit within which find pelvis, blood vessels, nerves and loose CT

Pelvis and calyxes (major and minor)

- lined with transitional epithelium
- **1 pelvis > 3 to 4 major calyxes > 7 to 14 minor calyxes**



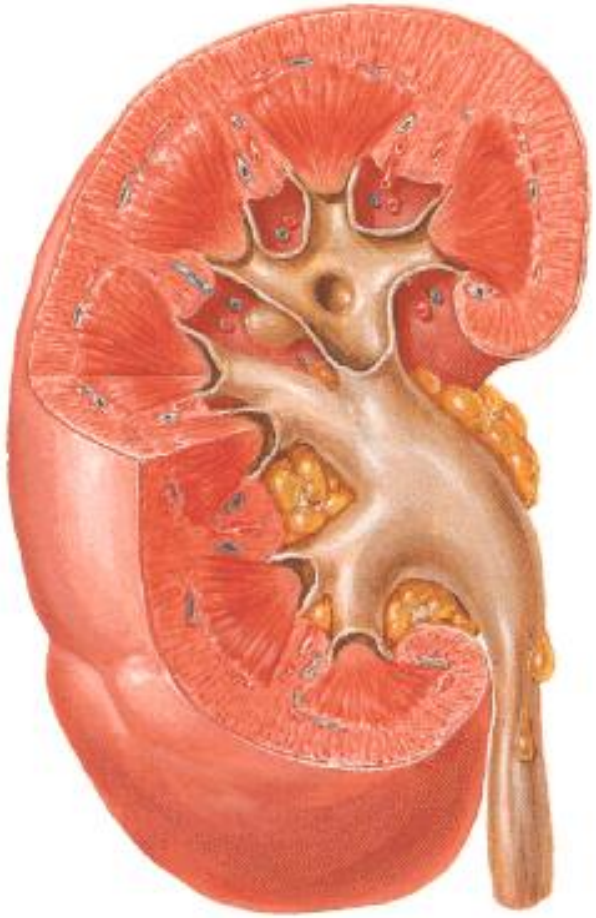
Cortex

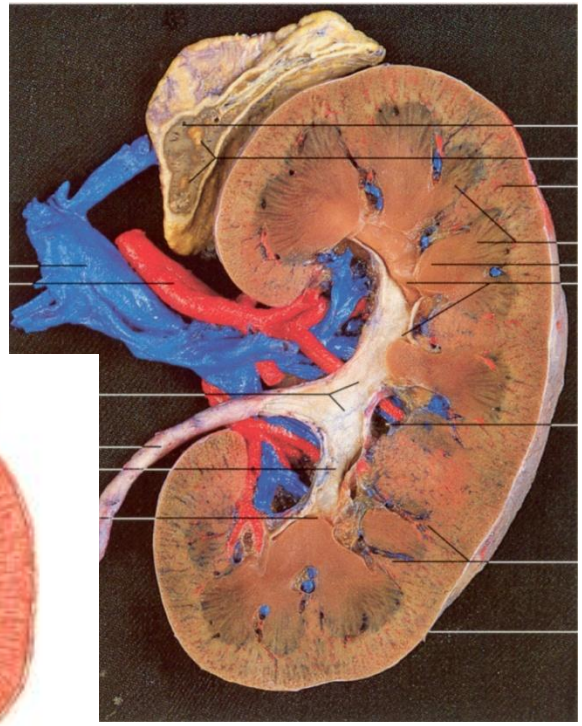
1) Outer zone
2) Renal columns

Medulla = renal pyramids

Striated pyramidal regions

Apex projects into minor calyx



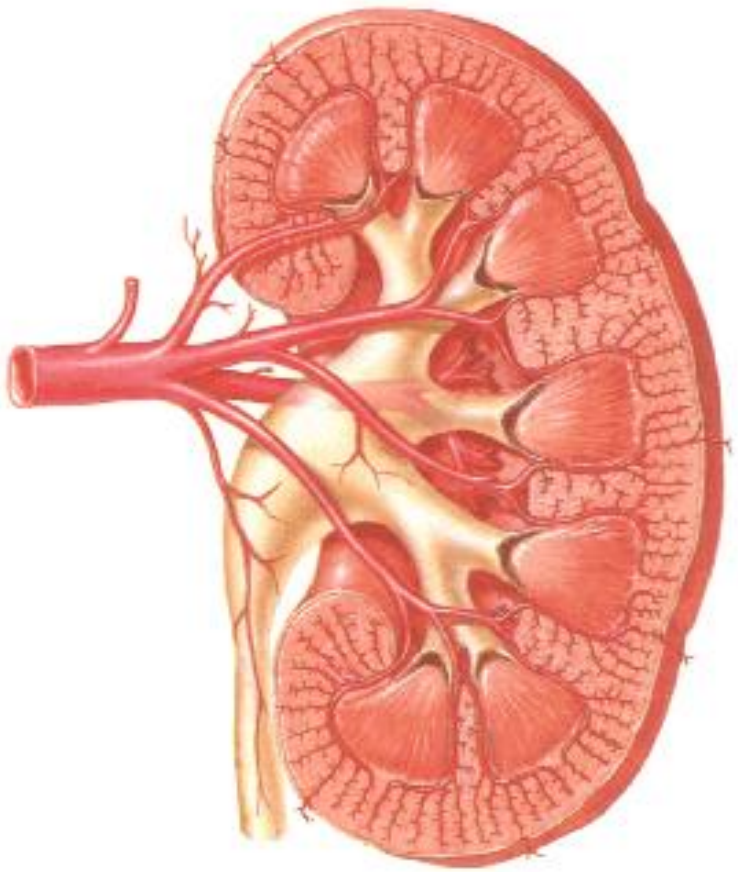


Lobe of kidney

Renal pyramid plus surrounding cortical matter, both outer cortex and within renal column

Lobule of kidney

Subunits within outer zone of cortex



Renal a.

Anterior and posterior divisions

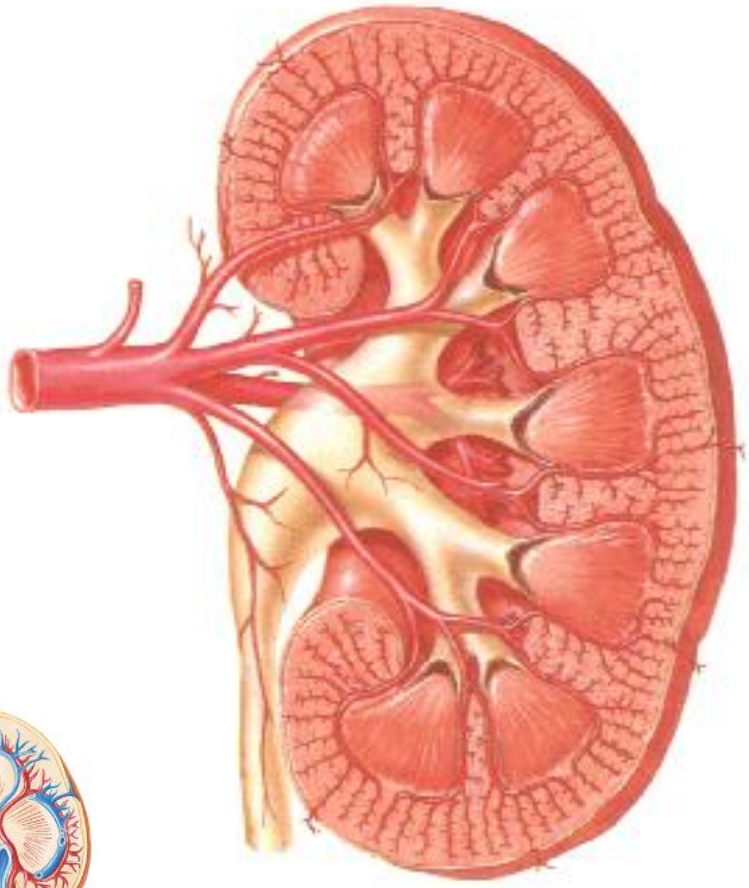
5 segmental aa.

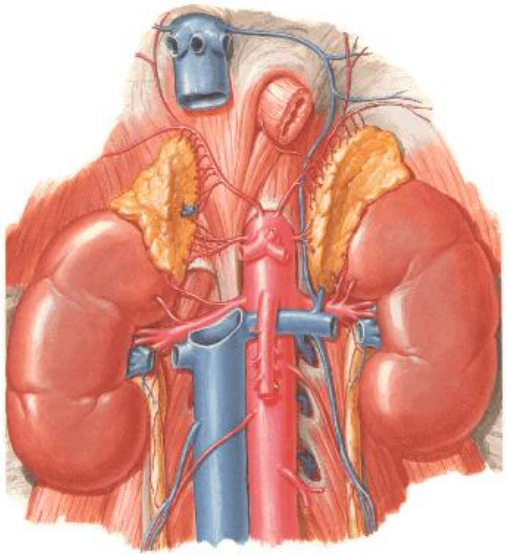
Interlobar a.

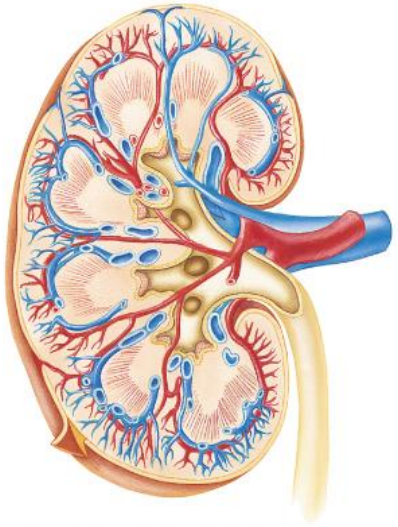
Arcuate a.

Interlobular a.

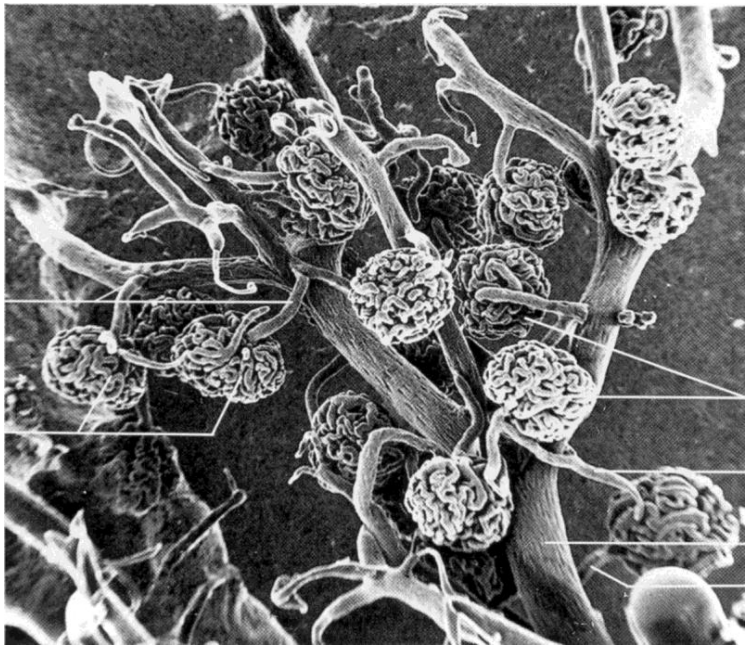
Afferent arterioles

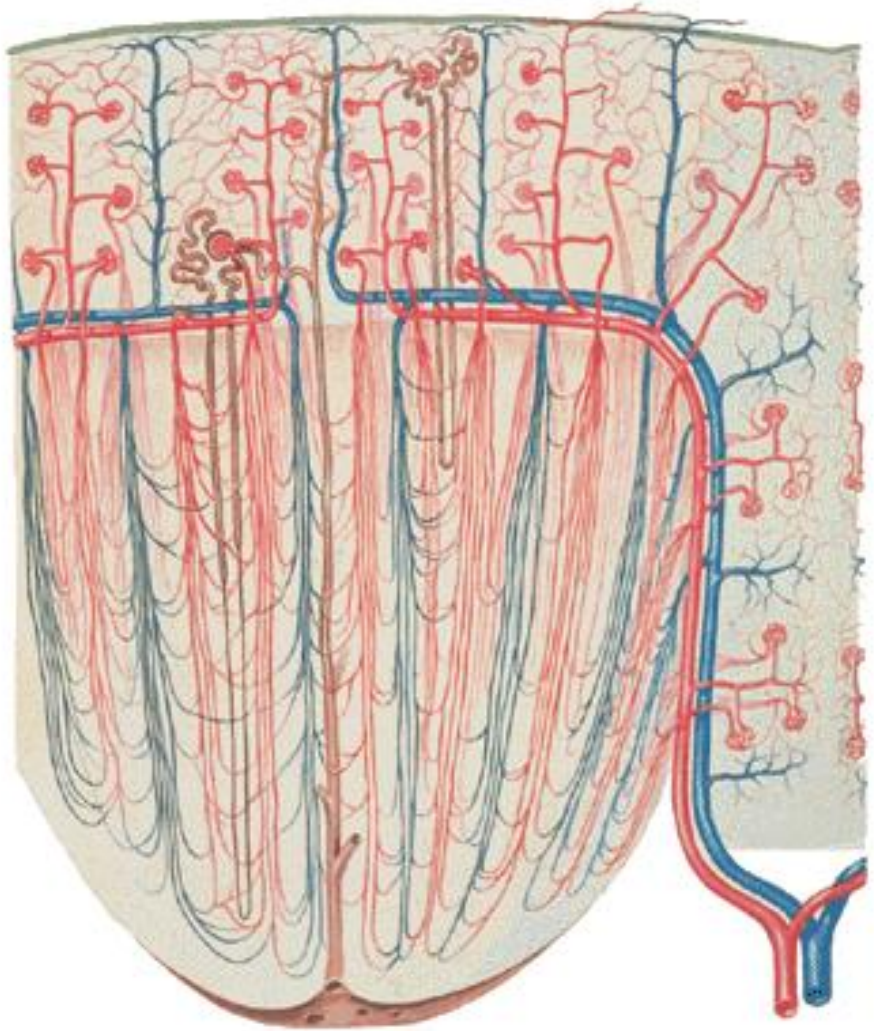






Afferent arterioles

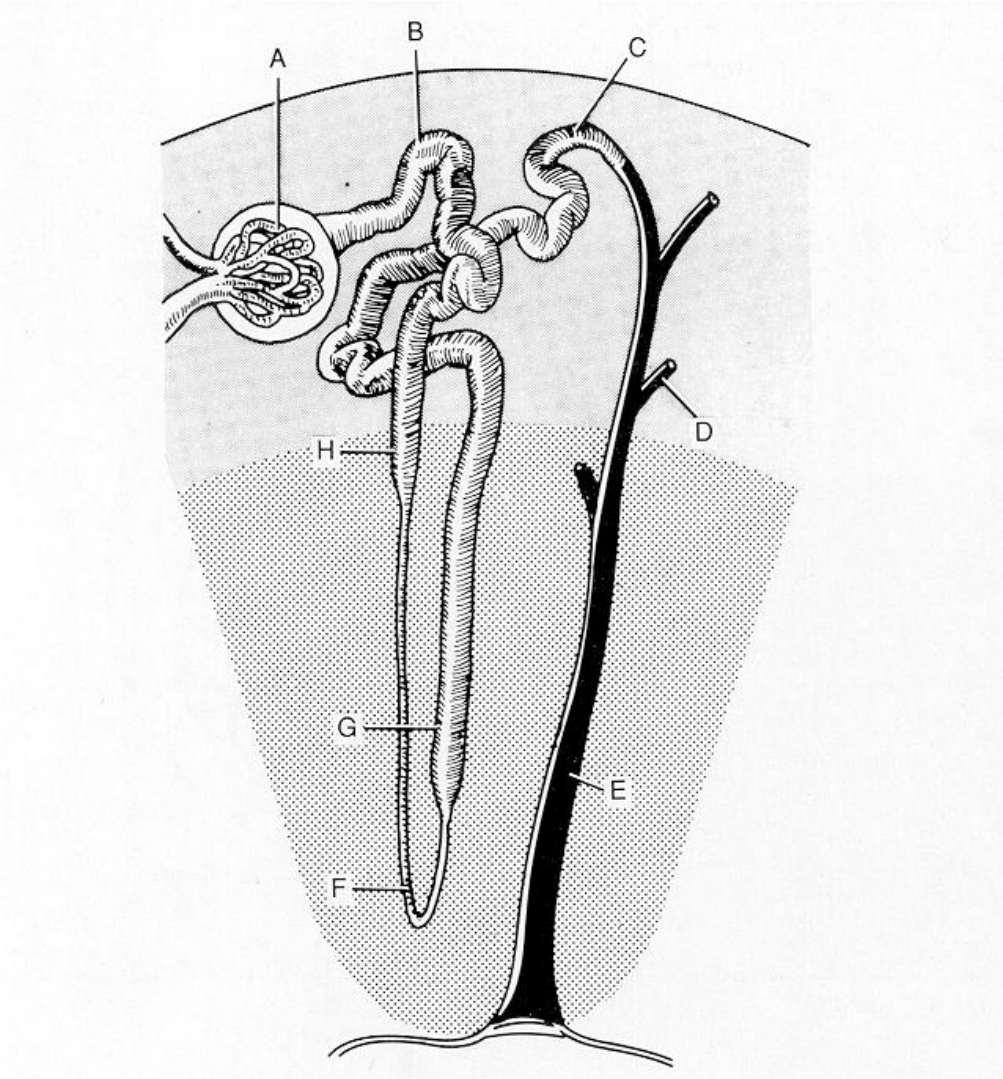




Efferent arterioles

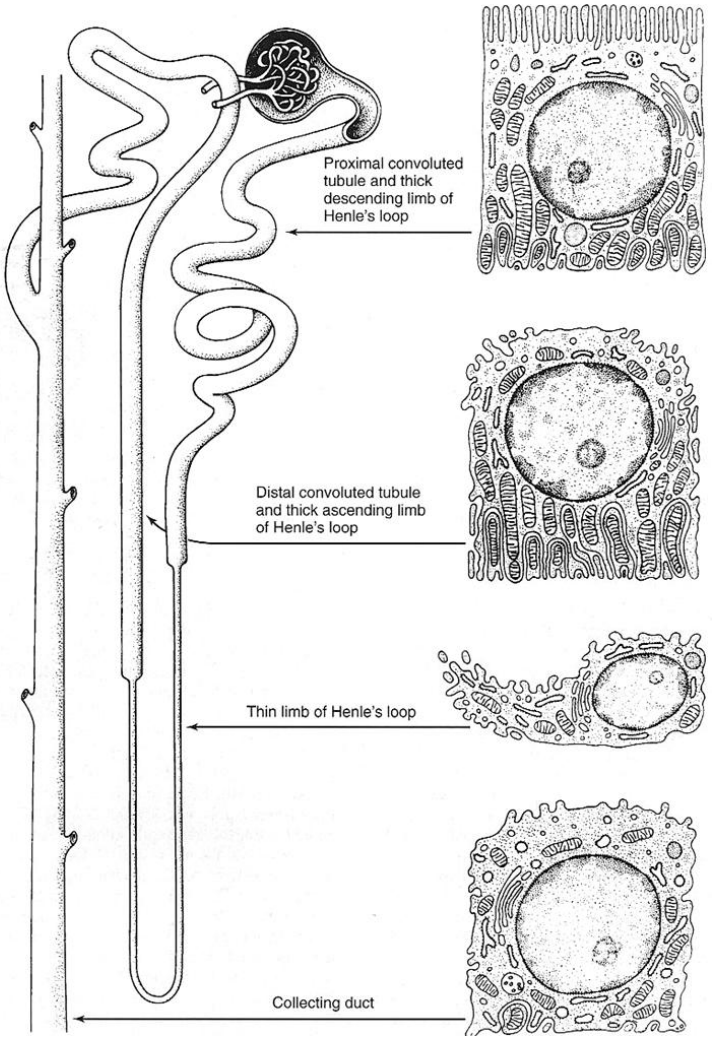
Functional unit = Uriniferous tubule

1) **Nephron**
2) **Collecting duct**



Nephron

1) **Renal corpuscle**
    1) **Glomerulus** - tuft of capillaries
    2) **Bowman's capsule** – double walled cup surround glomerulus
2) **Proximal convoluted tubule**
3) **Loop of Henle**
4) **Distal convoluted tubule**

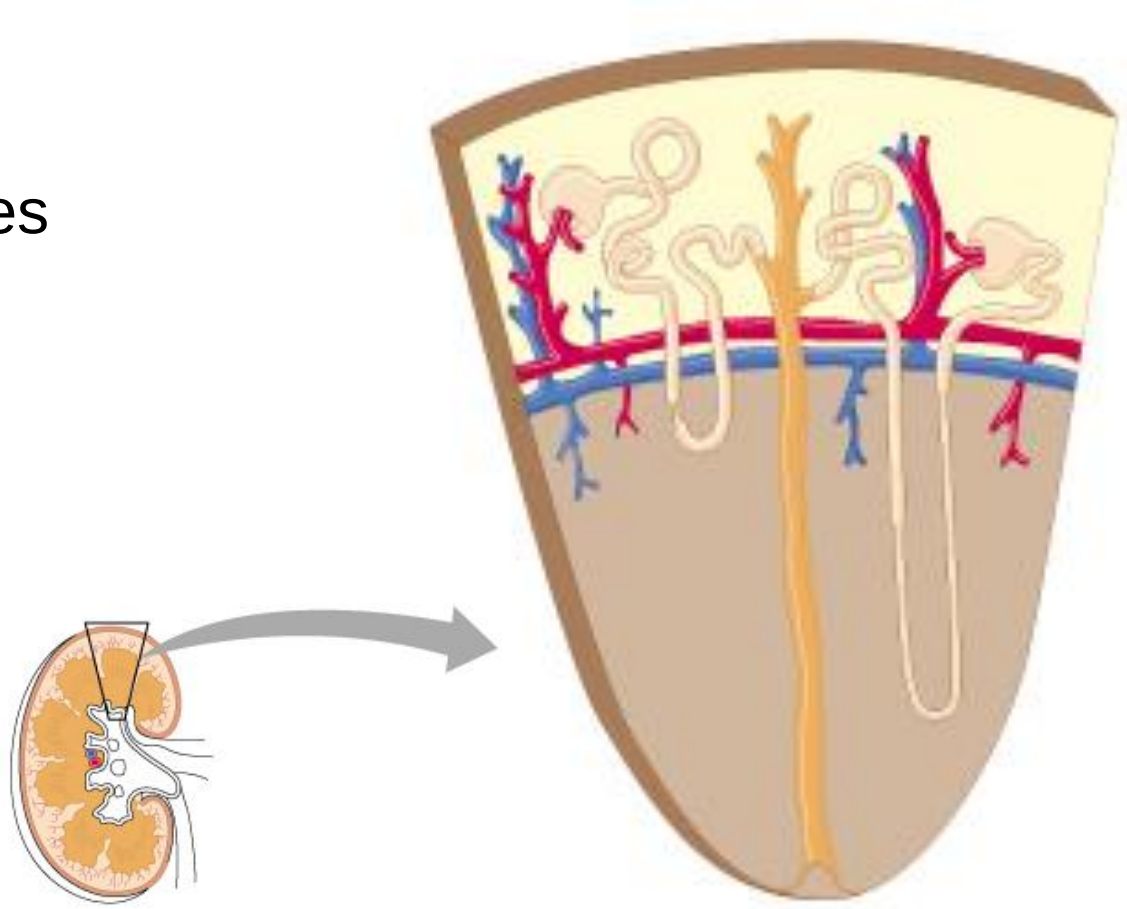


Cortex

- Convoluted tubules
- Renal corpuscles

Pyramids

- Loops of Henle
- Collecting ducts

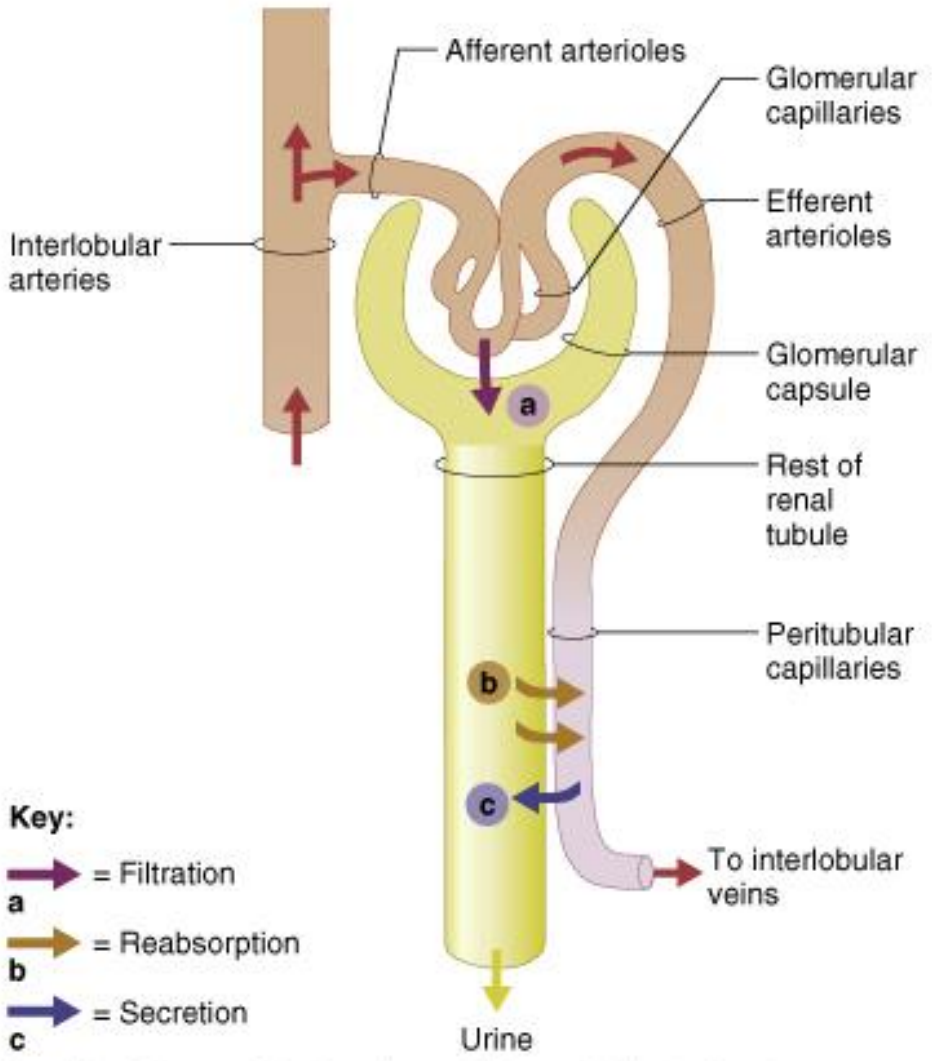


2 types of nephrons

- Cortical
- Juxtamedullary

Urine – formed by 3 processes

1) **Glomerular filtration** of blood plasma
2) **Tubular reabsorption** (filtrate > plasma)
3) **Tubular secretion** (plasma > filtrate)

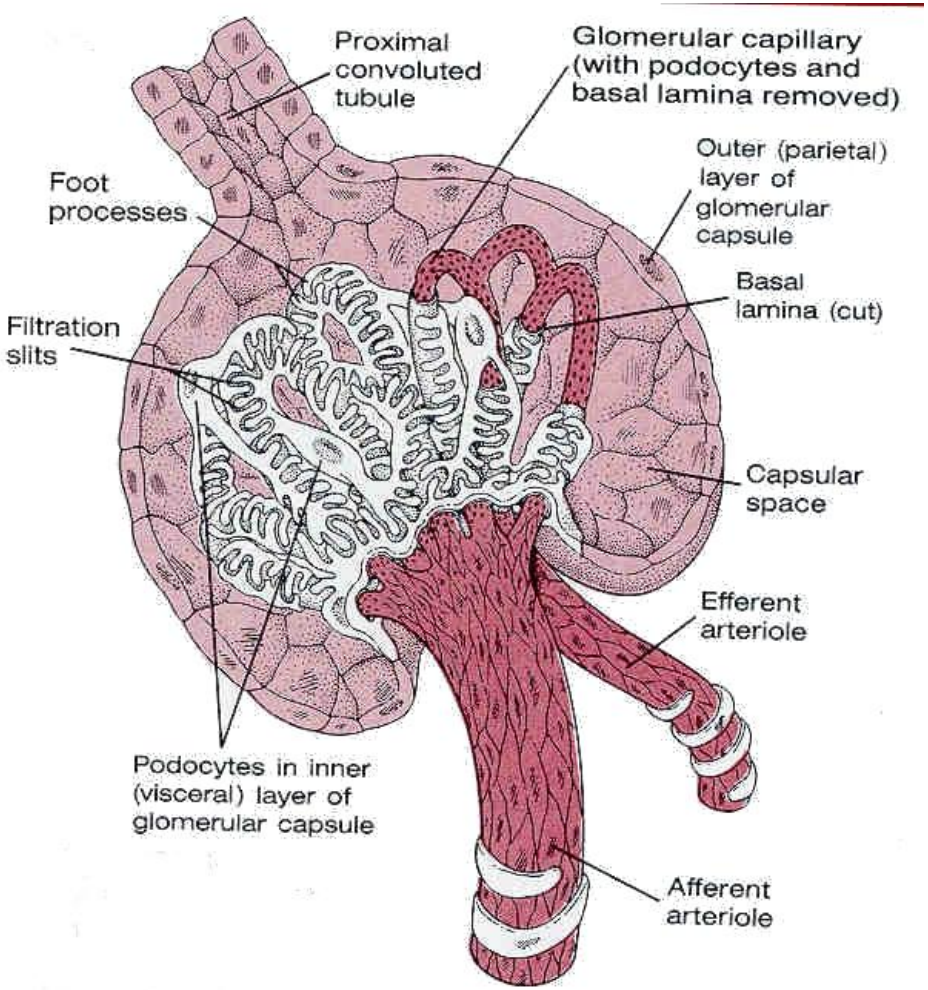


Bowman's capsule

2 walls

1) **Parietal layer** – simple squamous epithelium

2) **Visceral layer**– podocytes

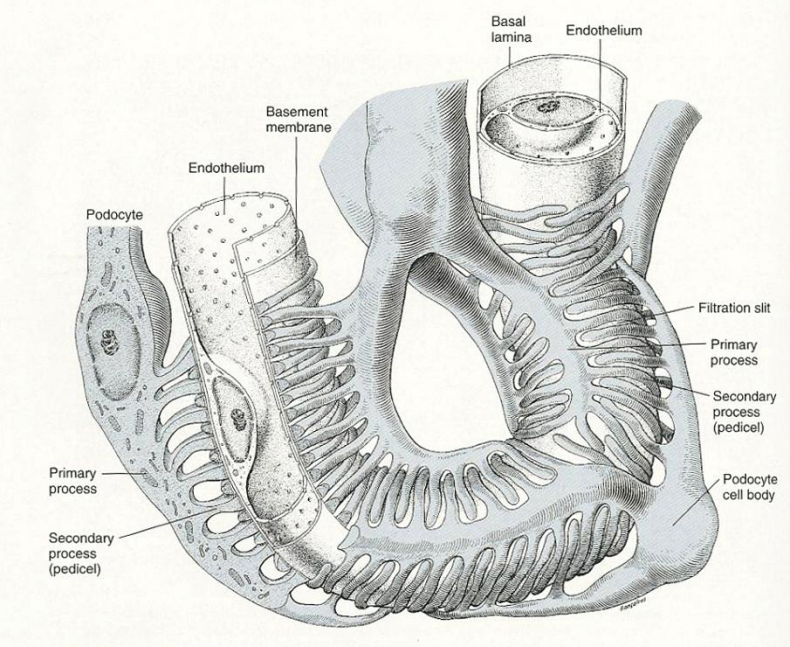


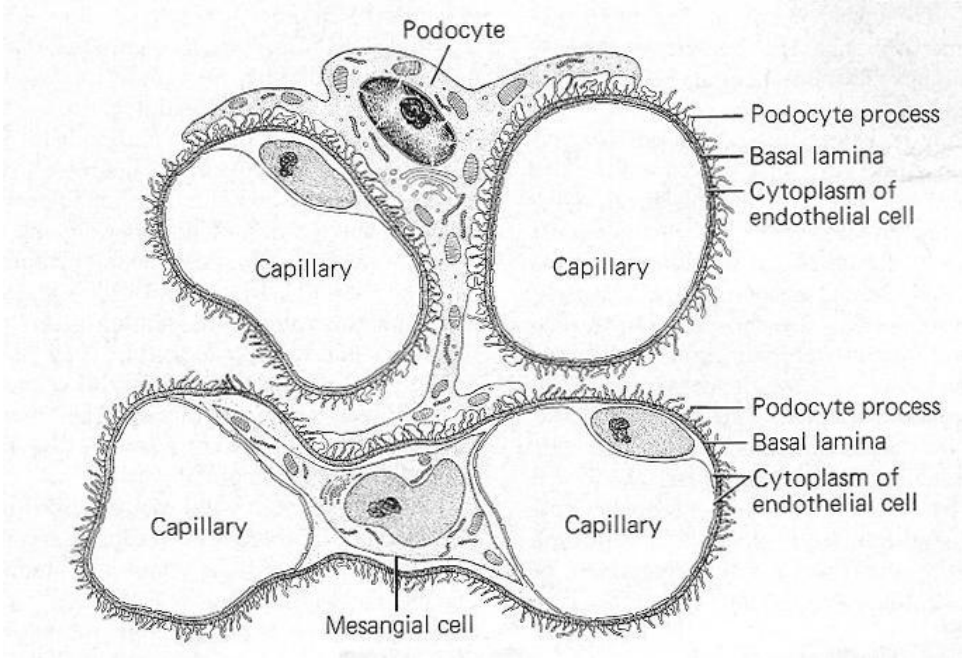
Podocytes

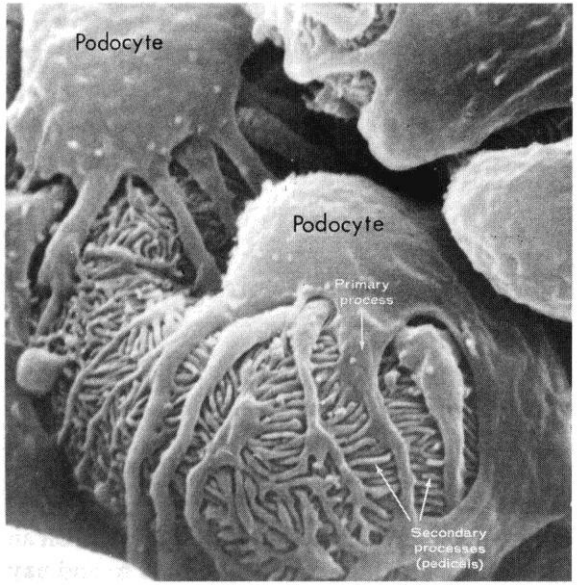
Branching processes interdigitate with processes of adjacent cells to totally coat glomerular capillaries

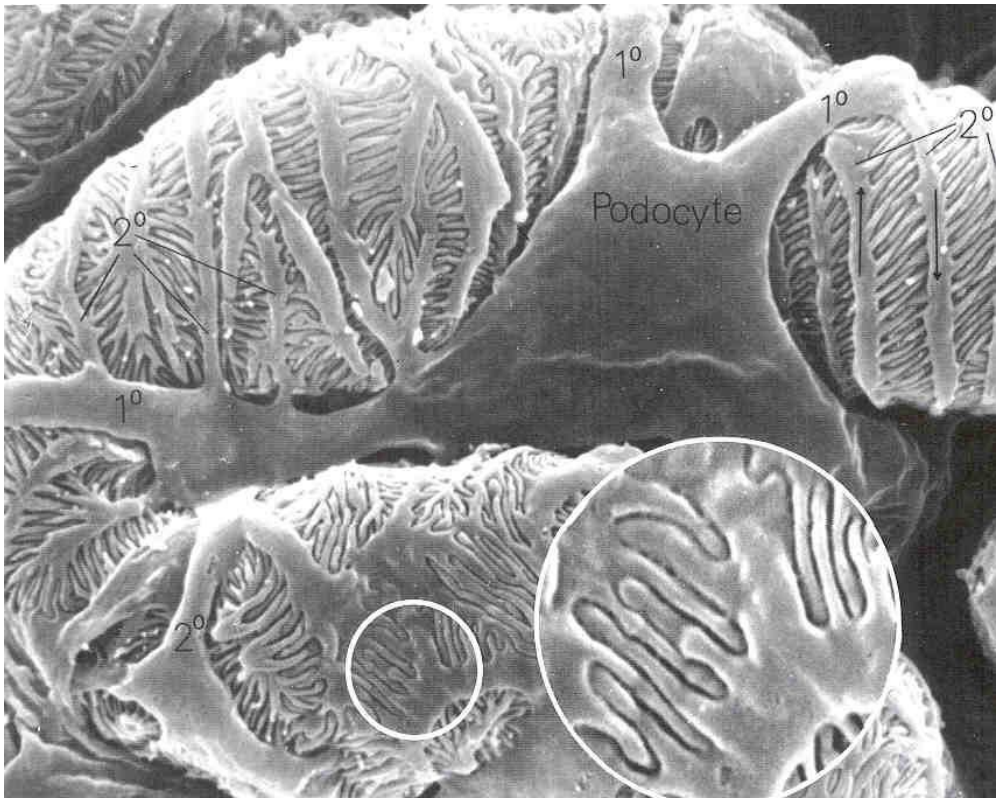
Interdigitating processes leave small slits

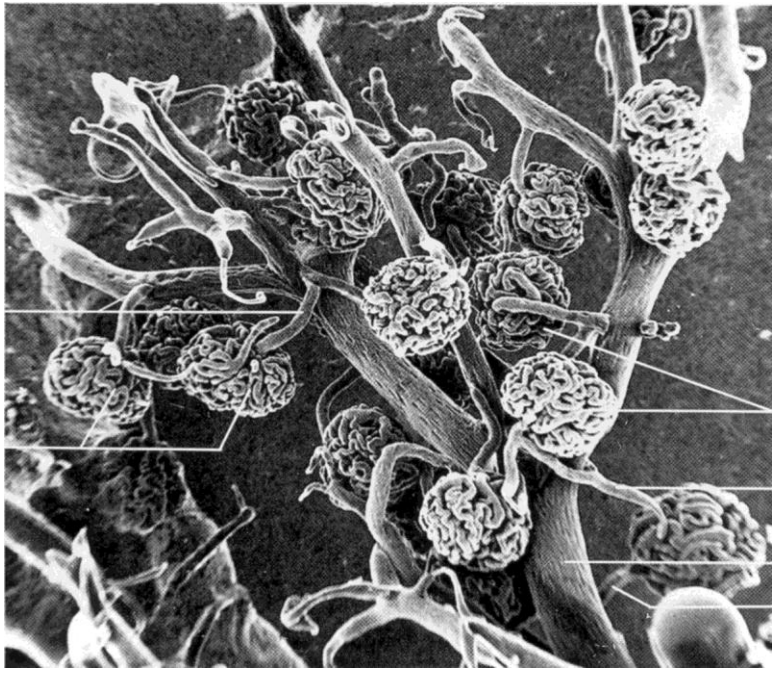
= filtration slits

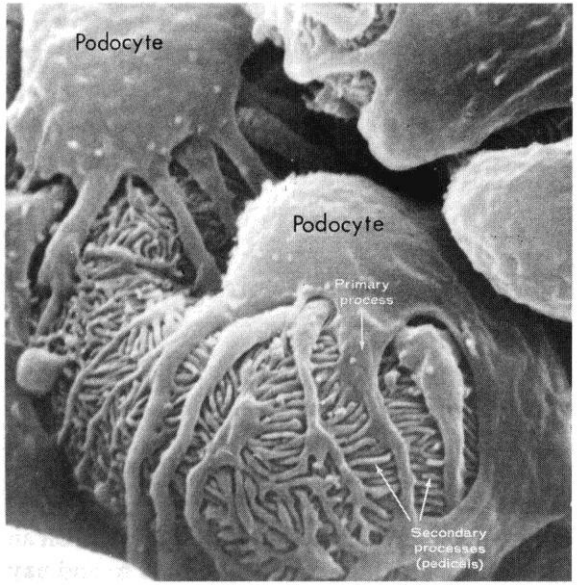


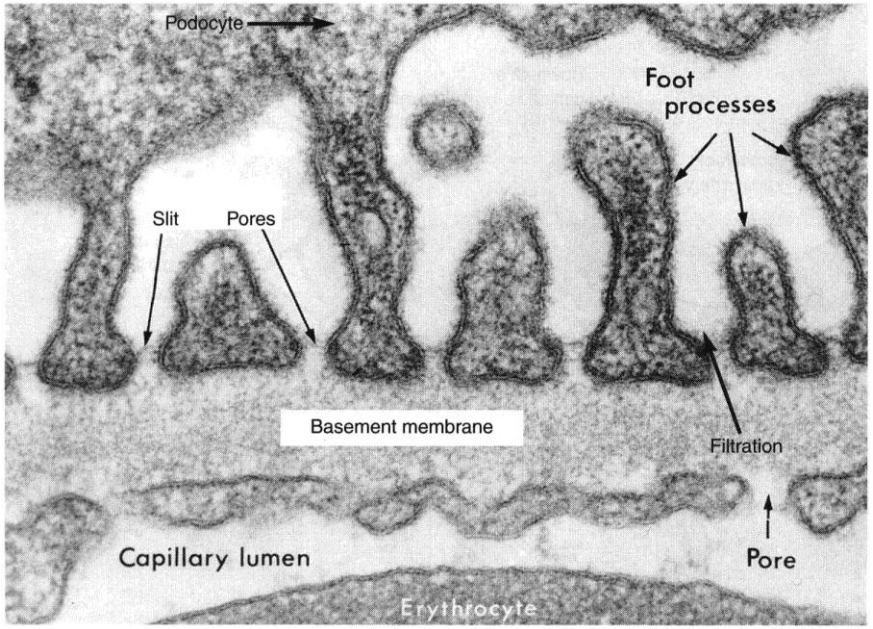



Podocyte
Podocyte
Primary process
Secondary processes (pedicels)


1°
1°
2°
Podocyte
2°
1°
2°




Podocyte
Podocyte
Primary process
Secondary processes (pedicels)


Podocyte
Foot processes
Slit
Pores
Basement membrane
Filtration
Capillary lumen
Pore
Erythrocyte


EP
P1
P2
EnC
GBM
L
a

Filtration barrier

Blood plasma filters from glomerular capillary to lumen of Bowman's capsule

1) **Fenestrated capillaries**

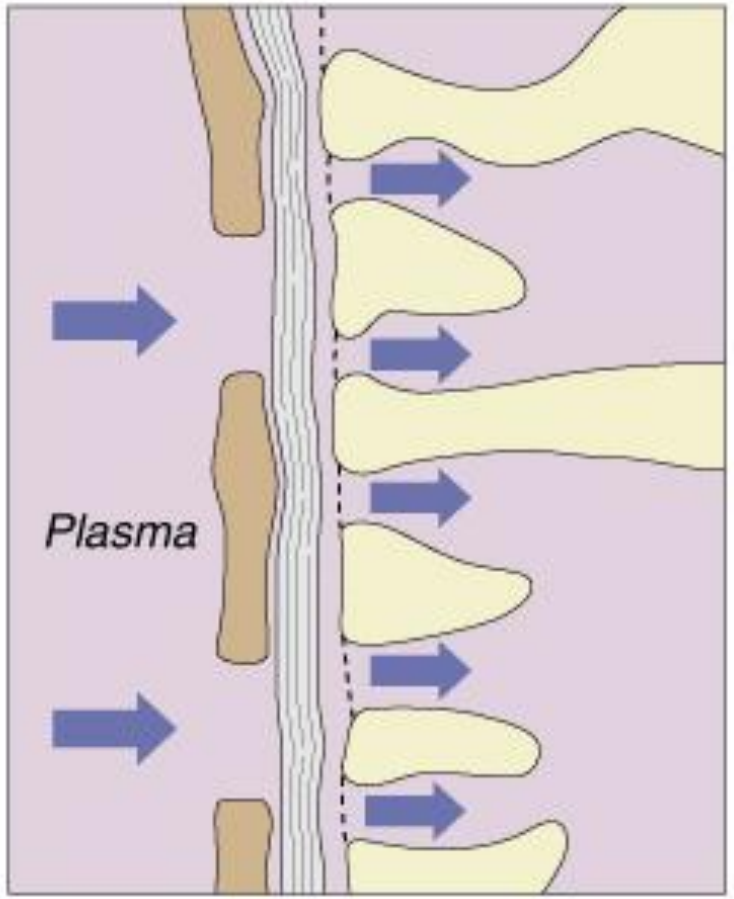
   Cells and platelets cannot pass

2) **Basement membrane**

   Large proteins (> 160,000) cannot pass

3) **Filtration slits**

   Small proteins (>40,000) cannot pass



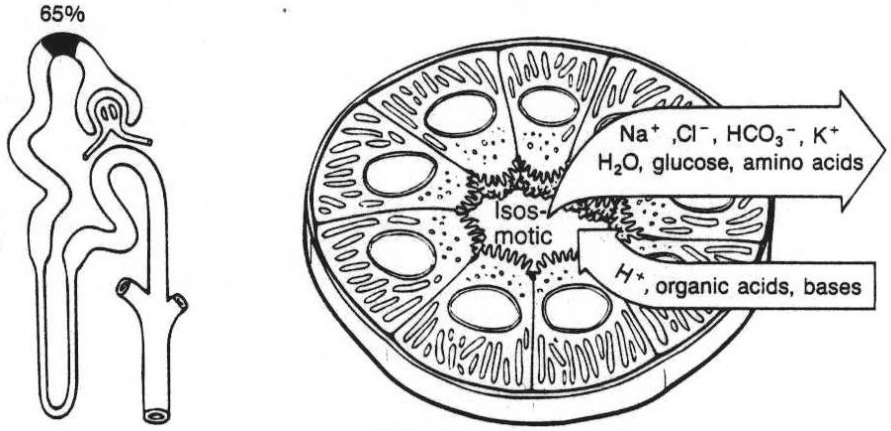
Proximal convoluted tubule

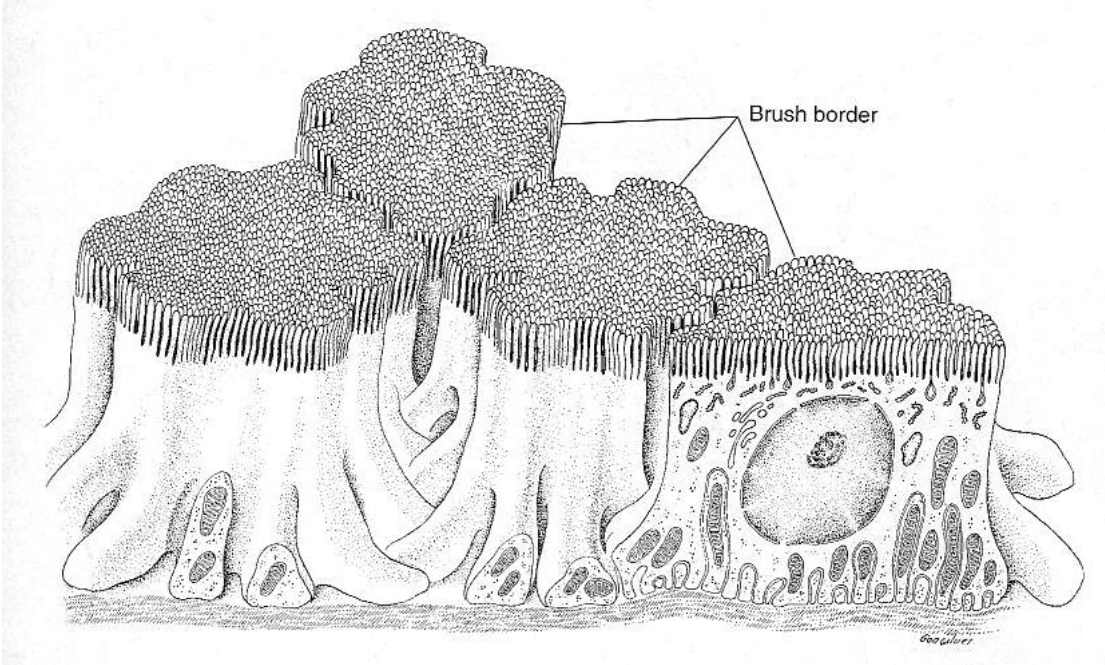
Simple columnar epithelium with brush border and basal striations

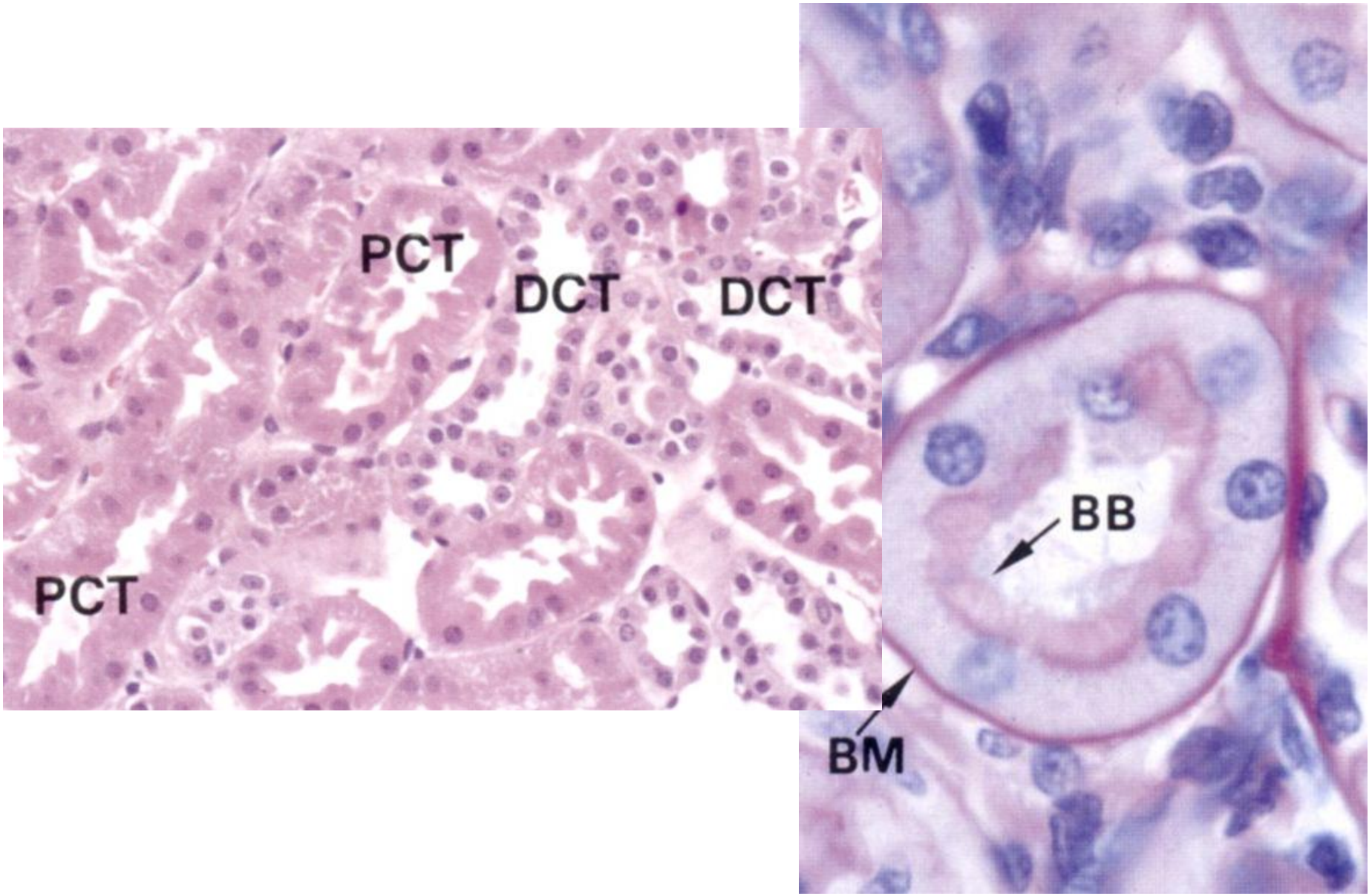
Function

1) Reabsorb glucose, NaCl, water, protein, amino acids; about 80% of filtrate

2) Secrete H+, foreign substances





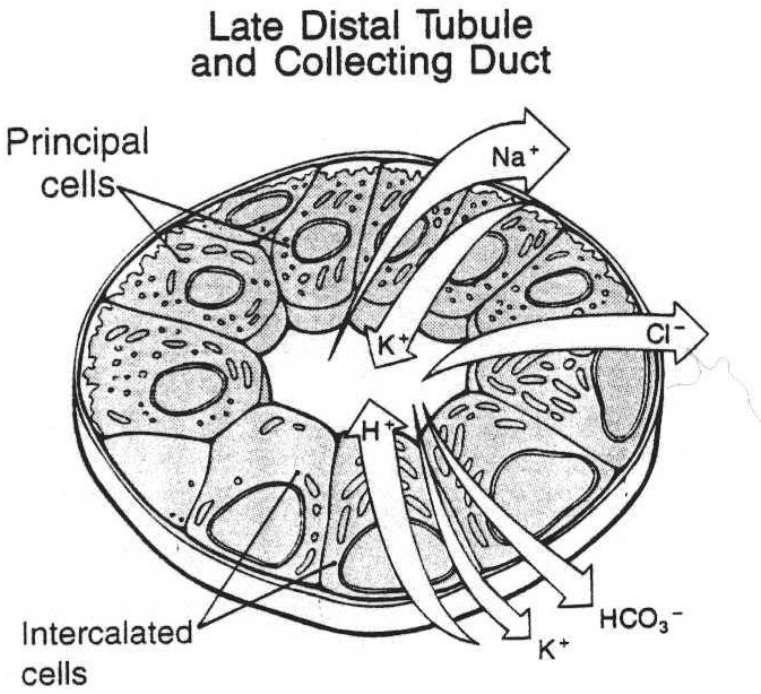

PCT
DCT
DCT
PCT
BB
BM

Distal convoluted tubule

Simple cuboidal epithelium with basal striations

Functions

1) Reabsorb Na+ controlled by aldosterone to regulate blood volume
2) Acid base balance



Loop of Henle

Simple cuboidal and

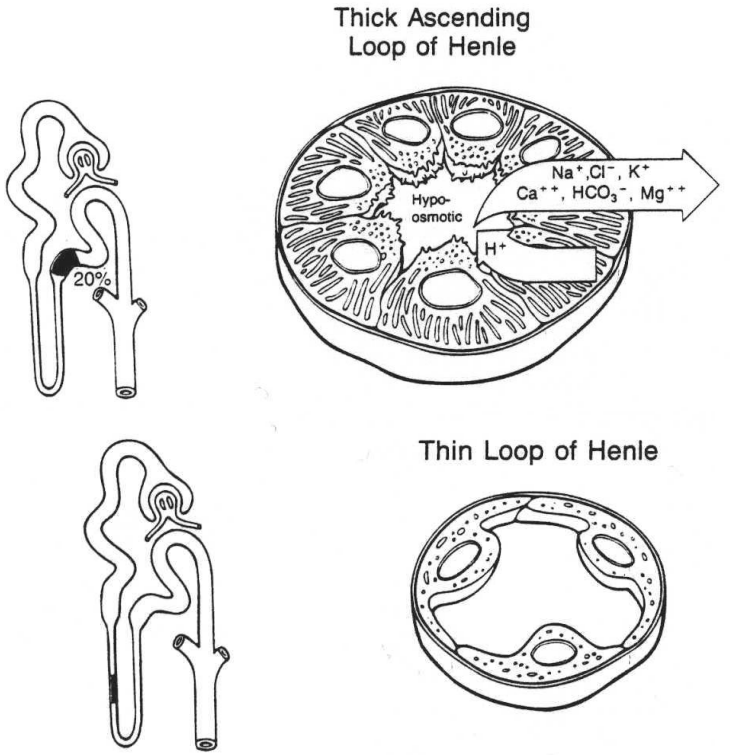
simple squamous epithelium

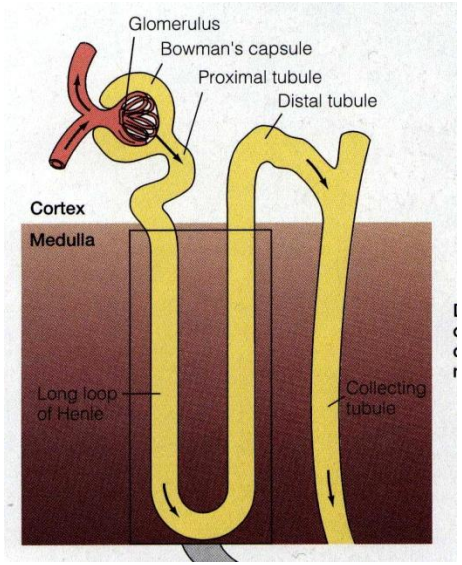
Function

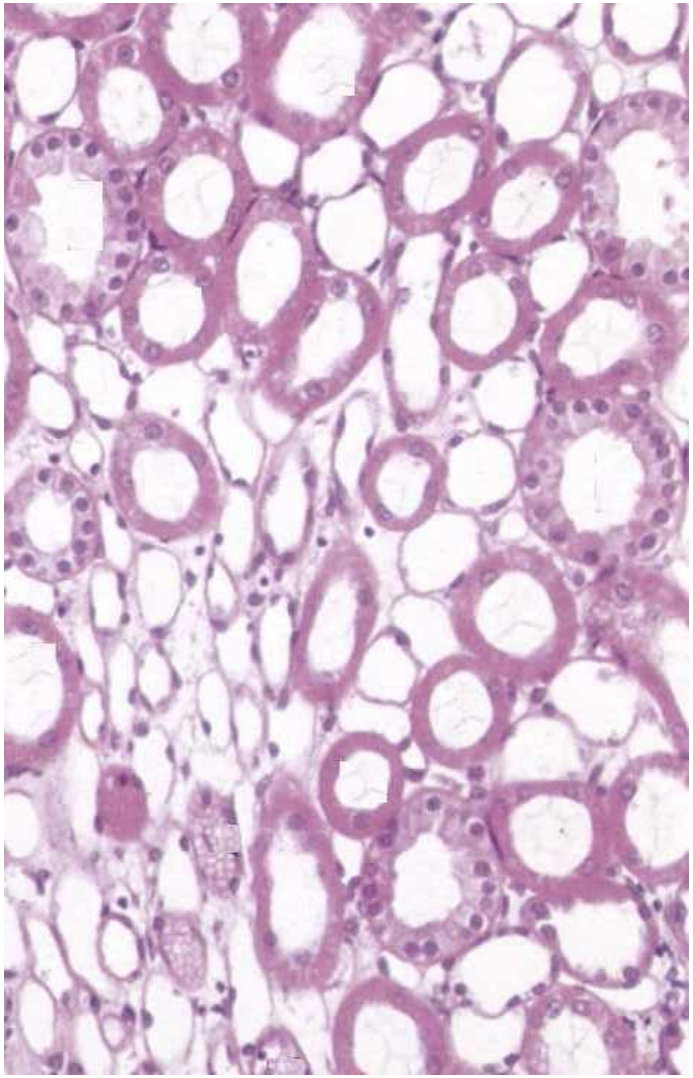
Counter-current multiplier

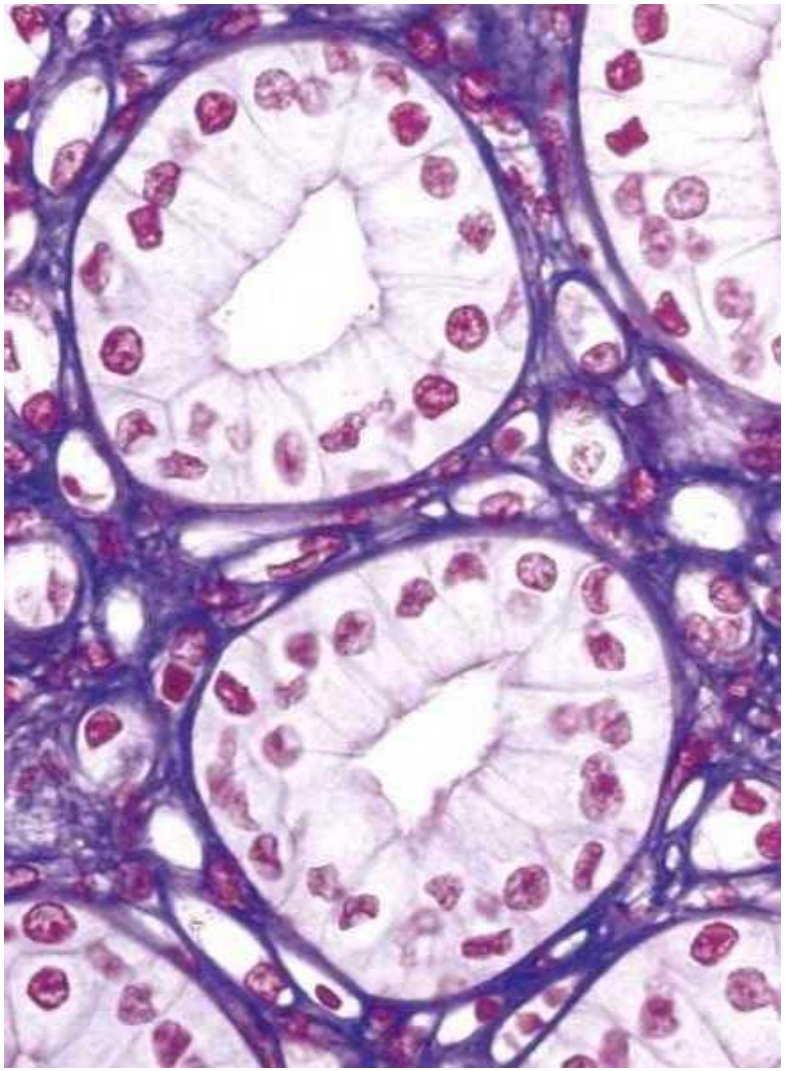
Increases hypertonicity of medullary interstitium to allow reabsorption of water in excess of sodium to regulate plasma osmolarity

Ascending limb pumps NaCl to interstitium









Collecting ducts

Simple cuboidal epithelium to simple columnar epithelium

Distinct cell boundaries

Function

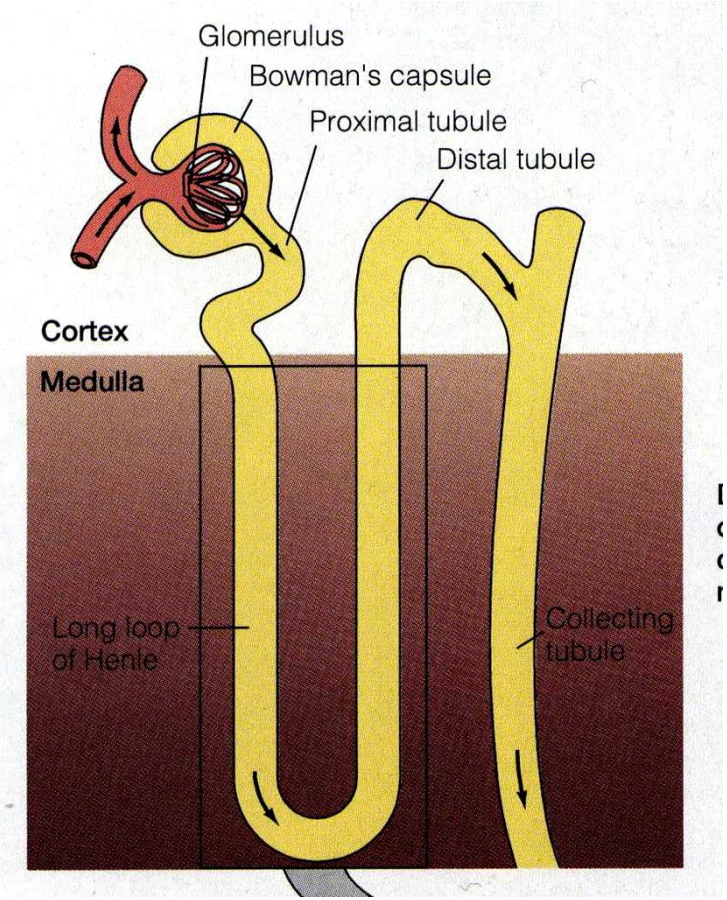
Concentrate urine to regulate plasma osmolarity

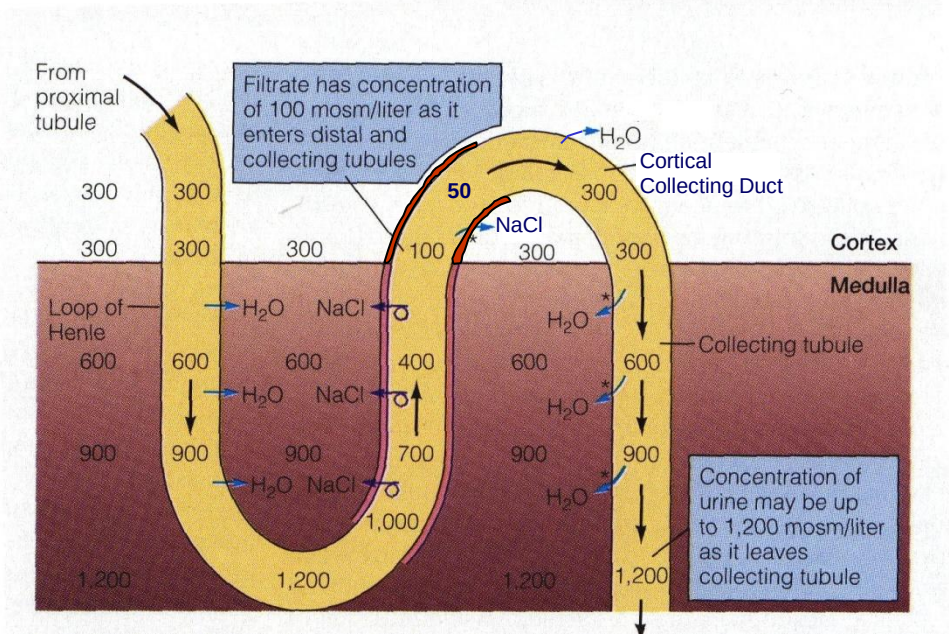
Water is reabsorbed by osmosis as CD passes through hypertonic interstitium

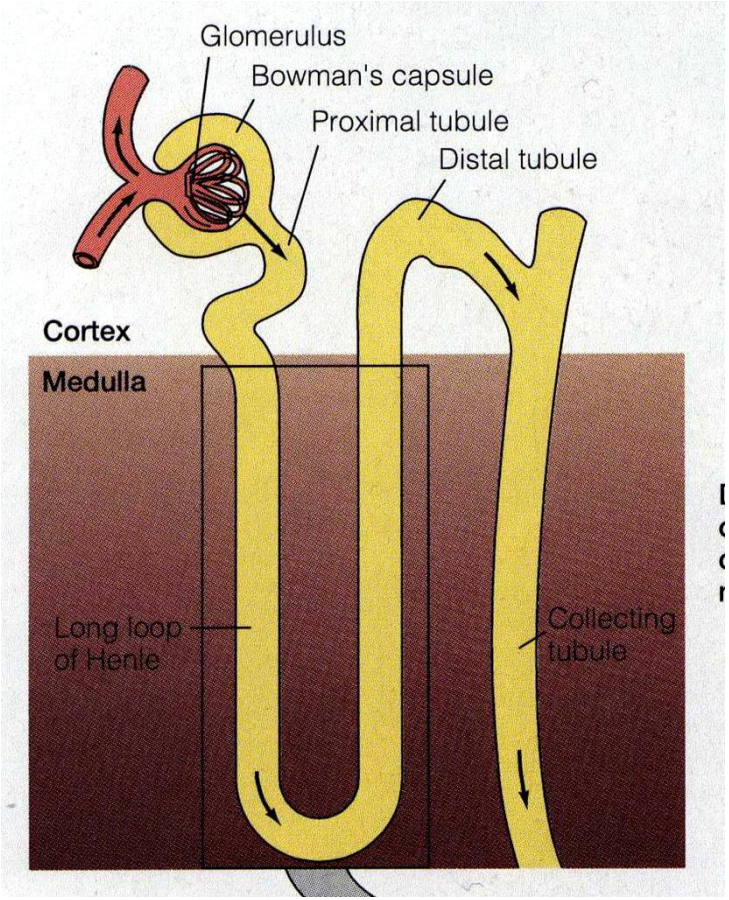
Regulated by ADH, which increases water permeability increasing water reabsorption

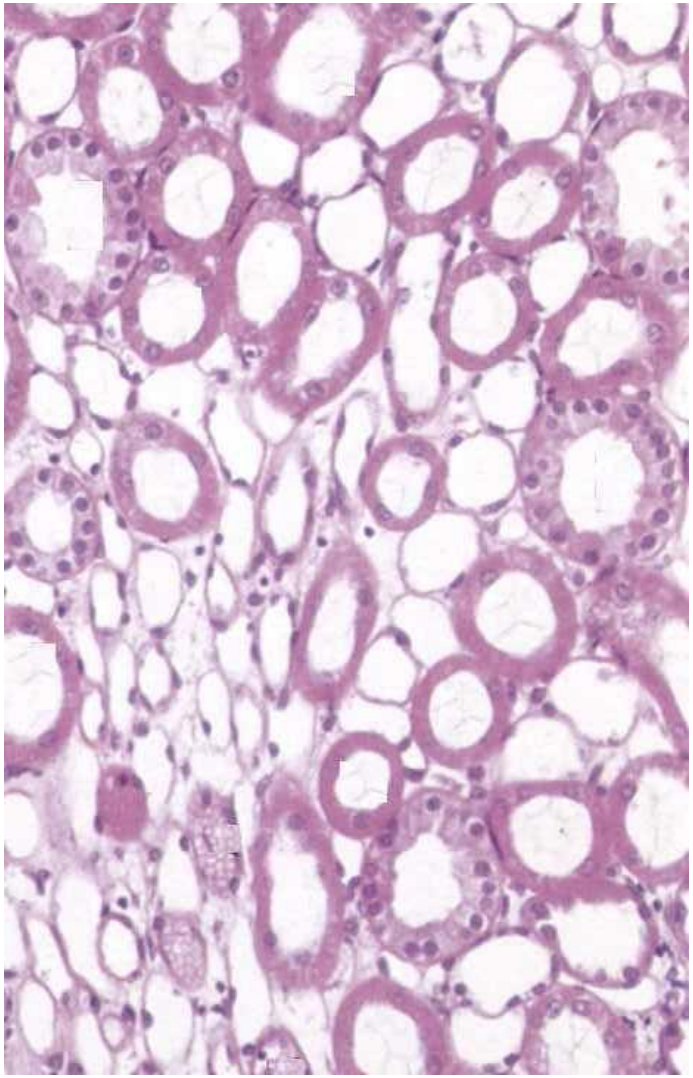
Decreased ADH > decrease water reabsorption

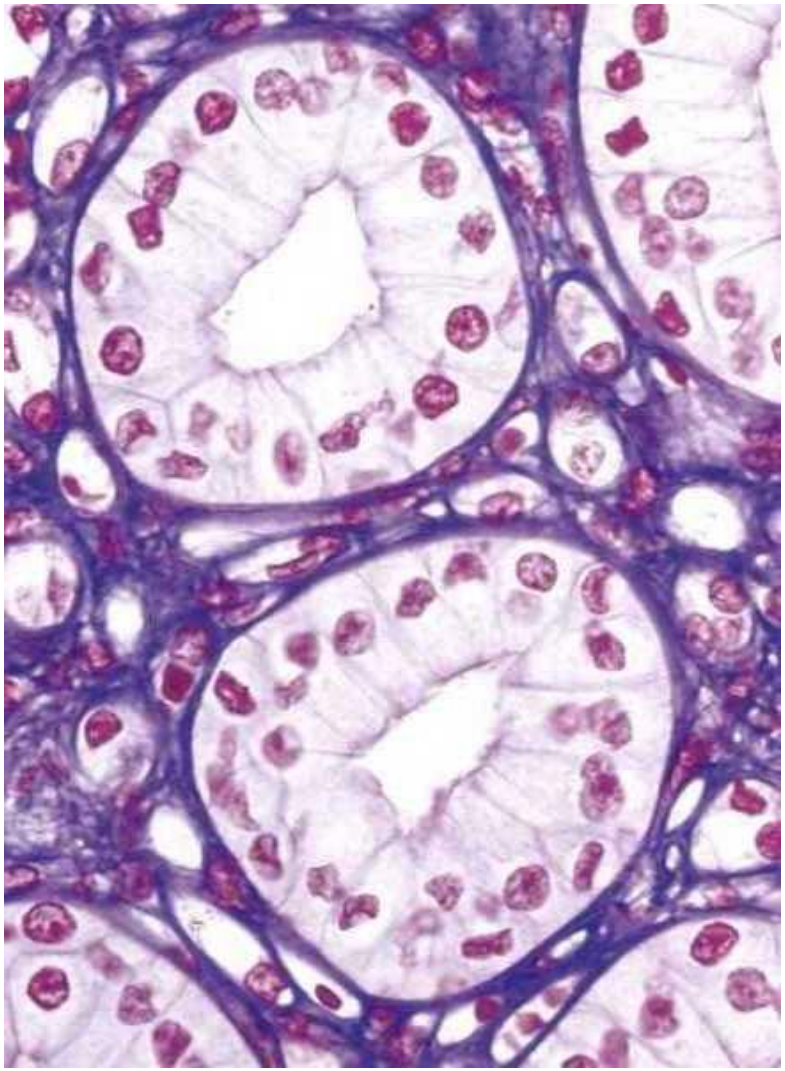
Lack of ADH: Diabetes insipidus




From proximal tubule
Filtrate has concentration of 100 mosm/liter as it enters distal and collecting tubules
H_2O
Cortical Collecting Duct
50
NaCl
Cortex
Medulla
Loop of Henle
Collecting tubule
300
600
900
1,200
100
400
700
1,000
Concentration of urine may be up to 1,200 mosm/liter as it leaves collecting tubule


Glomerulus
Bowman's capsule
Proximal tubule
Distal tubule
Cortex
Medulla
Long loop of Henle
Collecting tubule





Peritubular capilaries

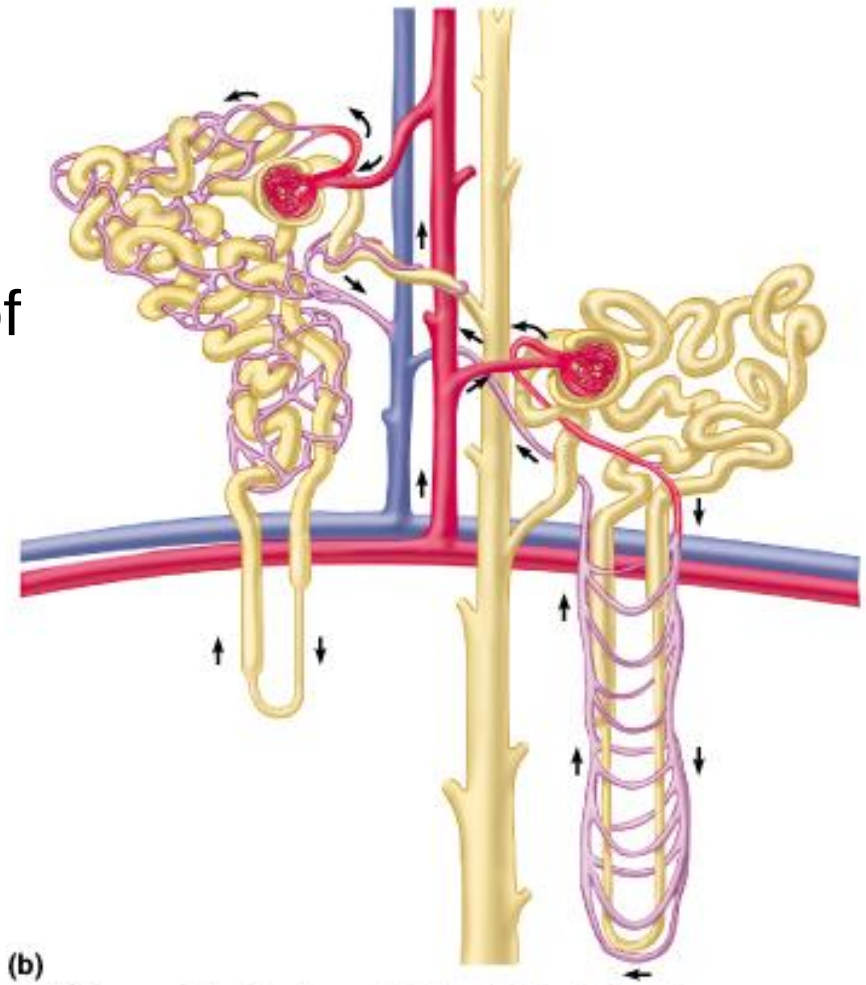
after efferent arterioles, capillaries surround tubule; special area: around Loop

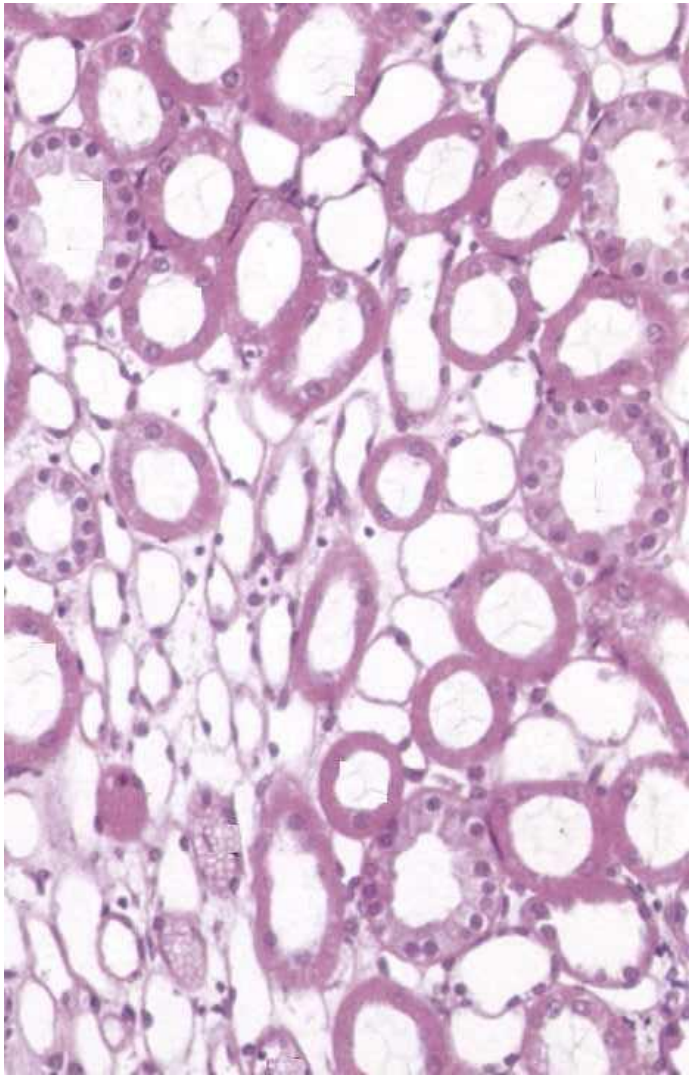
Vasa recta = capillary network of medulla

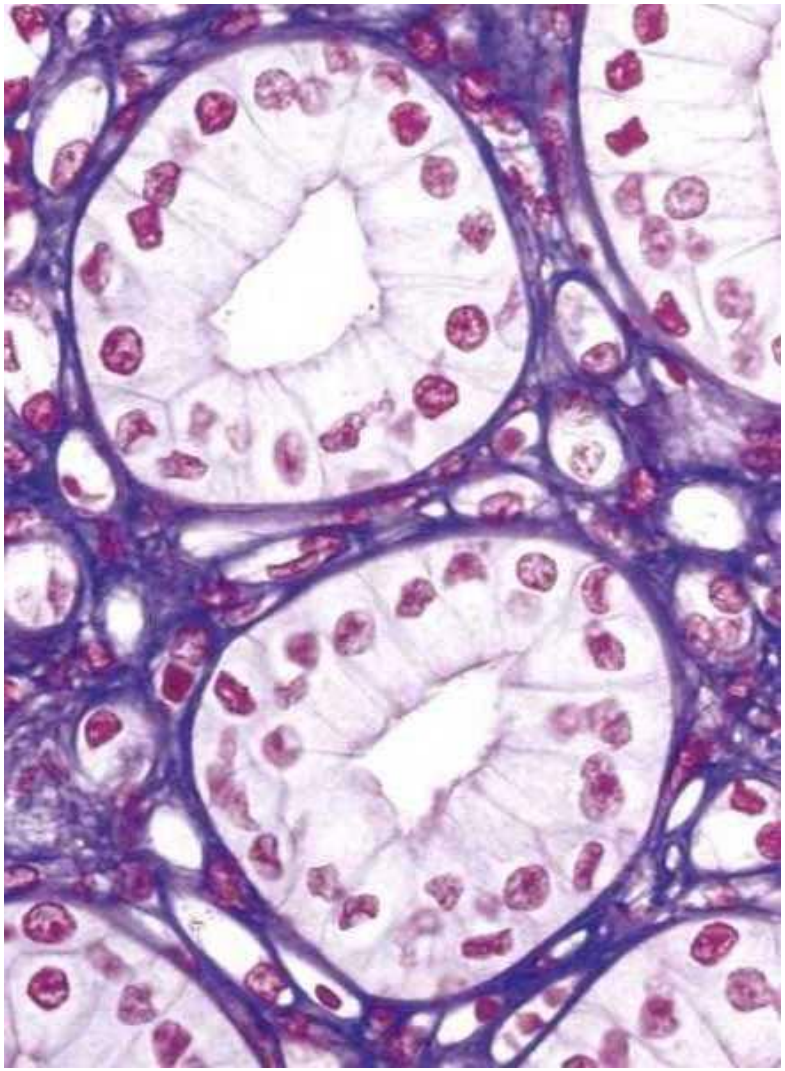
= **counter-current exchanger**

Capillaries loop in/out of pyramids

= a portal system

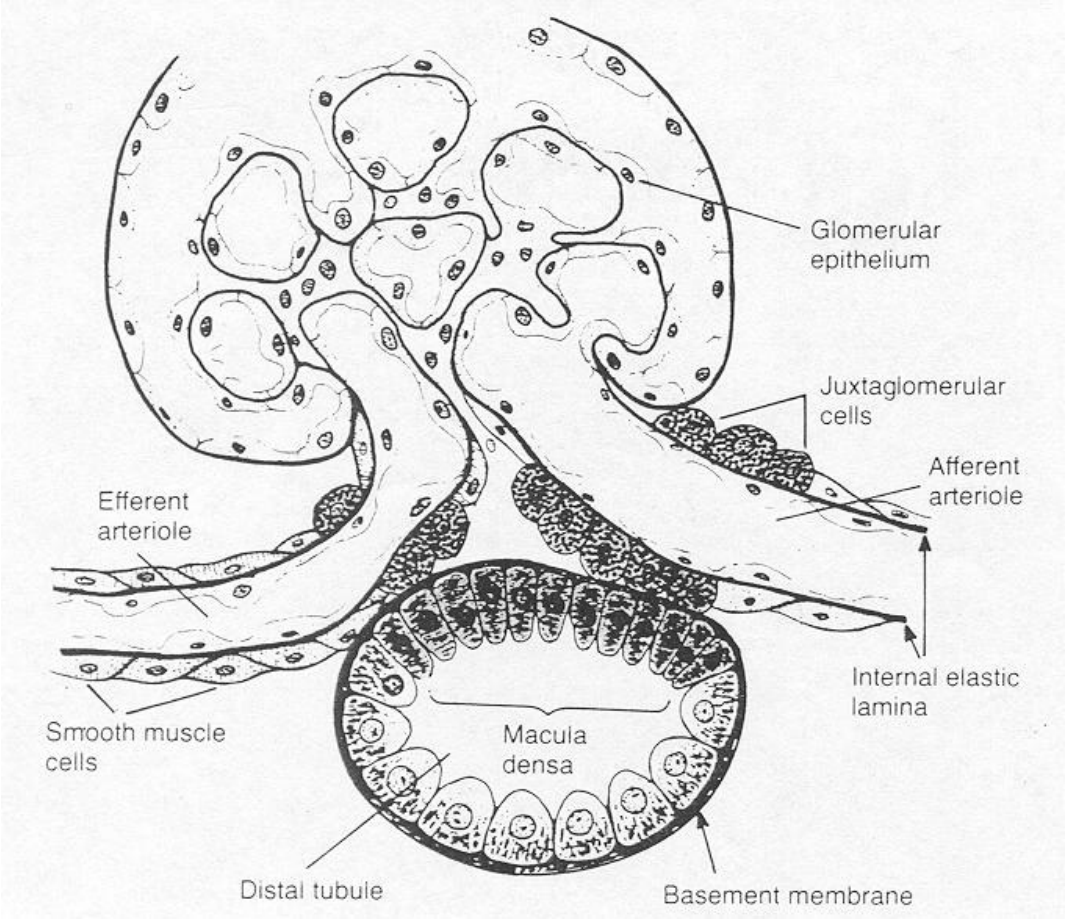






JG apparatus = Juxtaglomerular apparatus

1) **Macula densa**
2) **JG cells**

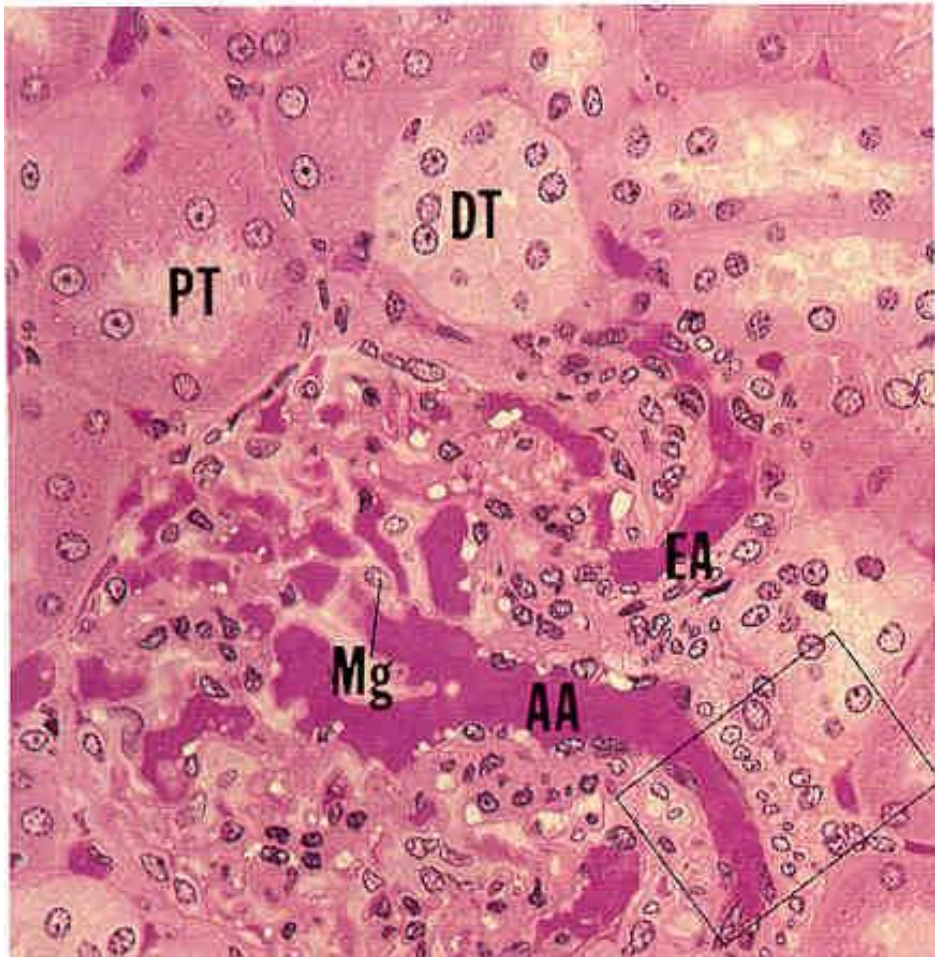


JG cells

Specialized smooth muscle of afferent arteriole

1) Act as **baroreceptors**
2) Secretory granules – secrete **renin**

Decreased blood pressure > increased secretion of renin



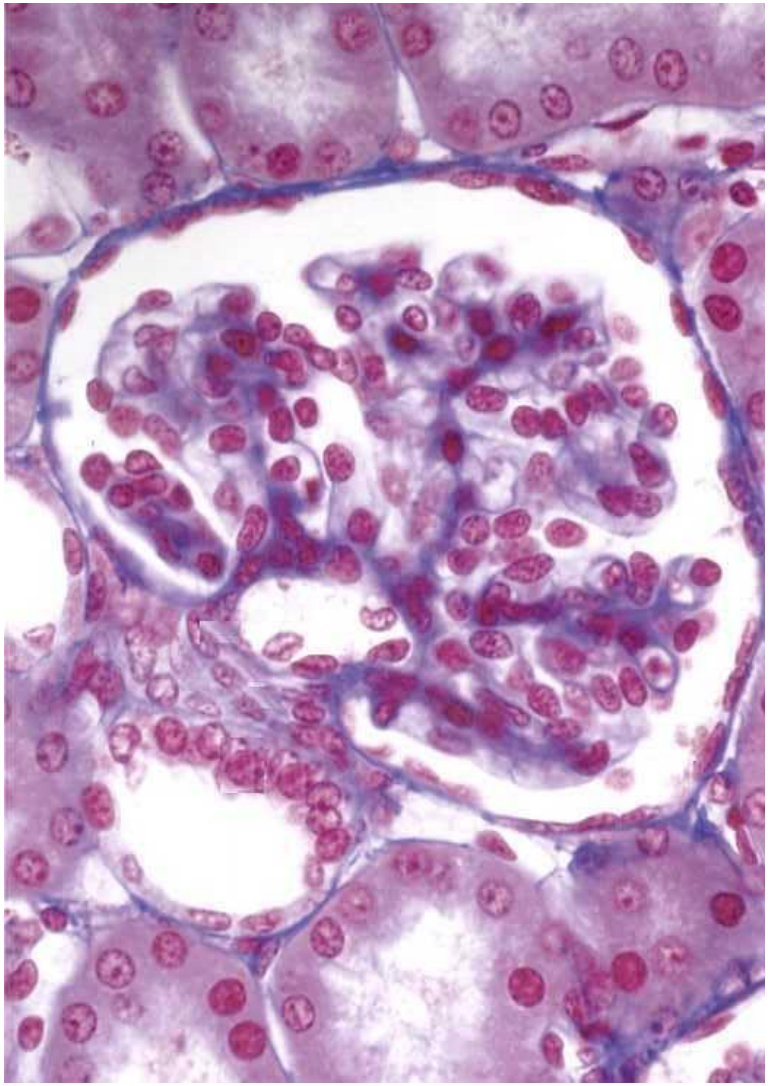
Macula densa

Tall, narrow, simple columnar epithelial cells in wall of DCT

Adjacent to JG cells

Sense NaCl content of filtrate

Decreased NaCl > increased renin secretion



Renin > Increased BP

Decreased blood pressure > increased renin

Renin = enzyme

Catalyzes: Angiotensinogen (from liver) > angiotensin I

Converting enzyme (in lung):

Catalyzes: Angiotensin I > angiotensin II

Angiotensin II:

Leads to increased BP

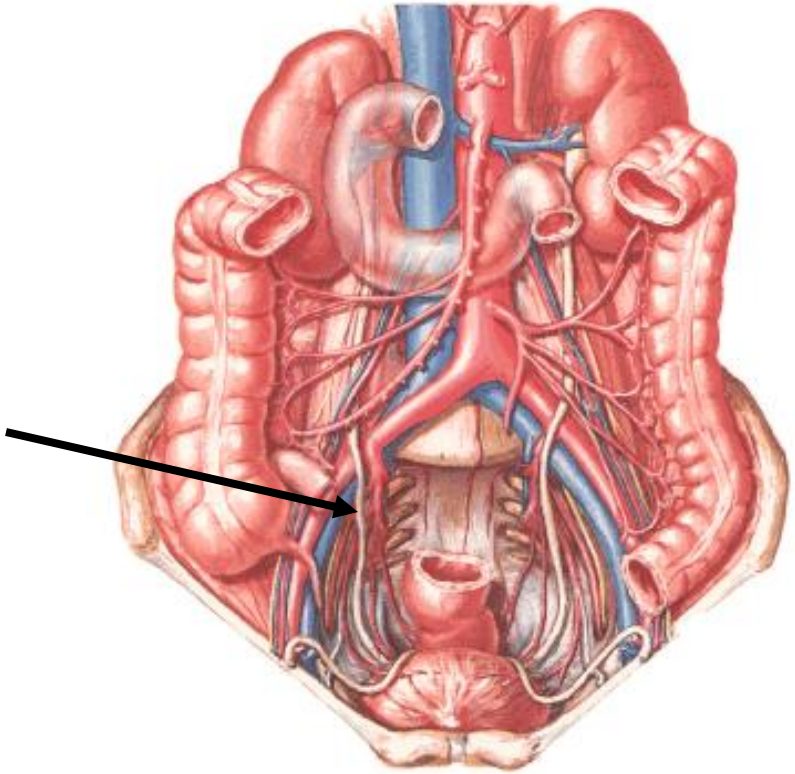
1) Vasoconstriction
2) Increased secretion aldosterone > increased Na+ reabsorption
3) Increased ADH > increase water reabsorption

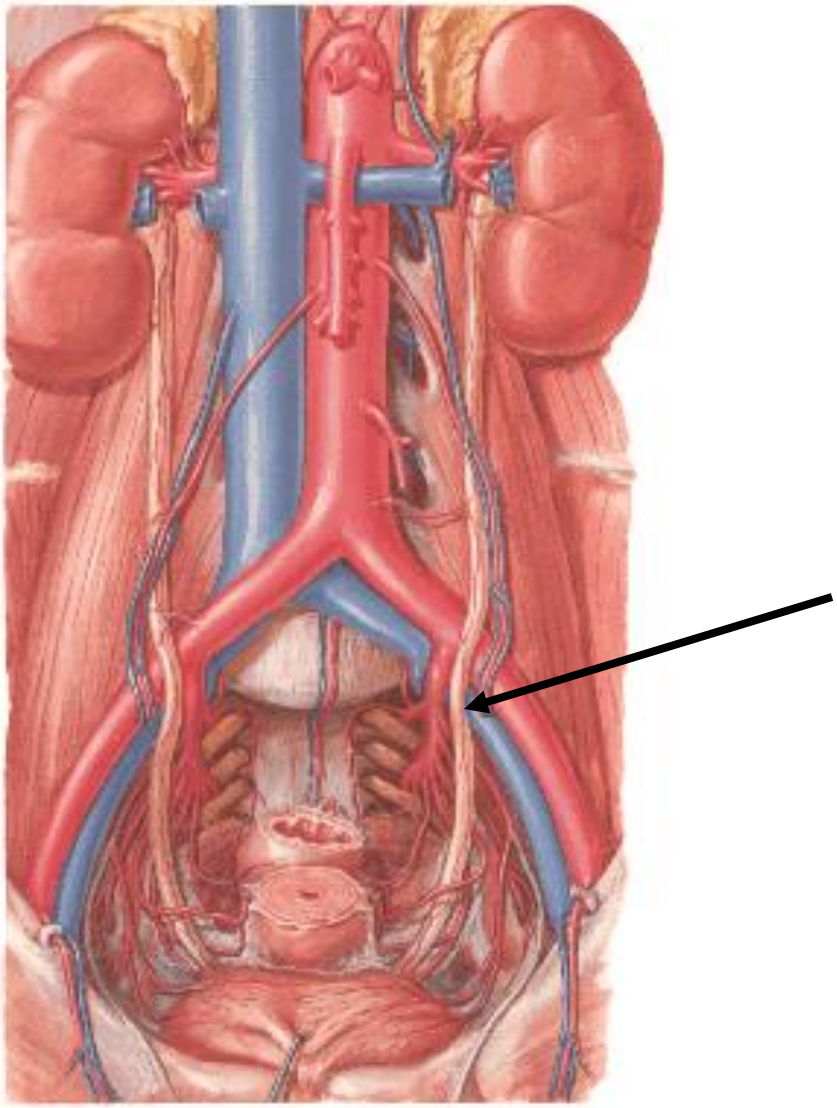
Ureters

25 to 30 cm by 4 to 5 mm

Retroperitoneal

Urine moves via peristalsis





Walls of calices, pelvis, ureter, bladder,1st part urethra:

1) **Mucosa**

   Transitional epithelium

   CT

2) **Muscularis**

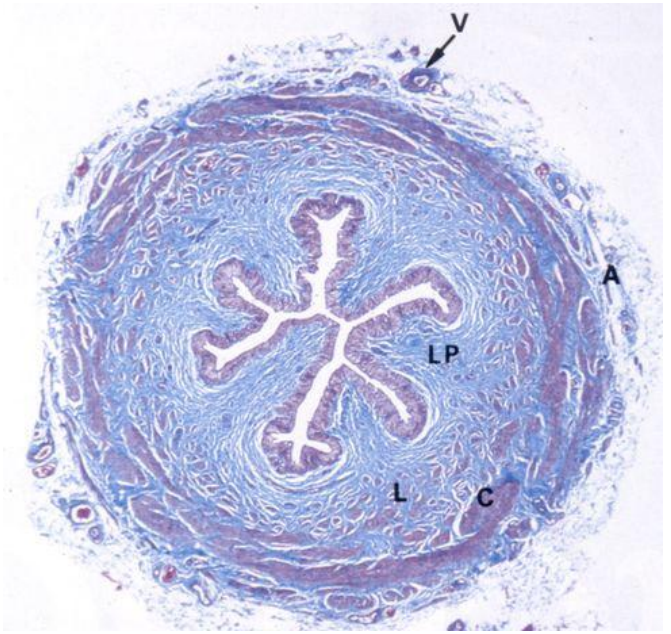
   Inner longitudinal

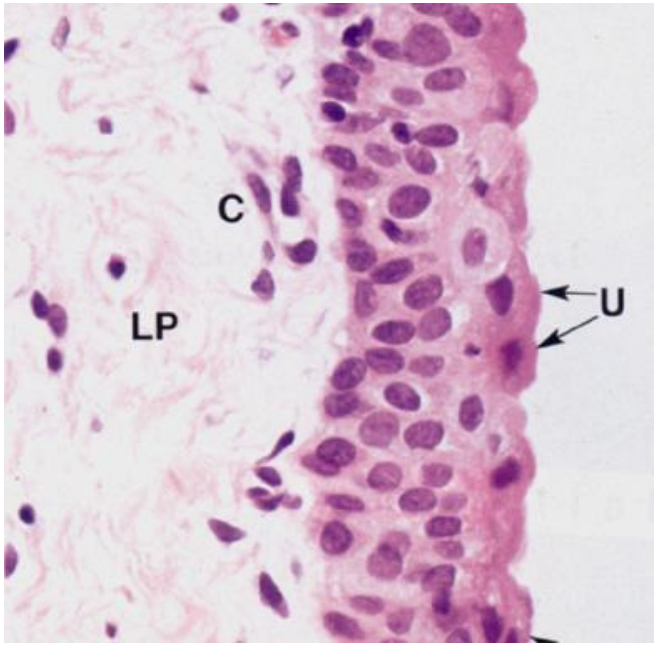
   Outer circular

   Outermost longitudinal in last ½ ureter & bladder

3) **Adventitia**

   CT





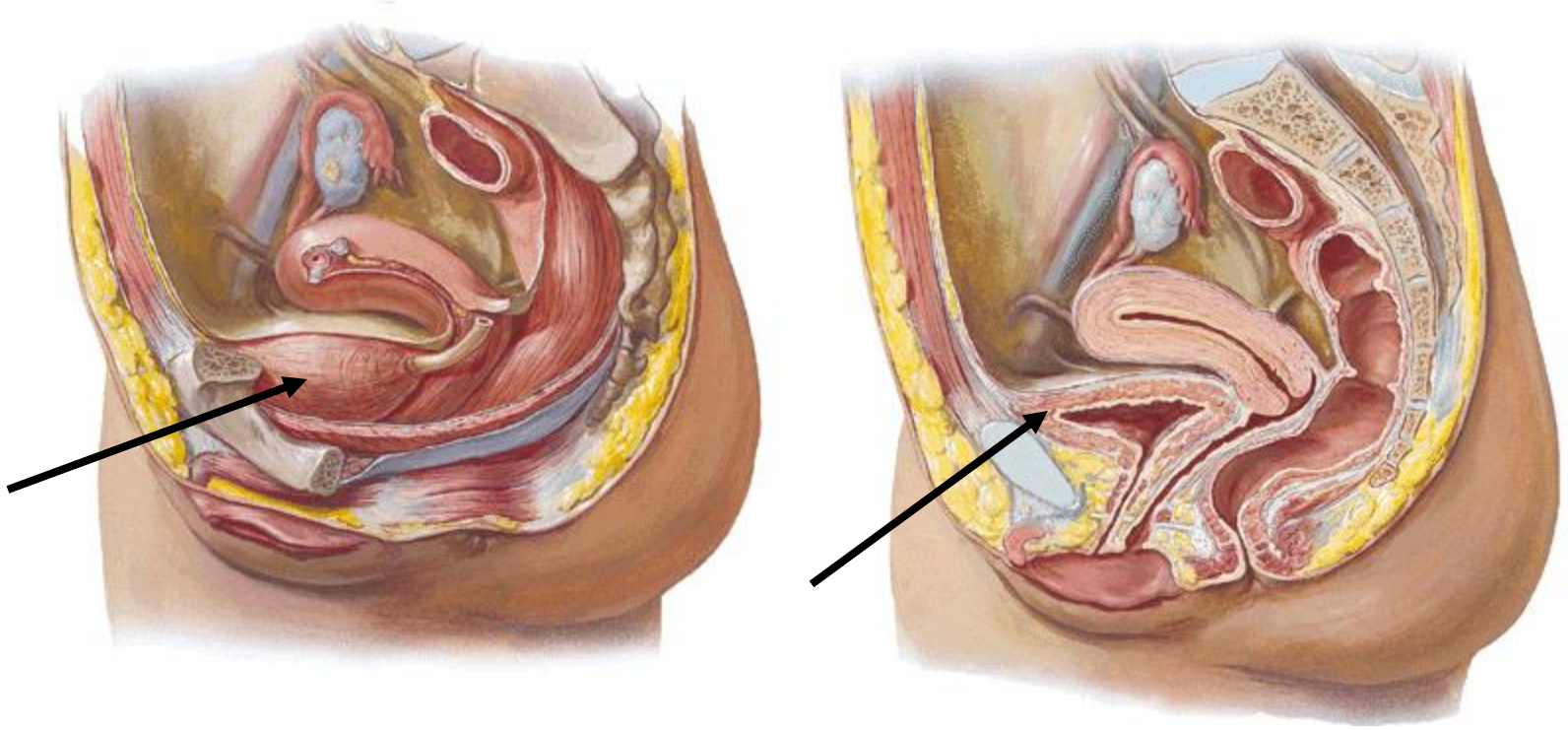
Bladder

300 ml storage capacity

Within true pelvis

Below peritoneal cavity

Posterior to symphysis pubis, anterior to uterus in female, anterior to rectum in male

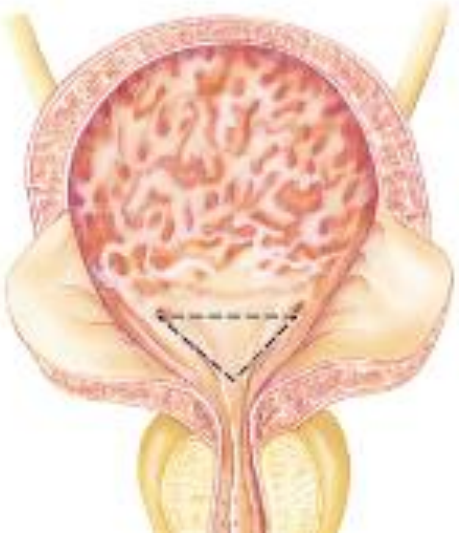


3 openings = **trigone of bladder**

Ureters

About 2 cm oblique path through posterior wall of bladder
No backflow

Urethra



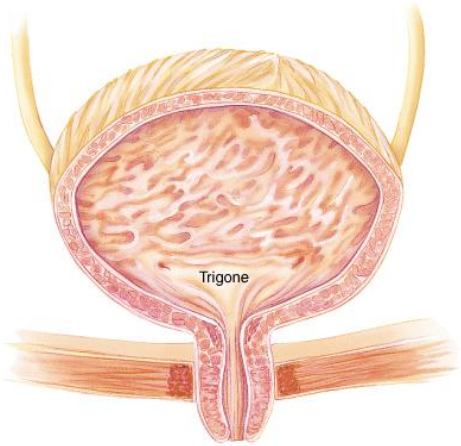
Sphincters:

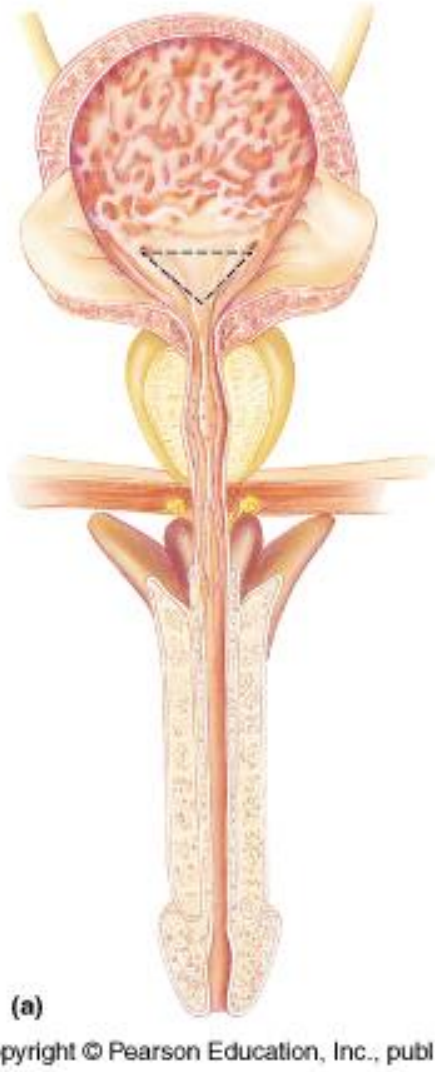
Internal

Smooth muscle at base of bladder

External

Skeletal muscle of urogenital diaphragm





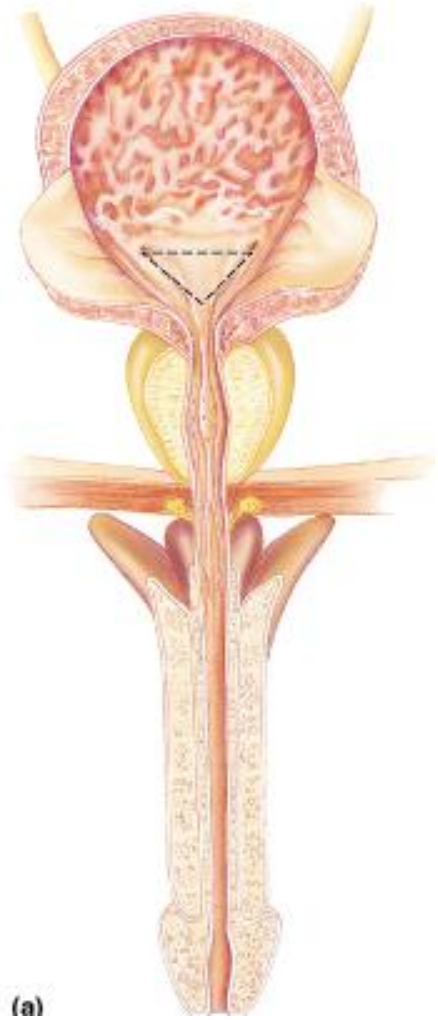
Male urethra

3 portions

Prostatic – pass through prostate

Membranous – through urogenital diaphragm

Penile or cavernous or spongy – through shaft of penis



About 20 cm long

Epithelium:

Transitional >

> pseudostratified

> stratified squamous

Female urethra

About 3 to 5 cm long

Same epithelial changes as in male