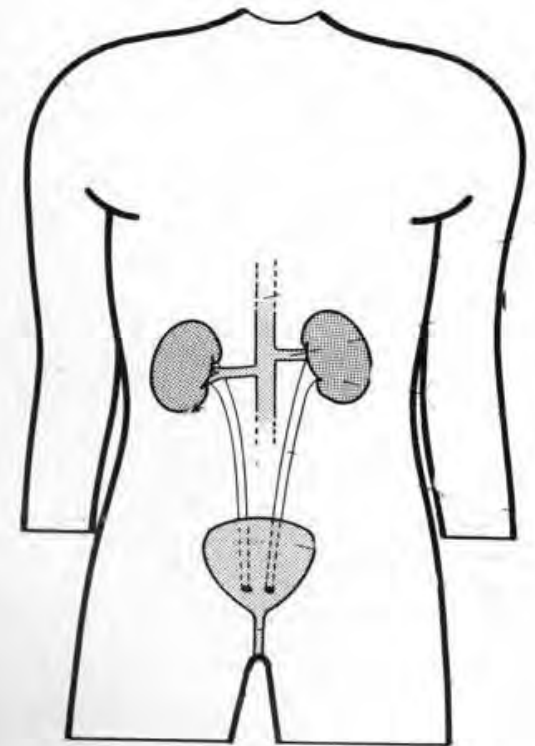


Chapter 14

Urinary System

Li Hong

*Division of Histology and Embryology
Anhui Medical University*

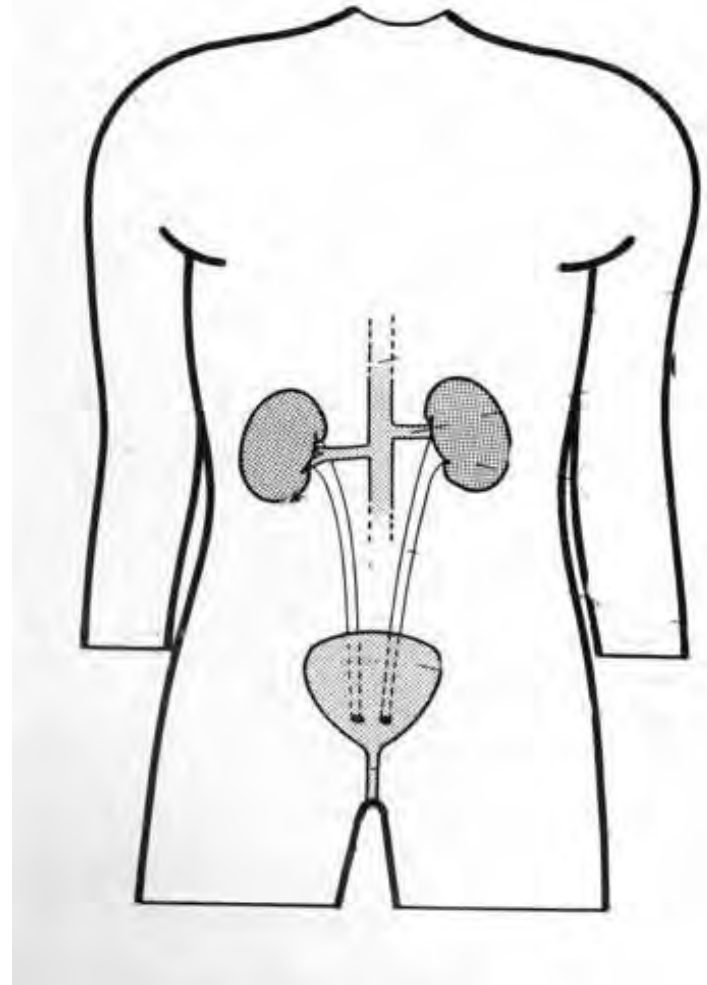


contents

- General description
- Kidneys

Components

- Kidneys
- Ureters
- Bladder
- urethra



Functions of kidneys

- Regulate the fluid and electrolyte balance of body
- Remove waste products of metabolism from body
- Function as endocrine organs:

Synthesize and secrete erythropoietin, rennin

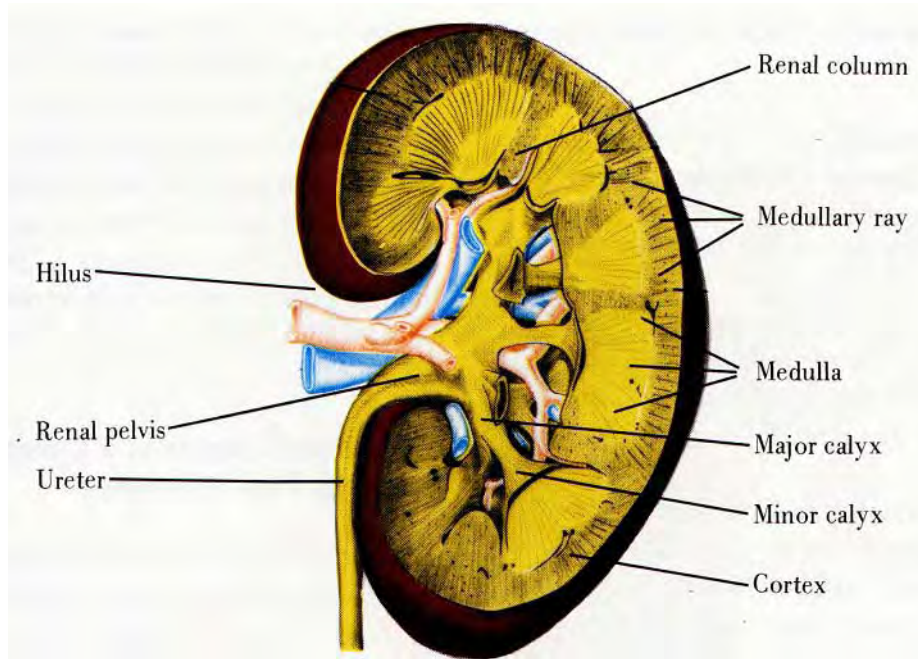
contents

- General description

- Kidneys

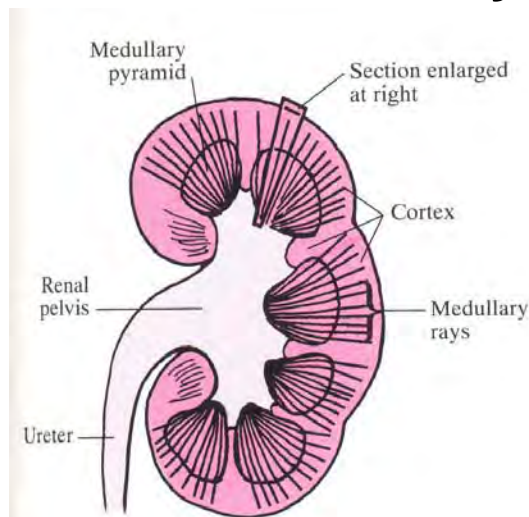
Kidney structure

The kidney is a bean-shaped organ covered by a fibrous tunic or renal capsule. Each kidney has a concave medial border, the **hilum**---where nerve enters, blood and lymph vessels enter and the ureter exits. the **renal pelvis**, expanded upper end of the ureter, is divided into 2 or 3 **major calyces**. Several small branches, the **minor calyces**, arise from each **major calyx**.

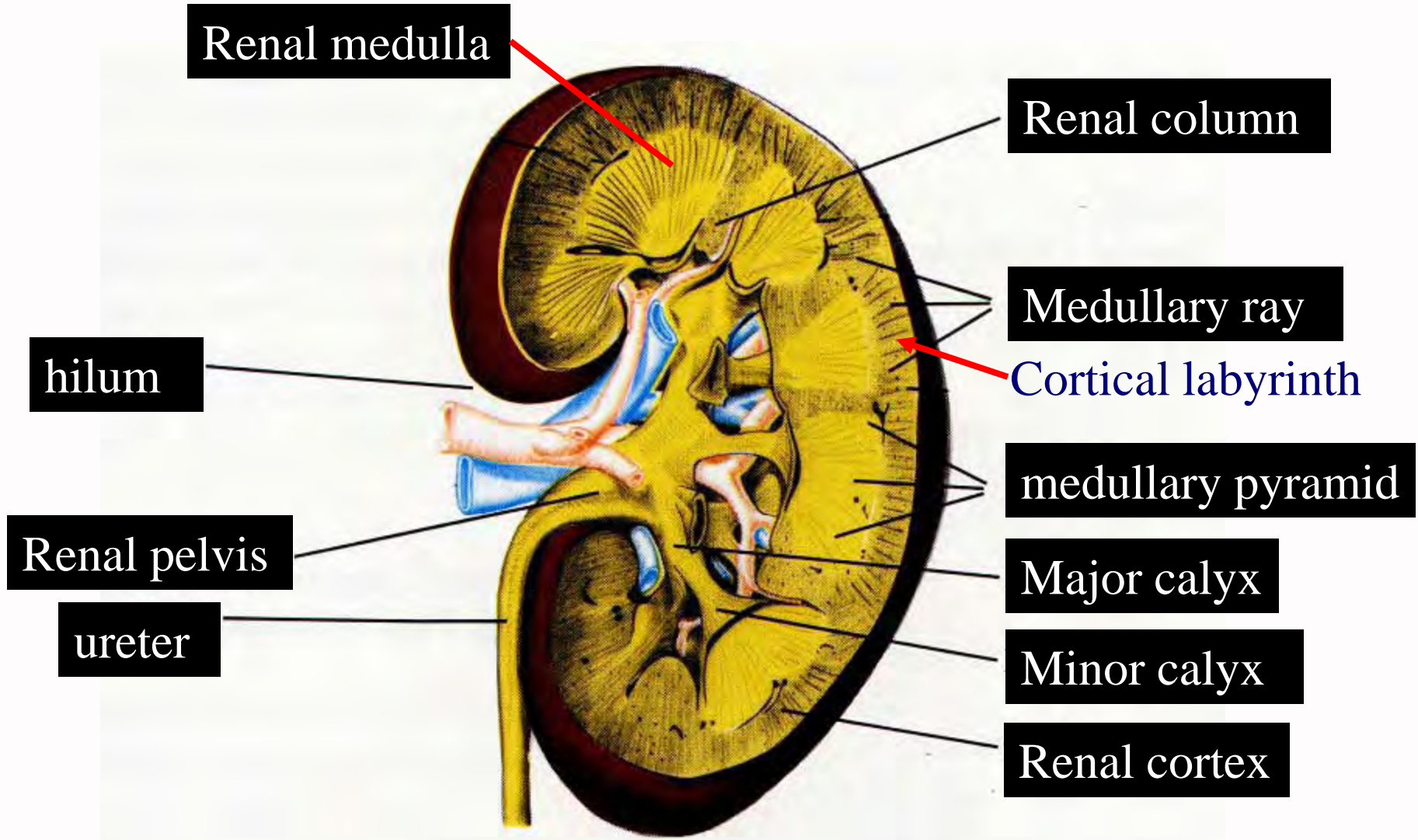


Kidney structure

The kidney can be divided into an outer **cortex** and an inner **medulla**.the renal medulla consists of 10-18 pyramidal structures,the **medullary pyramids** whose apices point toward the renal pelvis whose base help form the interface with the cortex.from the base of each medullary pyramid,parallel arrays of tubules,the **medullary rays**,penetrate the cortex.the granular cortical tissue between the medullary rays is termed the **cortical labyrinth**.the cortex between medullary pyramids are called **renal column**.

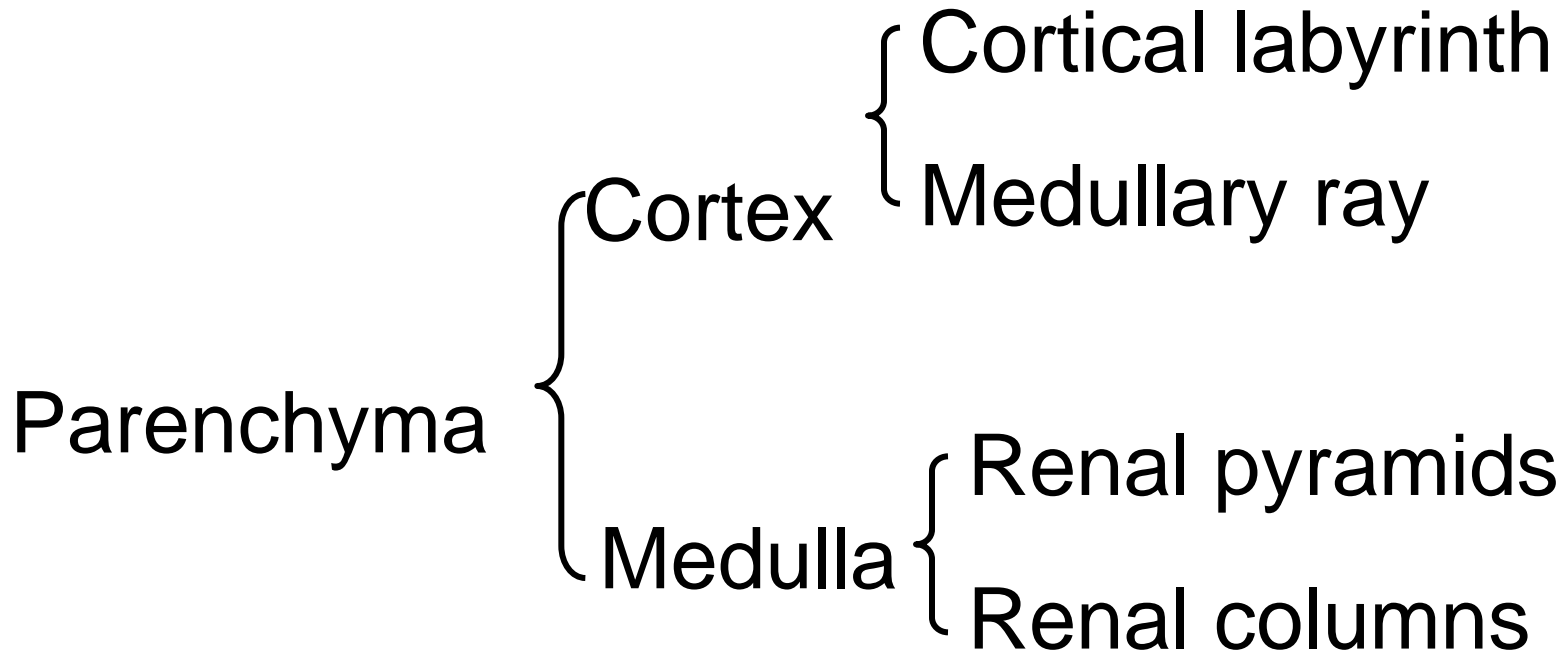
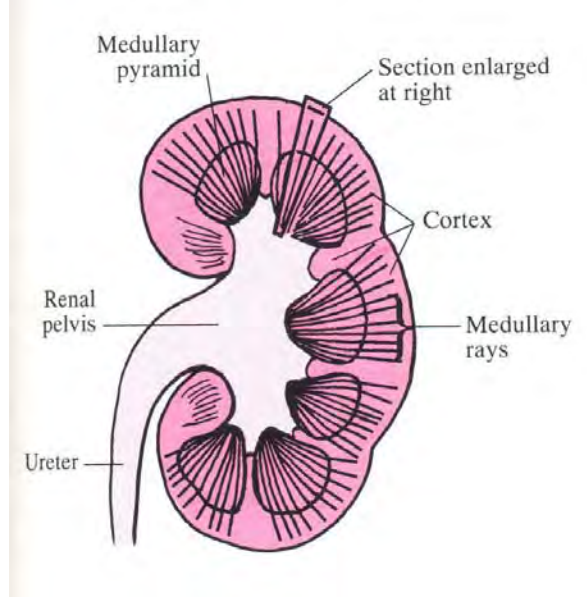


Kidney structure



Renal anatomic structure

Fibrosa



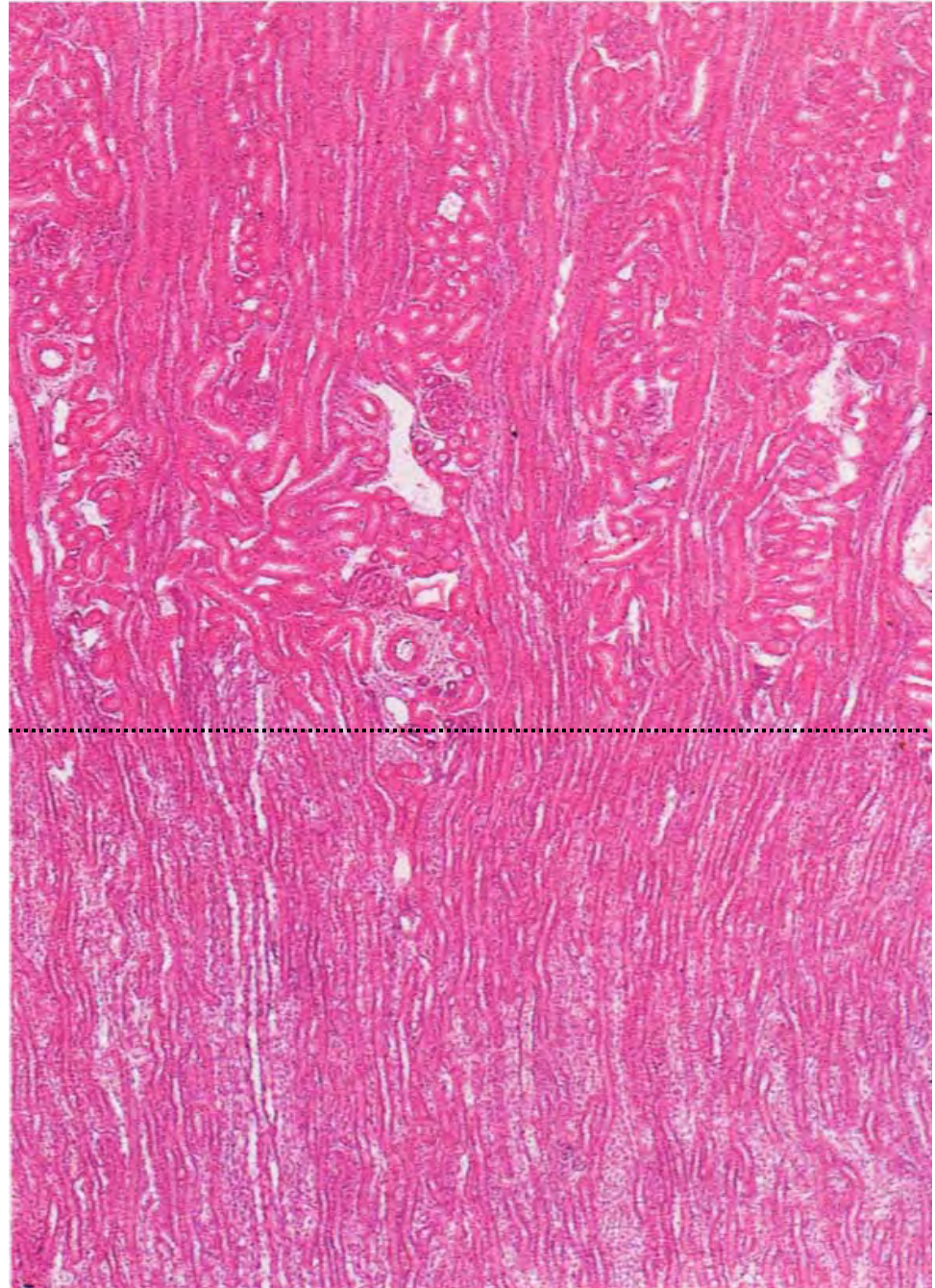
Kidney (HE)

Renal cortex:

Cortical labyrinth

Medullary ray

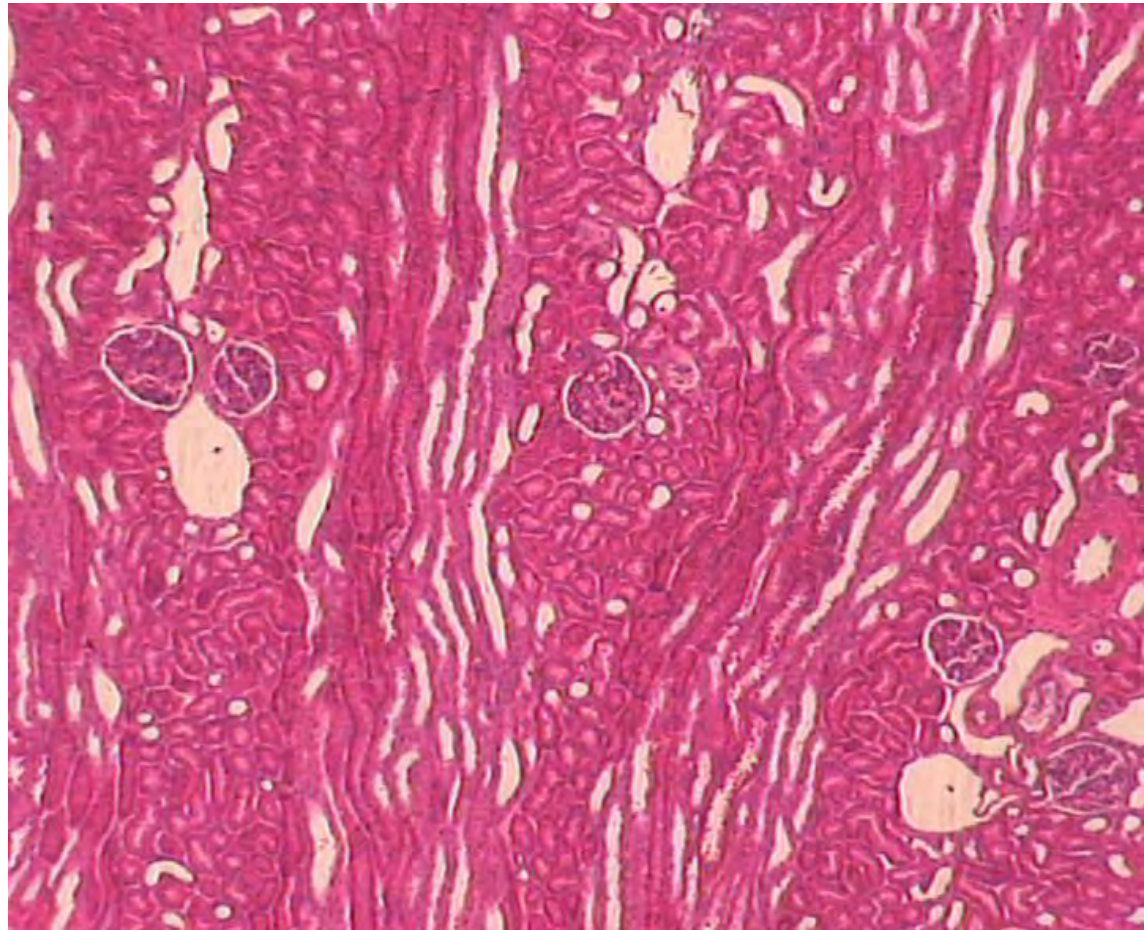
Renal medulla



Renal cortex (HE)

Cortical labyrinth

Medullary ray



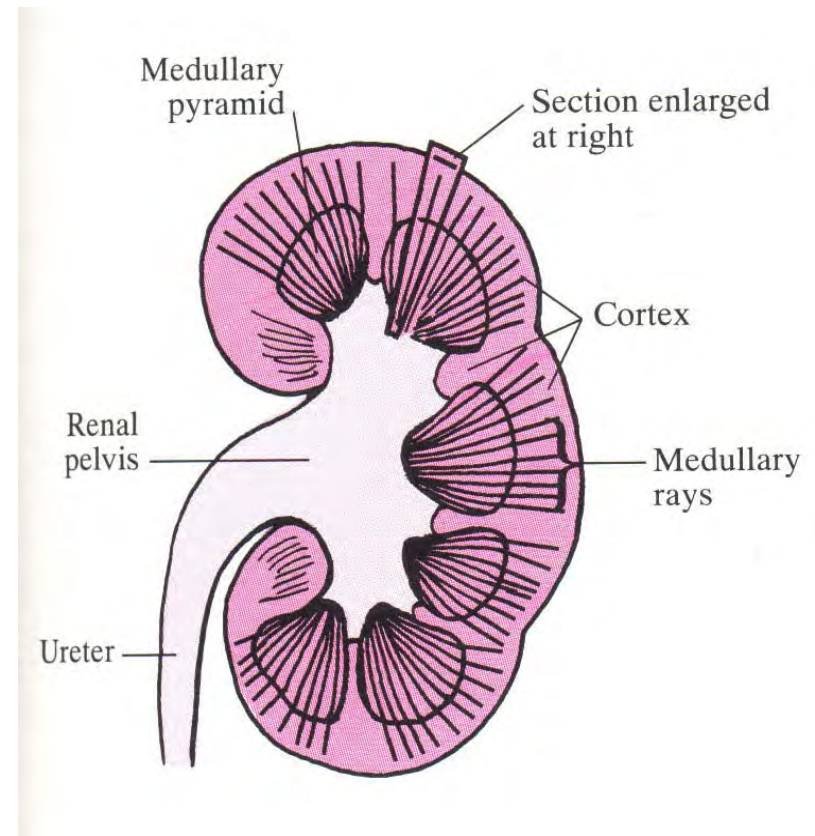
Kidney lobe and kidney lobule

A kidney lobe:

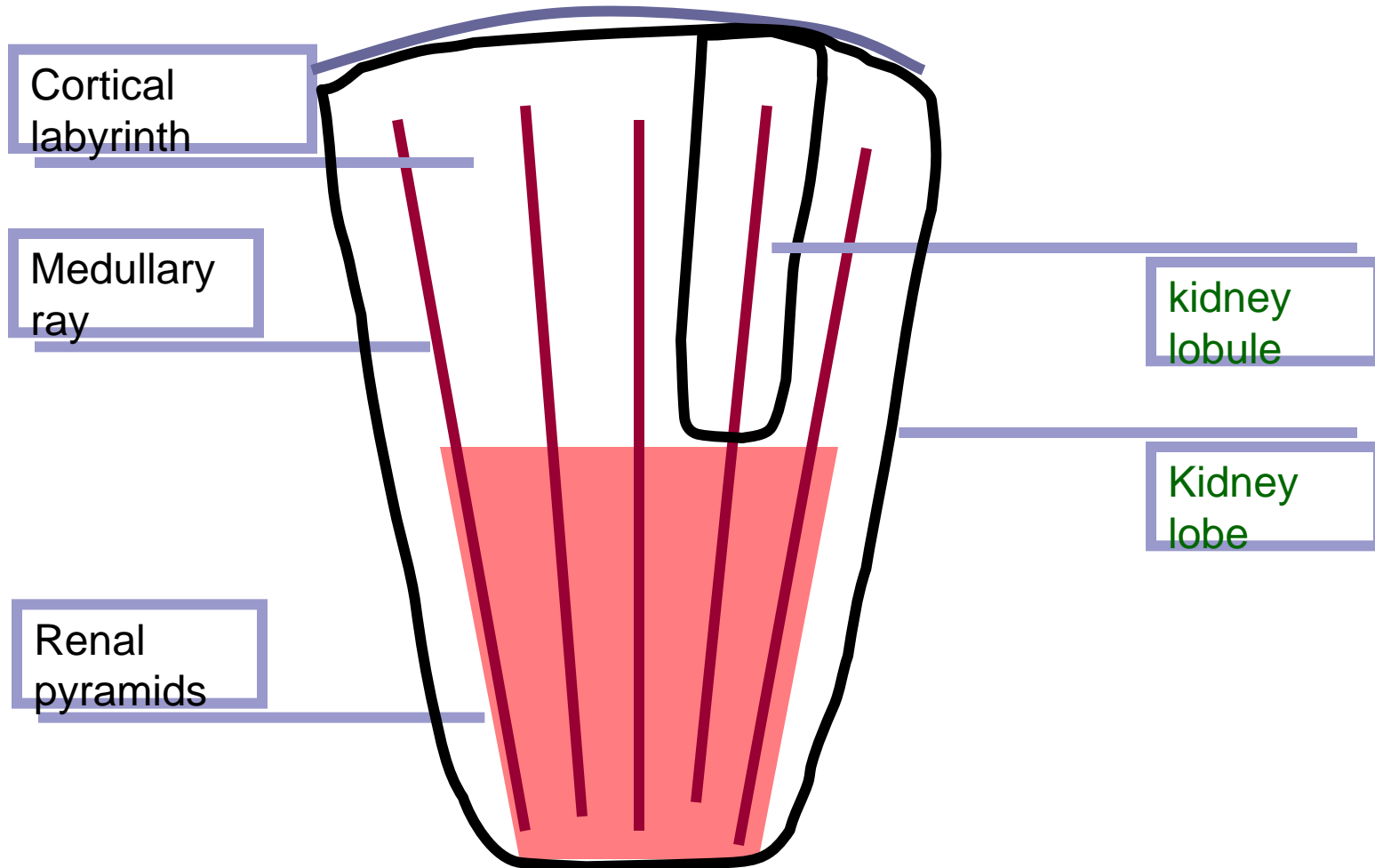
A medullary pyramid and the associated cortical tissue

A kidney lobule:

A medullary ray and the surrounding cortical labyrinth



Kidney lobe and kidney lobule



Renal histological structure

Covering membrane: Connective tissue capsule

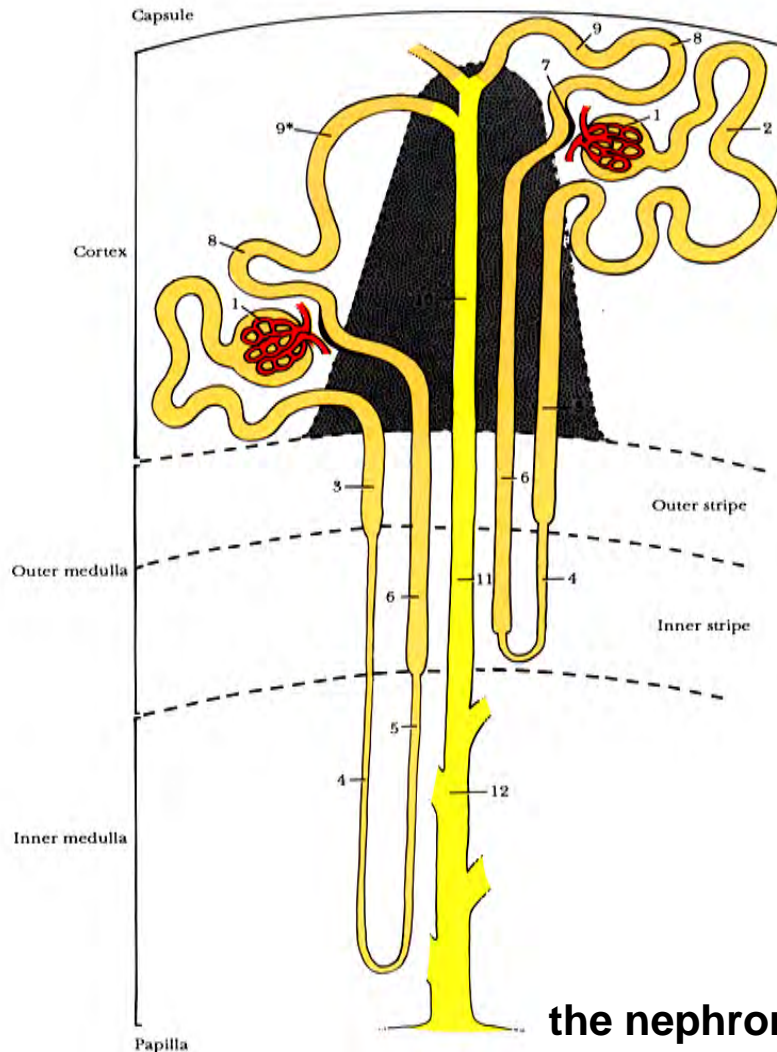
Parenchyma: Uriniferous tubules

Interstitium: Connective tissue

Blood vessels, Lymph vessels

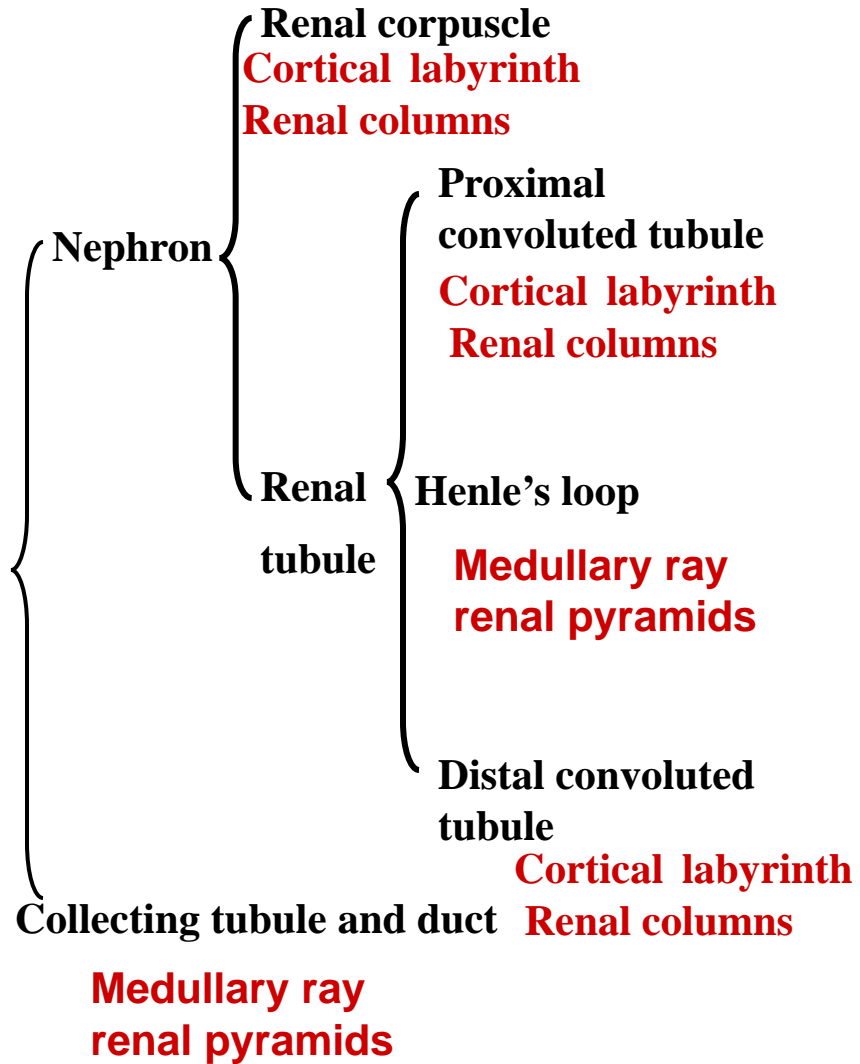
Nerves...

Urineriferous tubule (components)

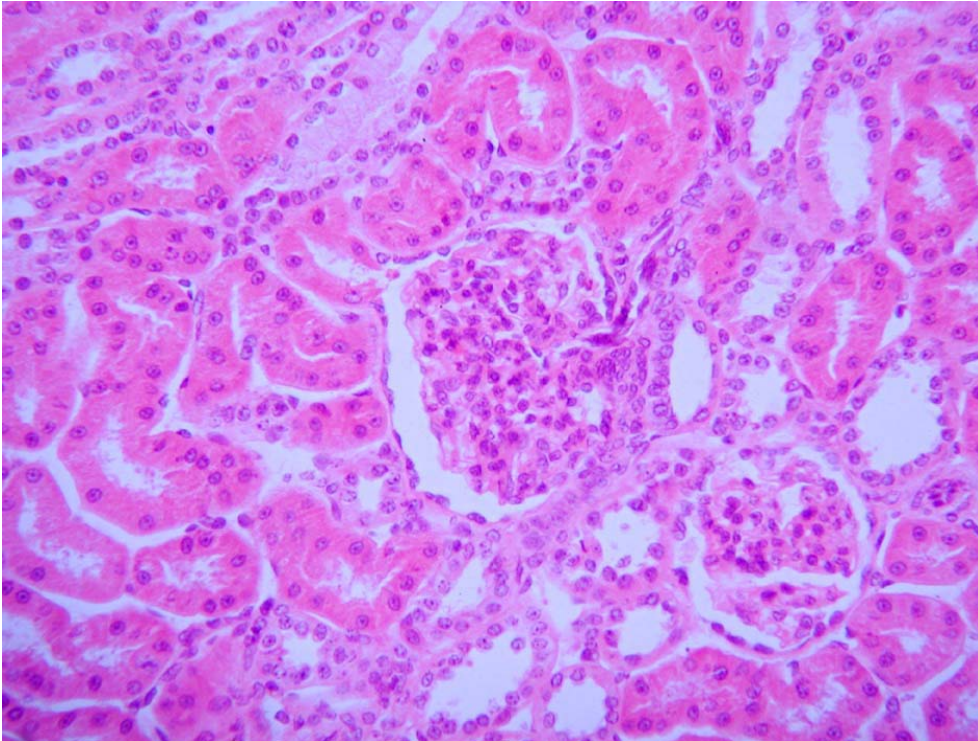


the nephron is the functional unit of the kidney

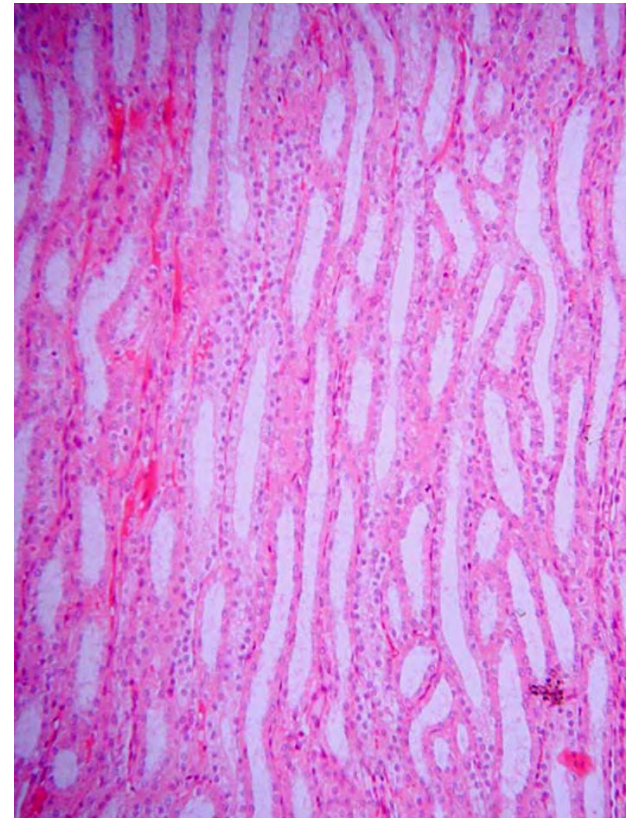
Urineriferous tubule



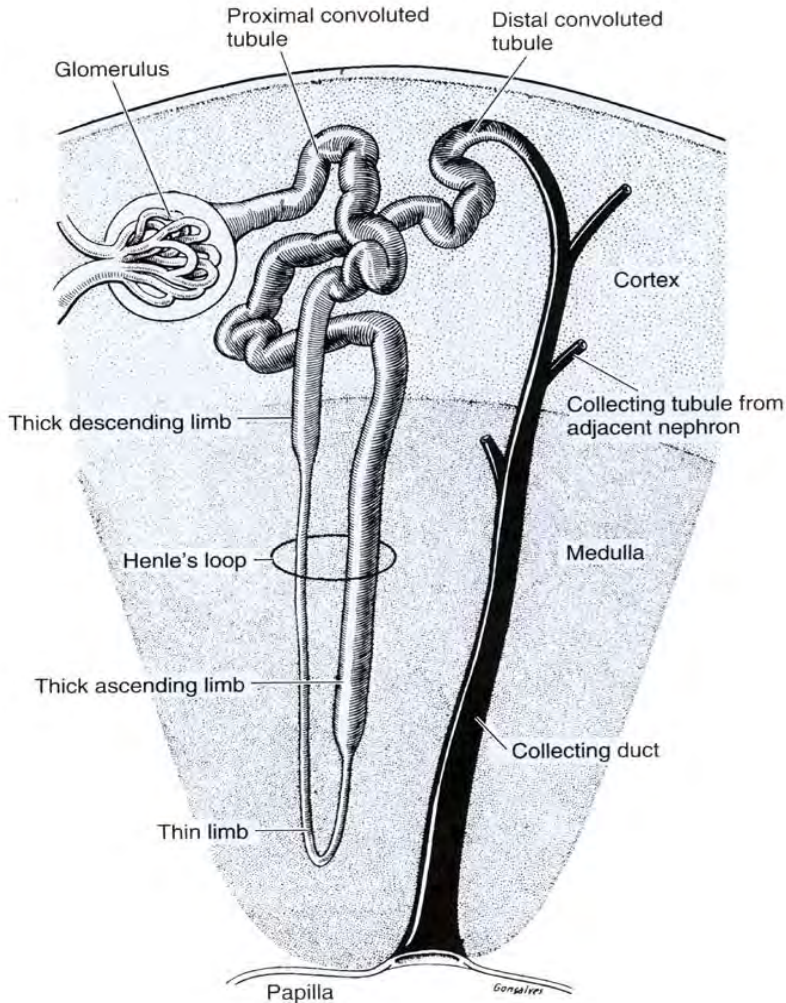
cortex(Cortical labyrinth)



medulla



Henle's loop



Henle's loop

Thick descending limb

Proximal straight tubule

Thin descending limb

Thin segment

Thin ascending limb

Thick ascending limb

Distal straight tubule

Renal corpuscle

Vascular pole

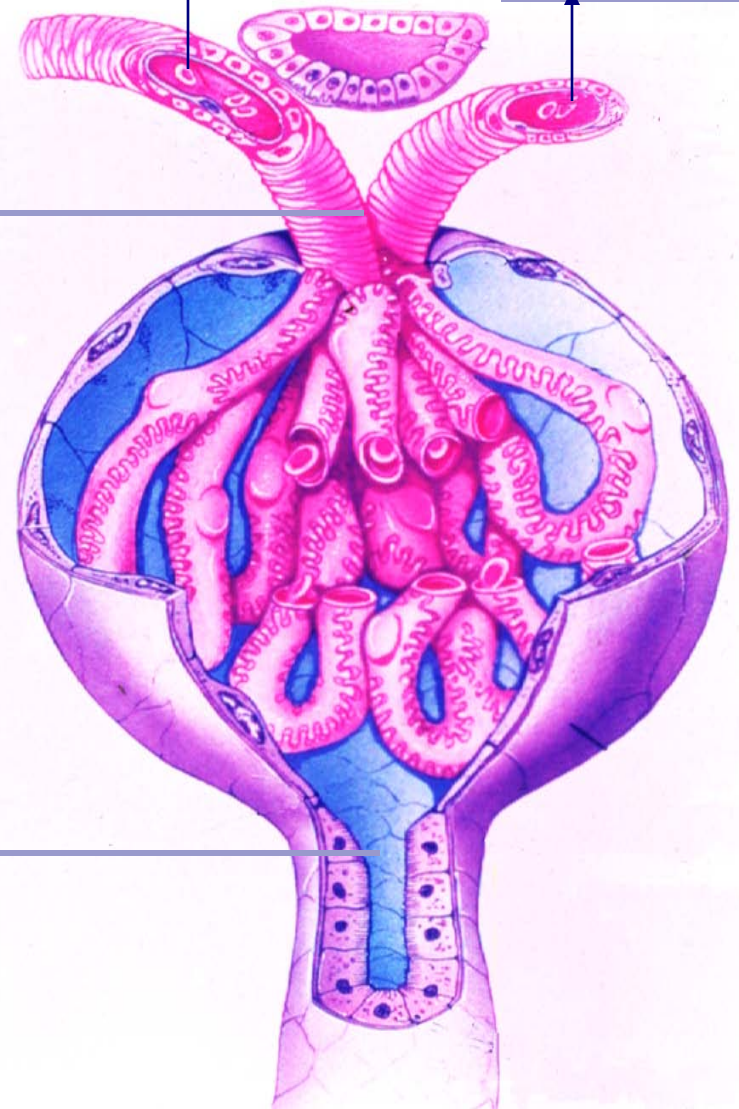
Glomerulus

Glomerular capsule

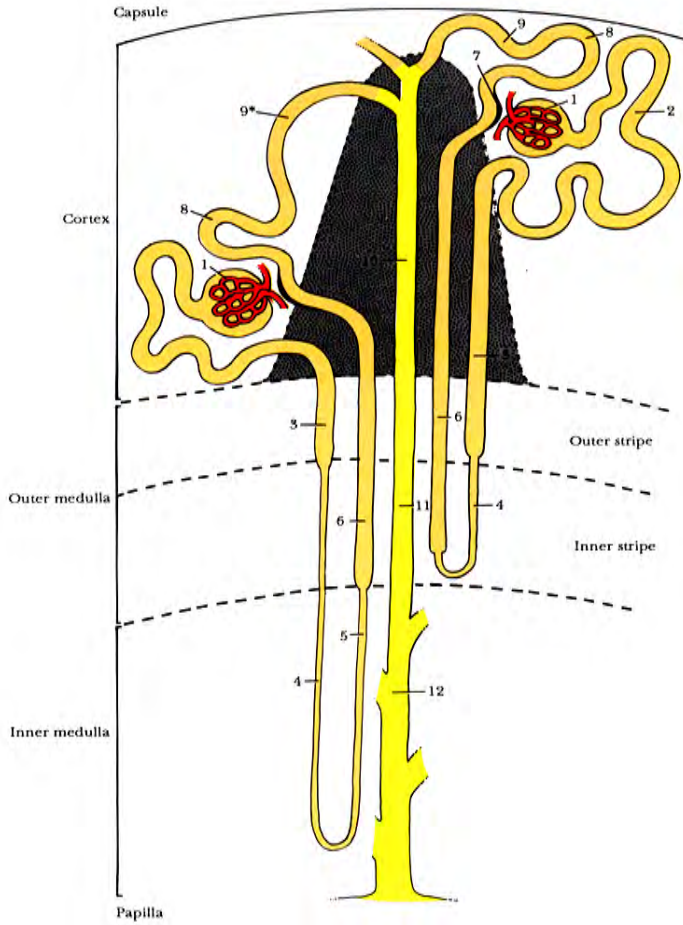
Urinary pole

Afferent arteriole

Efferent arteriole



Kidney



Henle's loop {

- Proximal straight tubule**
- Thin segment**
- Distal straight tubule**

Urineriferous tubule
Parenchyma

Collecting tubule
Medullary ray
renal pyramids

Renal corpuscle {

- glomerulus**
- renal capsule**

Cortical labyrinth **Renal columns**

Nephron

Proximal convoluted tubule

Cortical labyrinth
Renal columns

Renal tubule

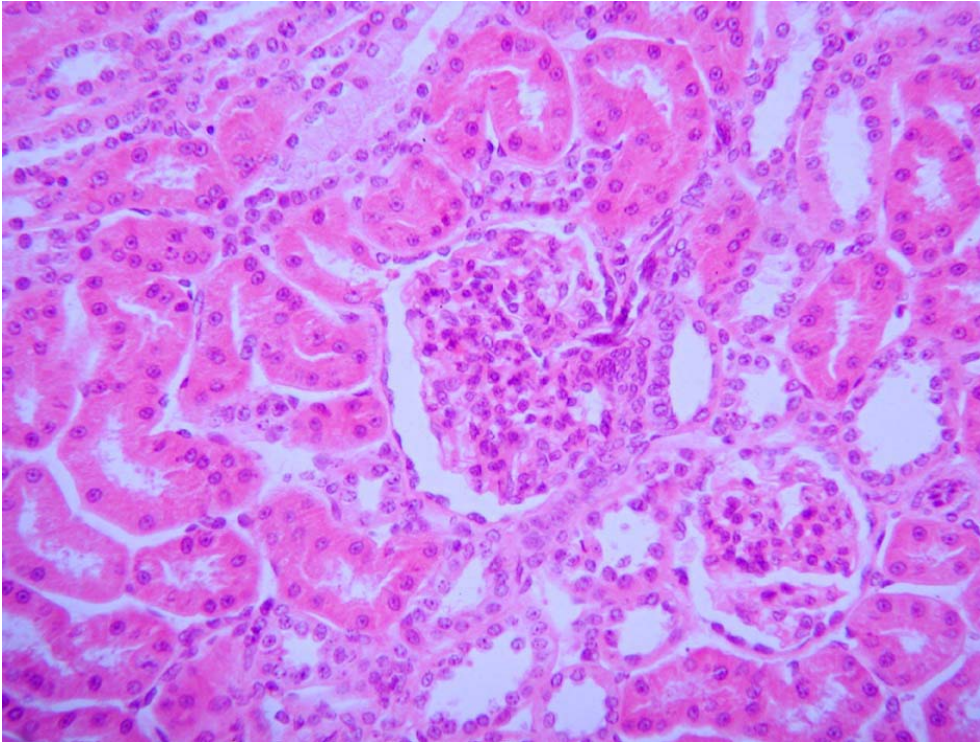
Henle's loop

Medullary ray
renal pyramids

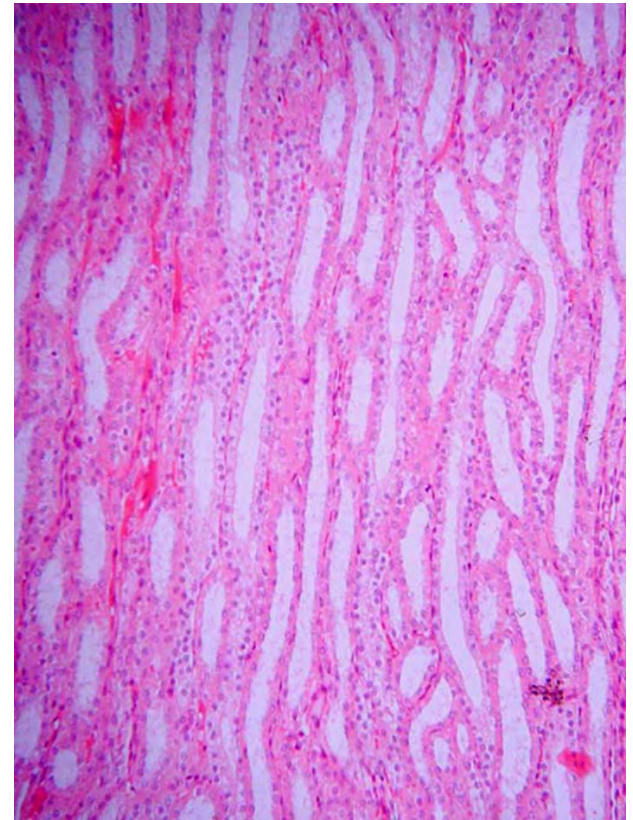
Distal convoluted tubule

Cortical labyrinth
Renal columns

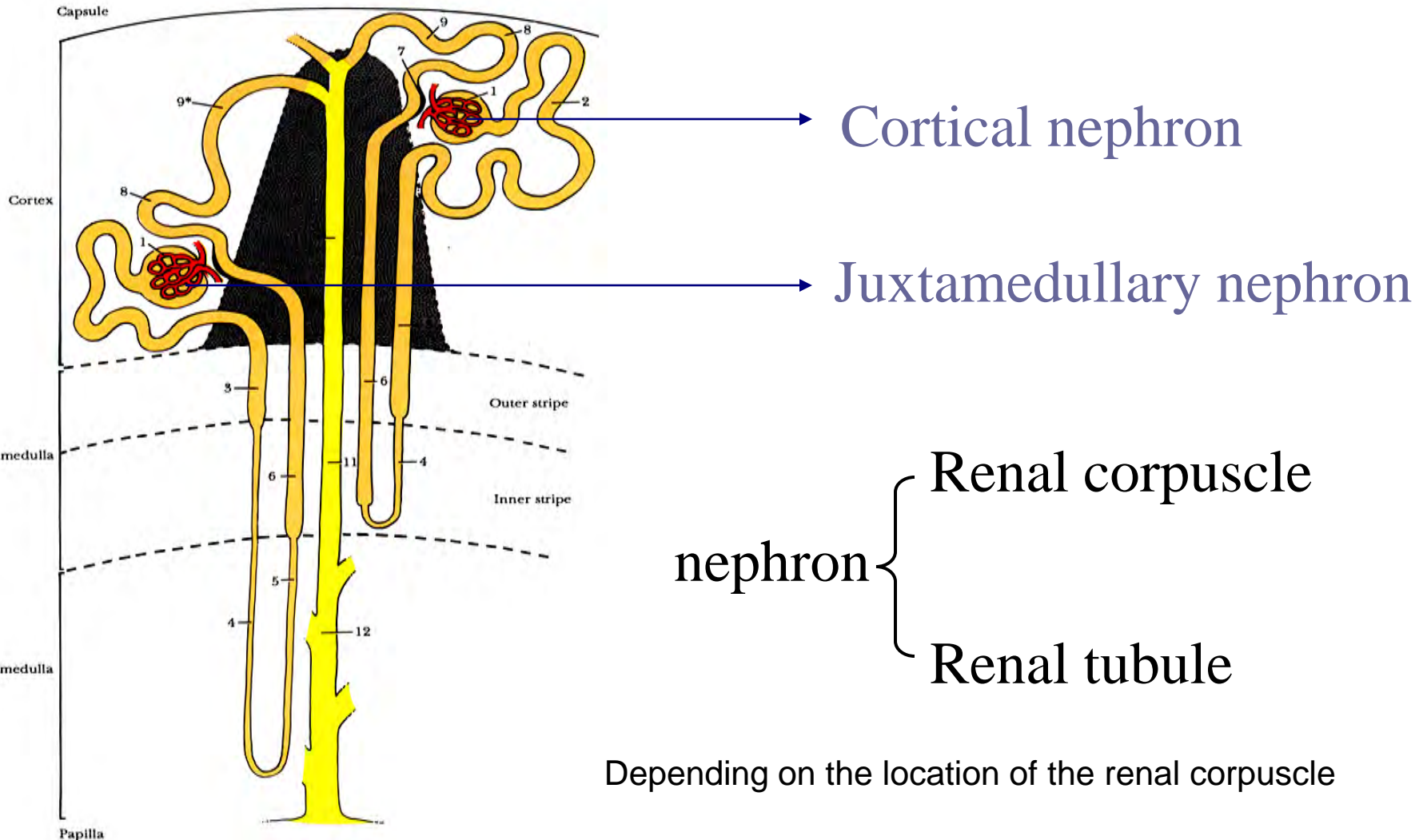
cortex(Cortical labyrinth)



medulla



Cortical nephron and juxtamedullary nephron



Renal corpuscle

Renal corpuscle is that part of the nephron responsible for the filtration of plasma. it is composed of Glomerulus and Glomerular capsule.

Each renal corpuscle has a vascular pole, where the afferent arteriole enters and the efferent arteriole leave. the urinary pole, where the proximal convoluted tubule begins.



Renal corpuscle

Vascular pole

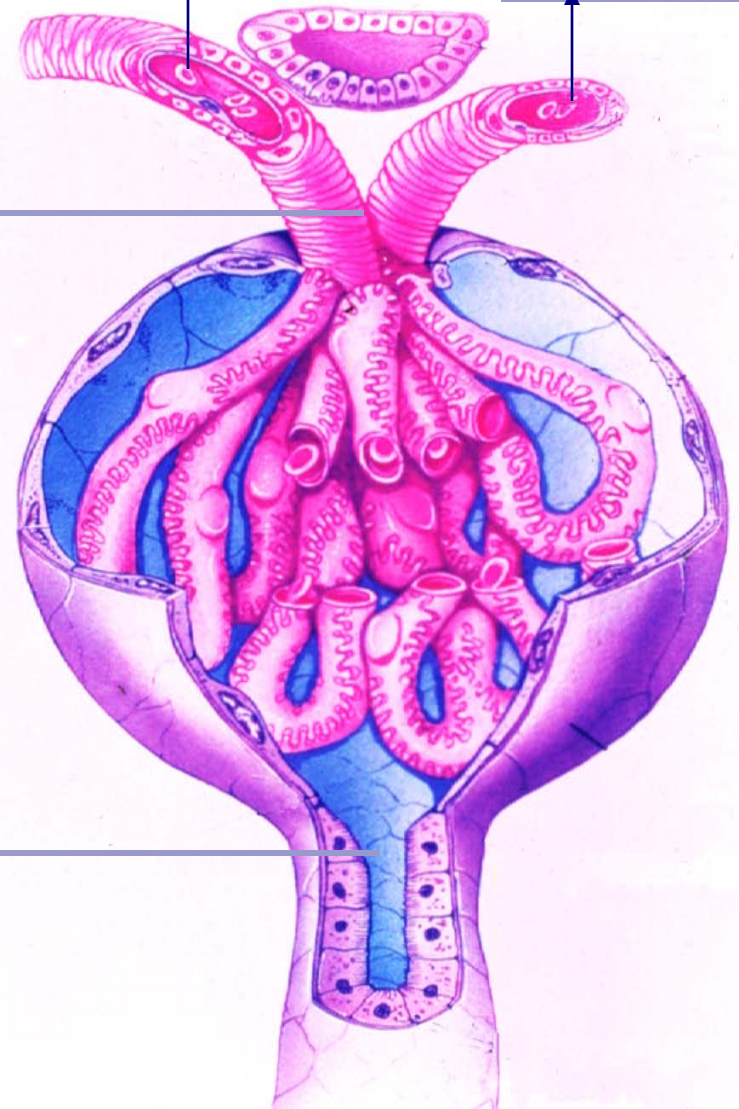
Glomerulus

Glomerular capsule

Urinary pole

Afferent arteriole

Efferent arteriole

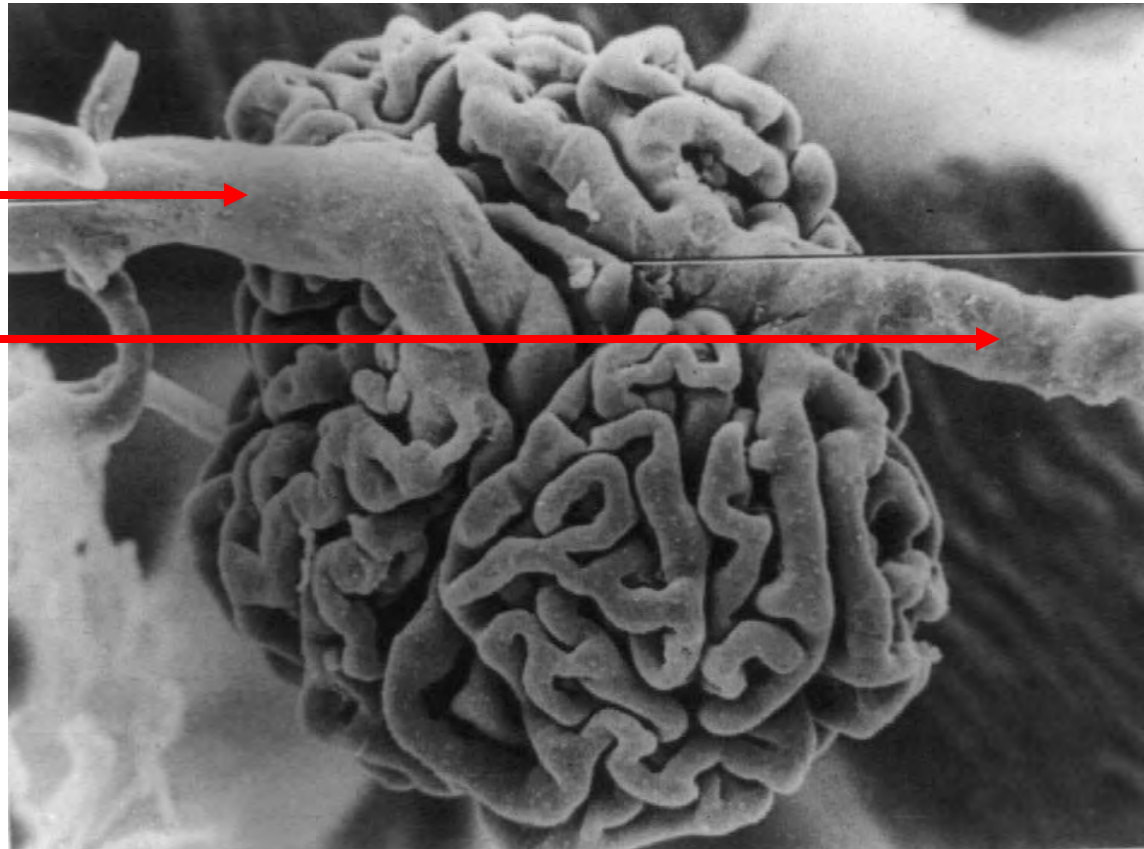


Glomerulus (SEM)

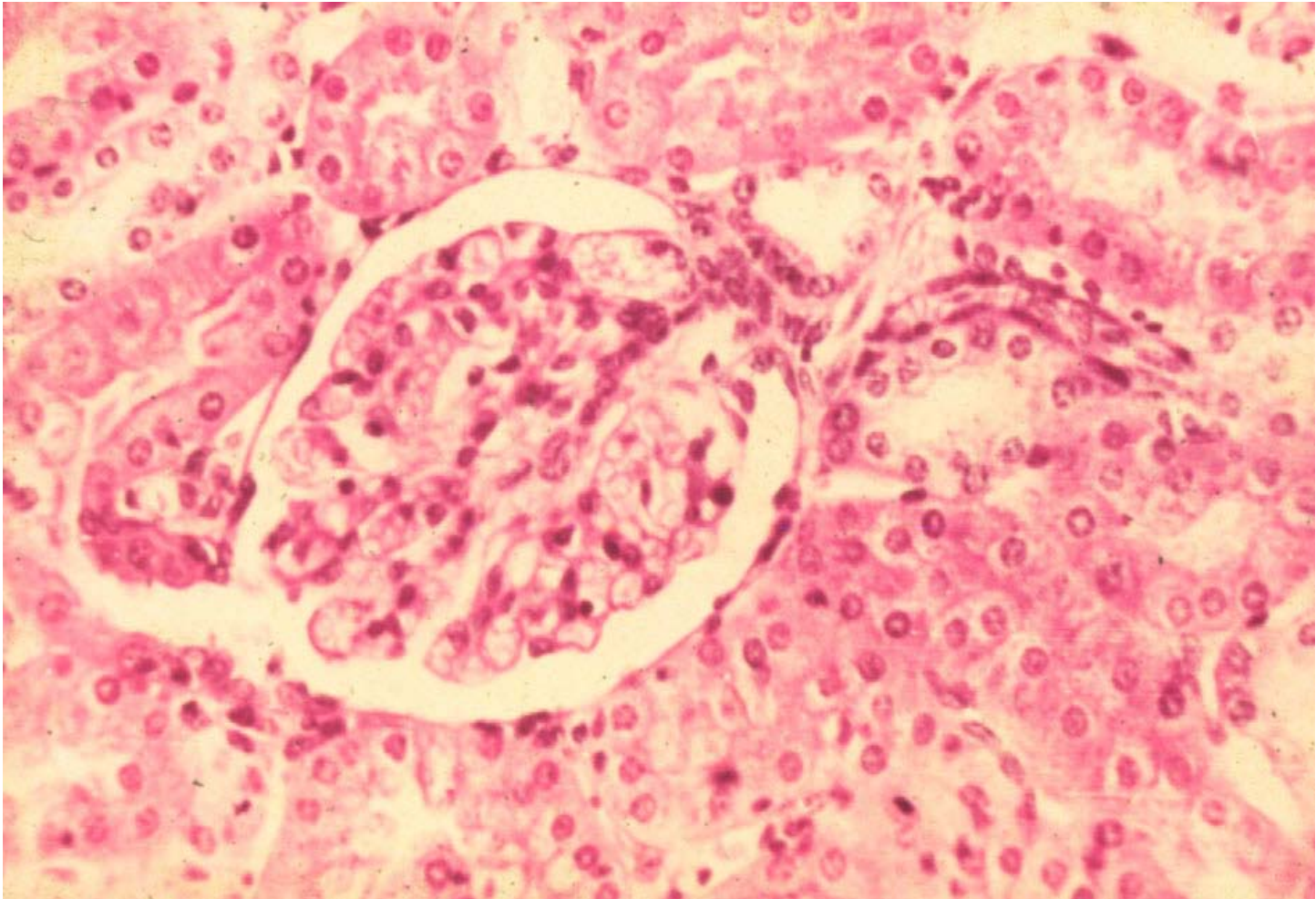
Afferent arteriole



Efferent arteriole



Renal corpuscle (HE)



Renal corpuscle

Glomerular capillary:

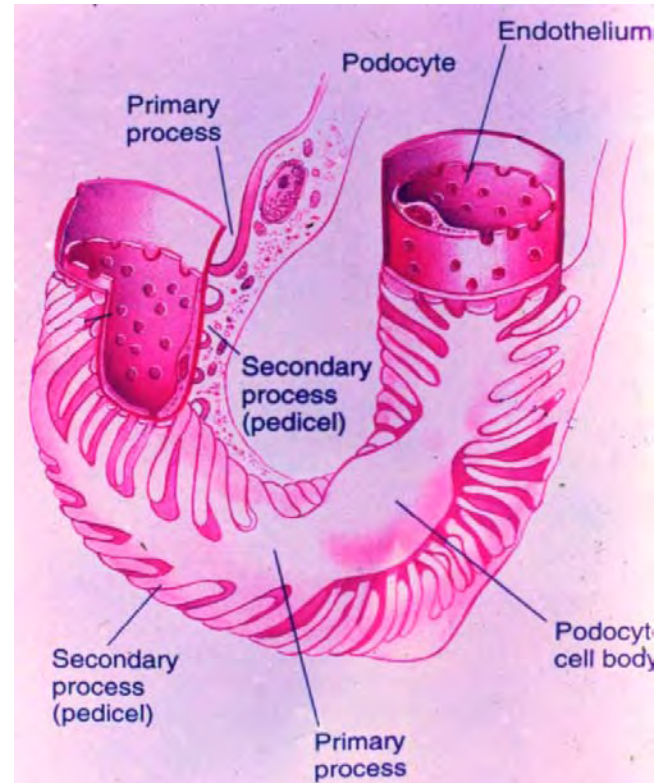
fenestrated capillary

Glomerular capsule:

double-walled epithelial chamber

parietal layer:

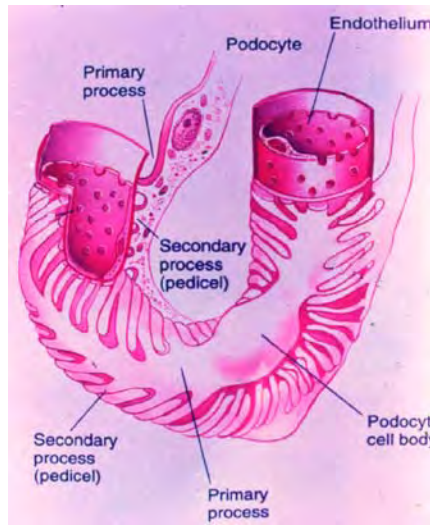
visceral layer: podocyte



Glomerular capillary

The glomerulus derived from the afferent arteriole and drained by the efferent arteriole, the afferent arteriole usually divides into 2 to 5 primary branches, each subdividing into capillaries and forming the renal glomerulus.

The endothelial cells of glomerular capillaries are of the fenestrated variety, but they lack the thin diaphragm that spans the openings of other fenestrated capillaries.



Renal corpuscle

Glomerular capillary:

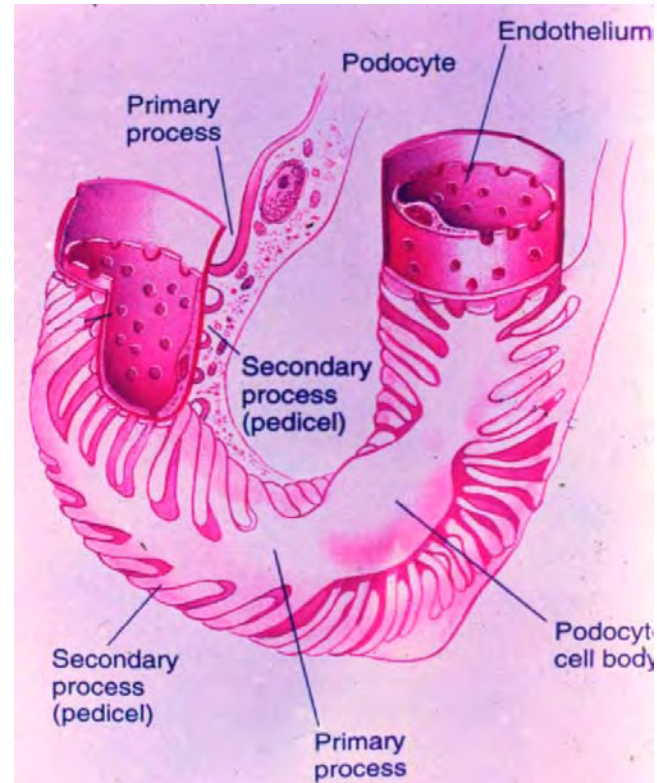
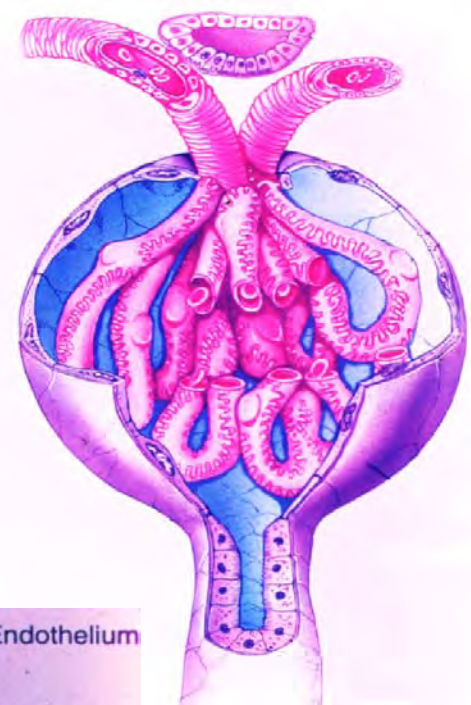
fenestrated capillary

Glomerular capsule:

double-walled epithelial chamber

parietal layer:

visceral layer: podocyte



Glomerular capsule

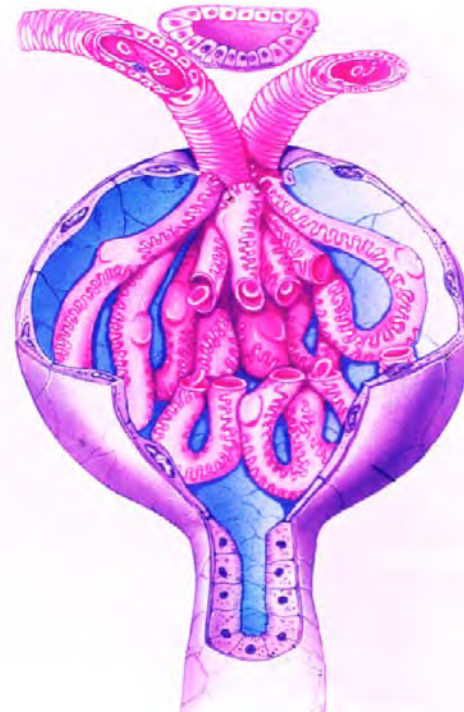
The glomerular capsule is a double-walled epithelial chamber. The internal layer of the capsule envelops the capillaries of the glomerulus. The external layer forms the outer limit of the renal corpuscle and is called the parietal layer of Glomerular capsule. Between the two layers is the urinary space.



Glomerular capsule

The parietal layer of Glomerular capsule consists of a simple squamous epithelium .

The cell of the internal layer, the podocytes, have cell body from which arise several primary processes. each primary process gives rise to numerous secondary processes, called pedicels.



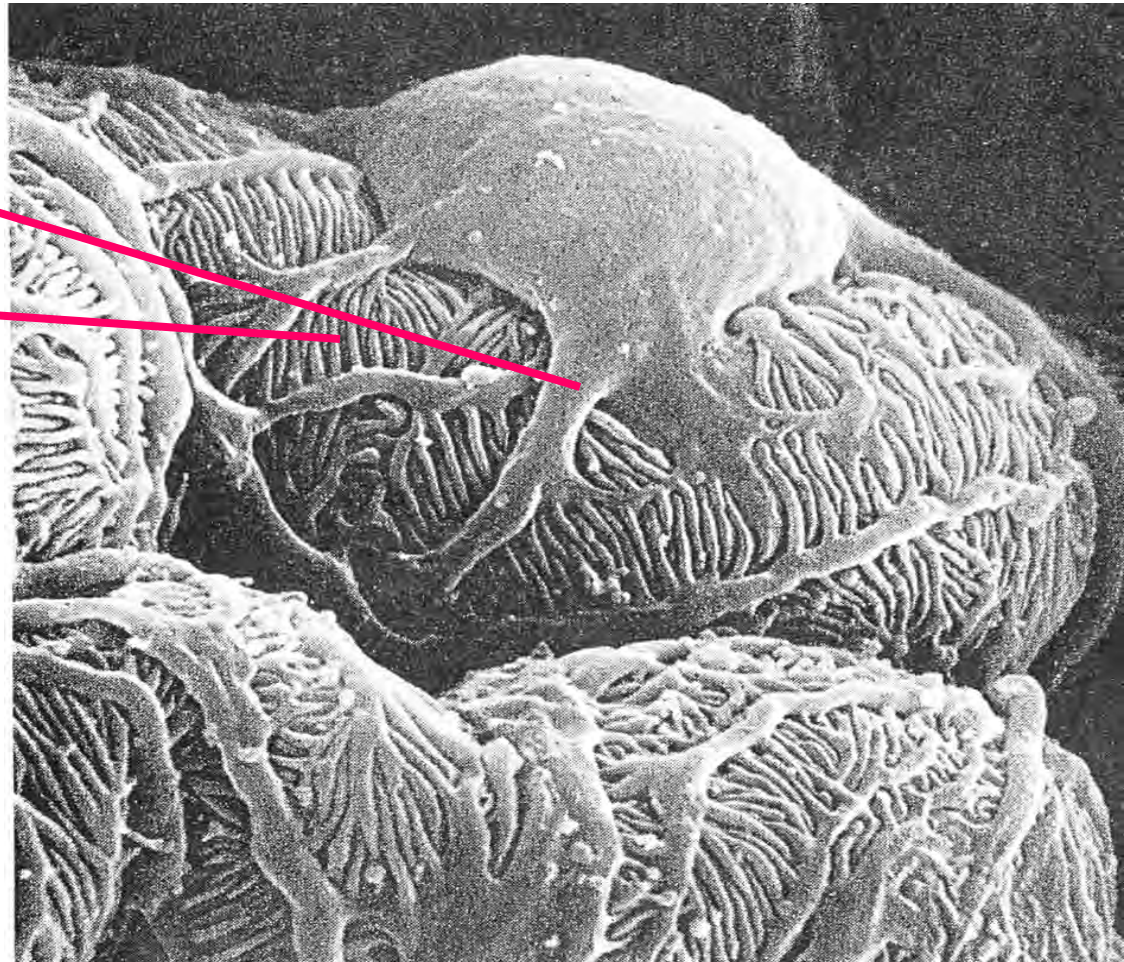
Podocyte (SEM)

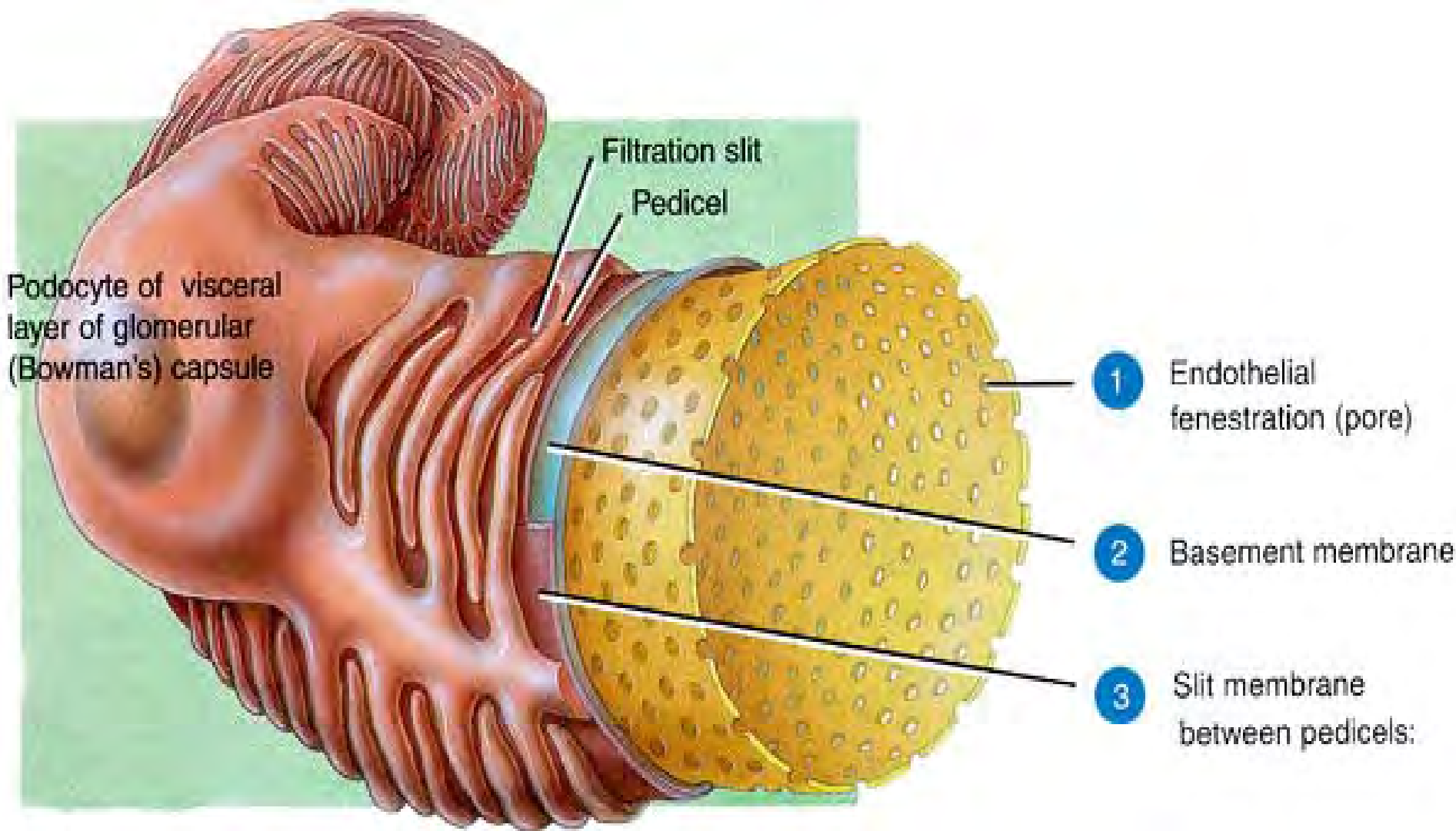
primary process

secondary process

(pedicel) : interdigitate with pedicels from neighboring podocyte, embrace the glomerular capillaries

filtration slit: covered by a thin membrane





Podocyte of visceral layer of glomerular (Bowman's) capsule

Filtration slit
Pedicel

- 1 Endothelial fenestration (pore)
- 2 Basement membrane
- 3 Slit membrane between pedicels:

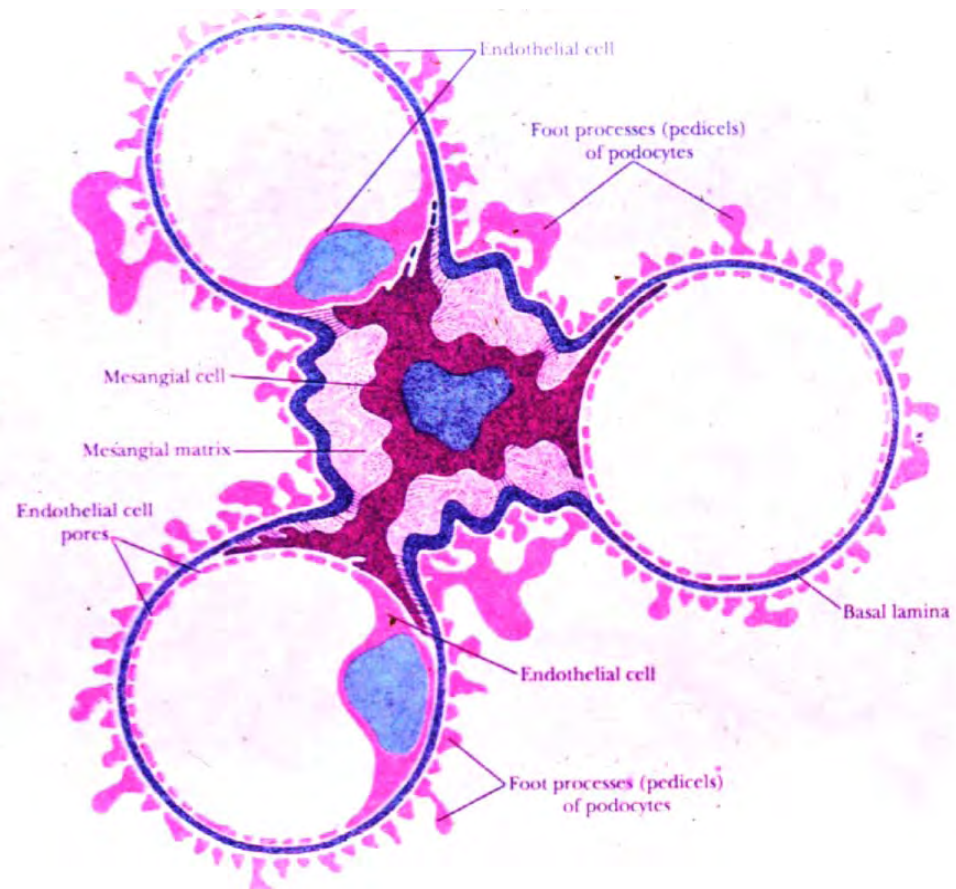
Mesangium (mesangial cell)

mesangial cell adhering to capillaries walls

Function:

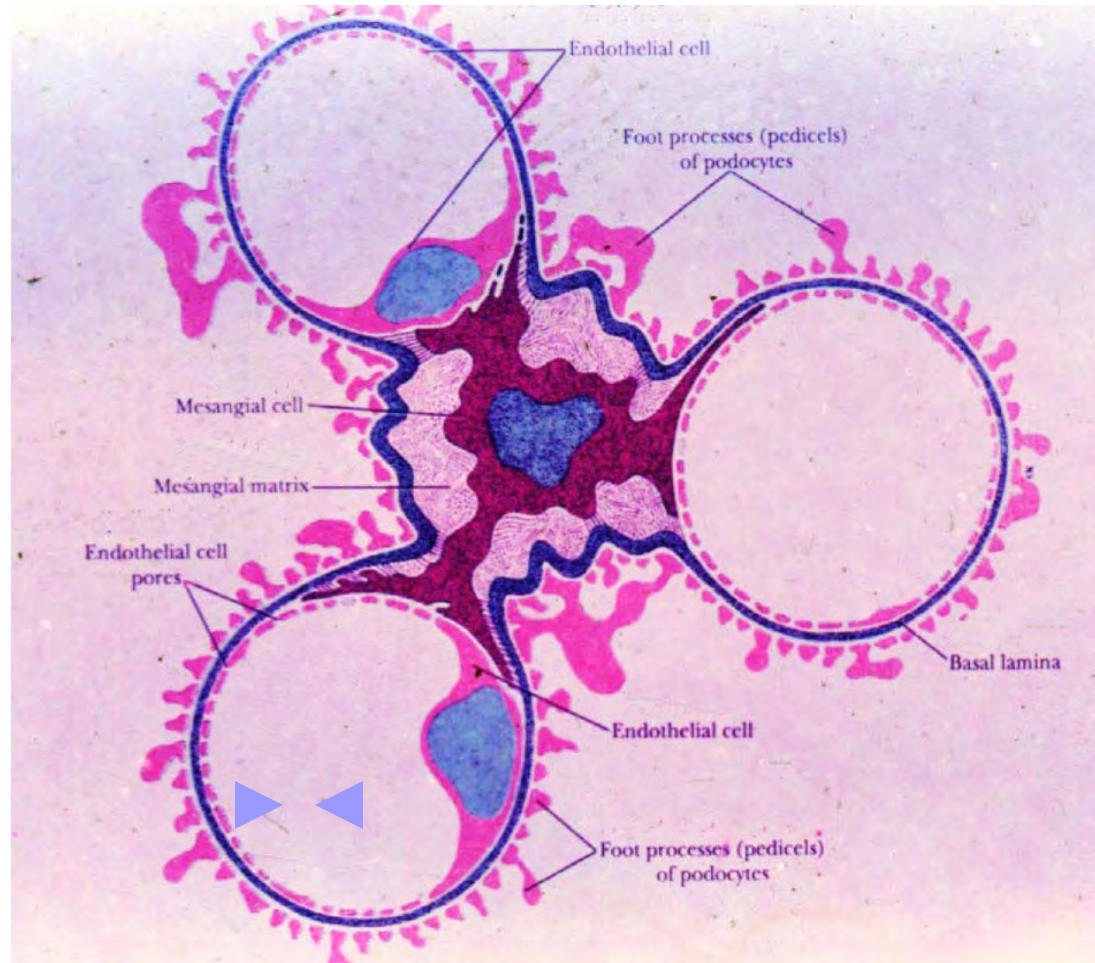
remove the particles and
clean the membrane

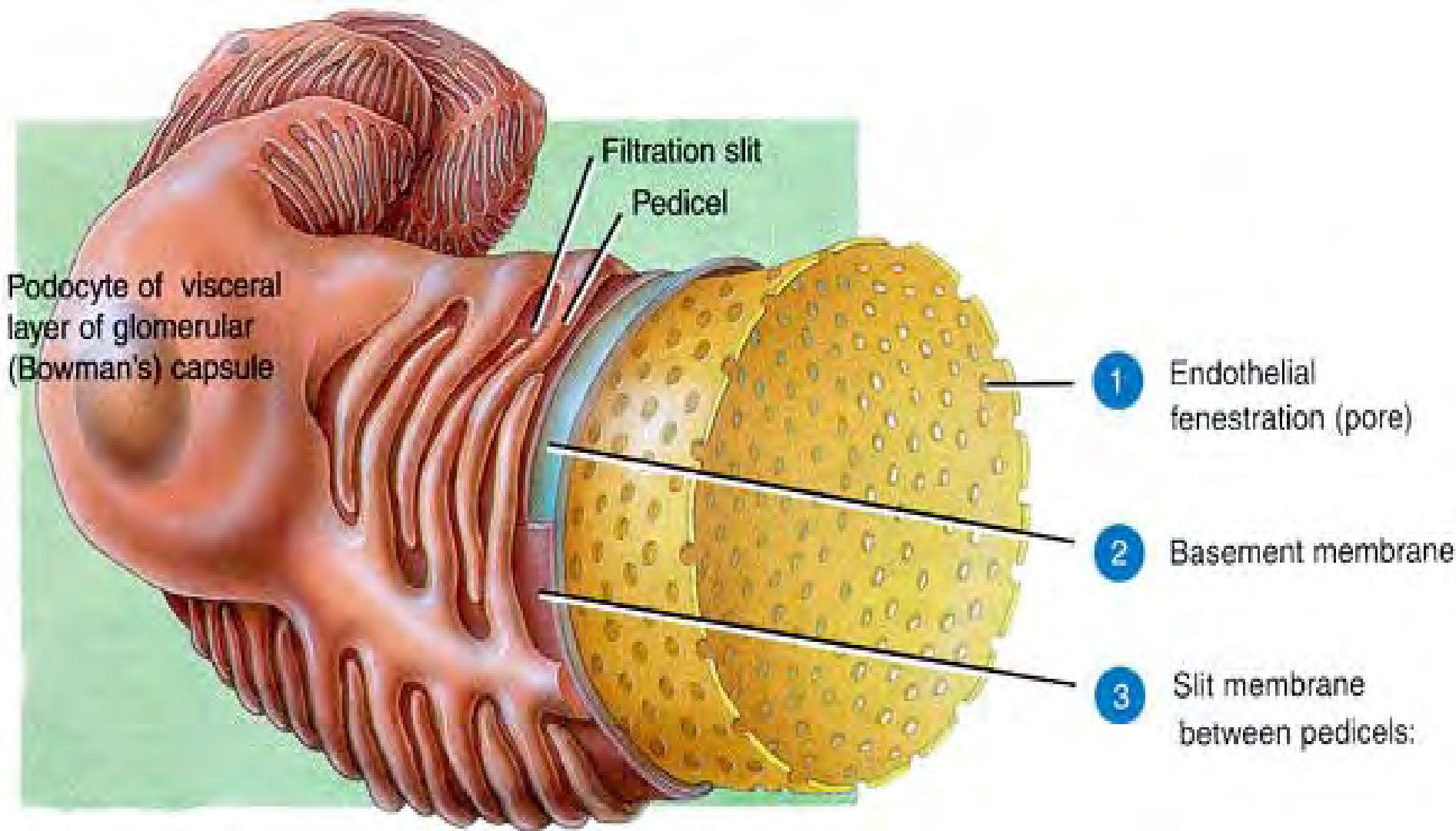
provide support of
the capillary wall



Filtration barrier

- 1) Endothelium of the glomerular capillaries
- 2) The basement membrane
- 3) The filtration slit membrane



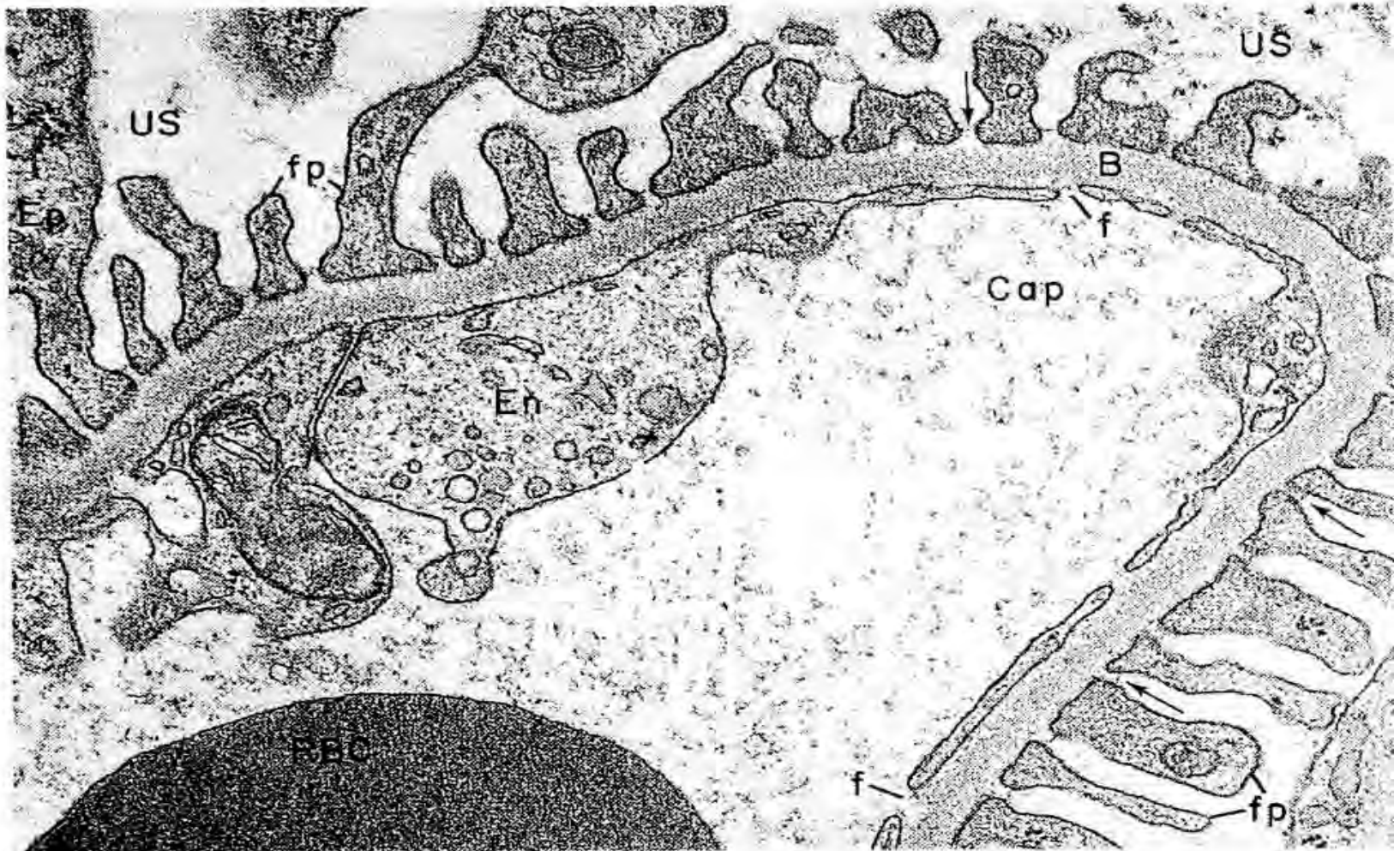


Podocyte of visceral layer of glomerular (Bowman's) capsule

Filtration slit
Pedicel

- 1 Endothelial fenestration (pore)
- 2 Basement membrane
- 3 Slit membrane between pedicels:

Filtration barrier



Filtration barrier

Function:

The function of the filtration barrier of renal glomerulus is filter the blood plasma. barrier permits water and small molecules to enter the capsular.

plasma is filtered from glomerular capillaries into Glomerular capsule, then pass into the renal tubule.

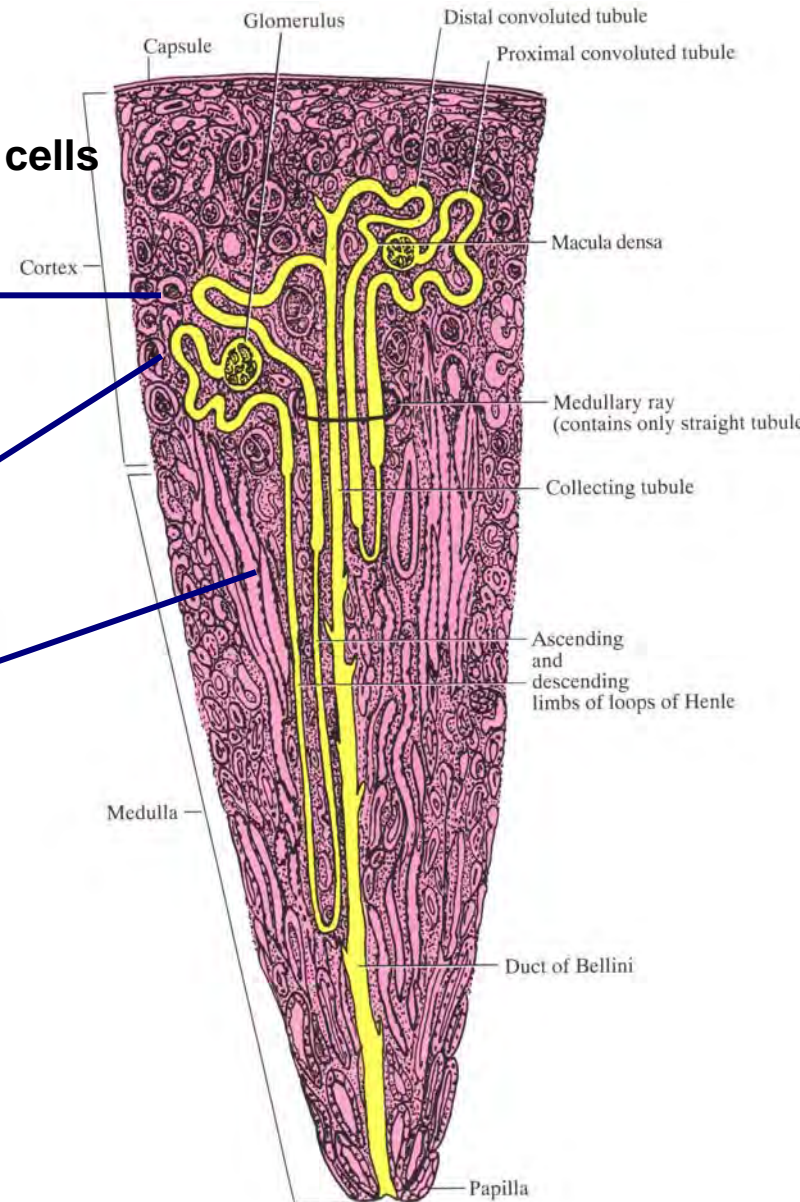
Renal tubule

The renal tubule is lined by a single layer of epithelial cells

Distal convoluted tubule

Proximal convoluted tubule

Henle's loop



Proximal convoluted tubule

A simple cuboidal epithelium

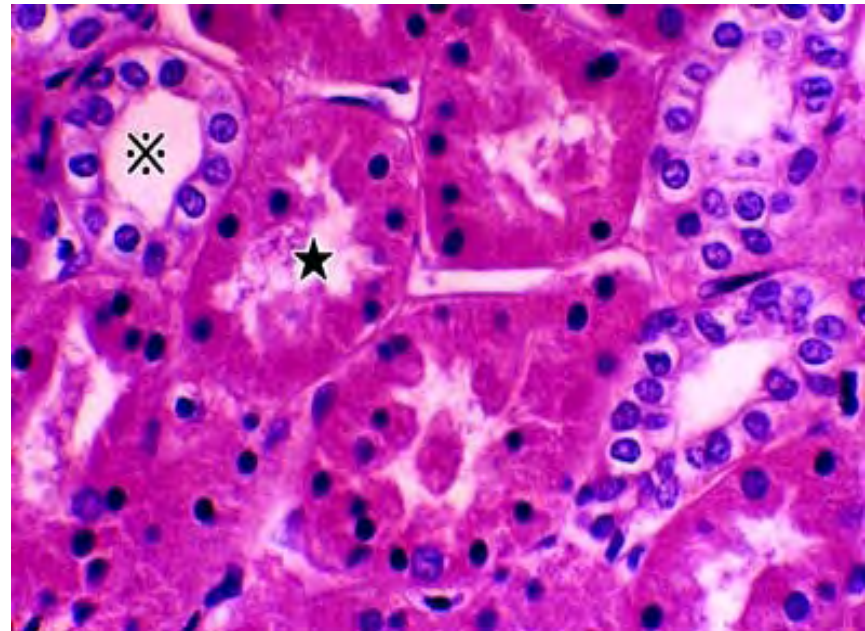
Cell shape:

cuboidal cell with brush border

Nucleus:

small, round, located in the base

Cytoplasm: strong acidophilic



Proximal convoluted tubule cell

ultrastructure

Microvilli

Canaliculi and vesicles

lysosomes

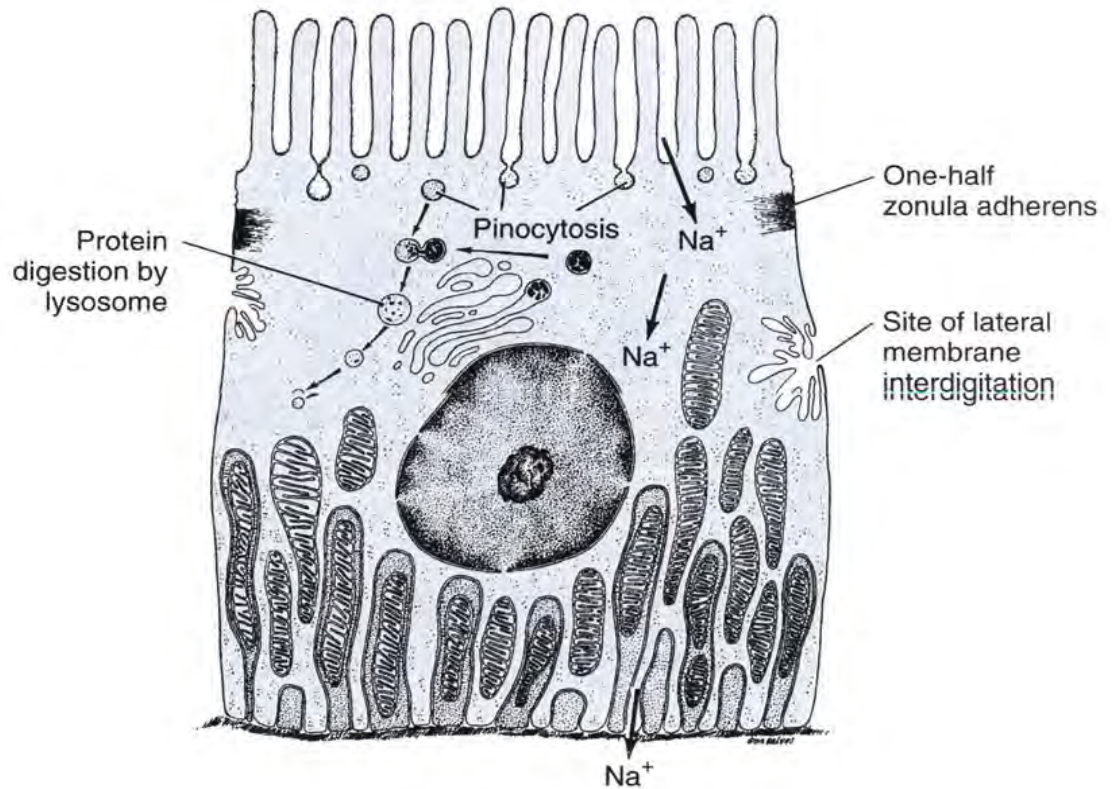
Membrane folds

Mitochondria

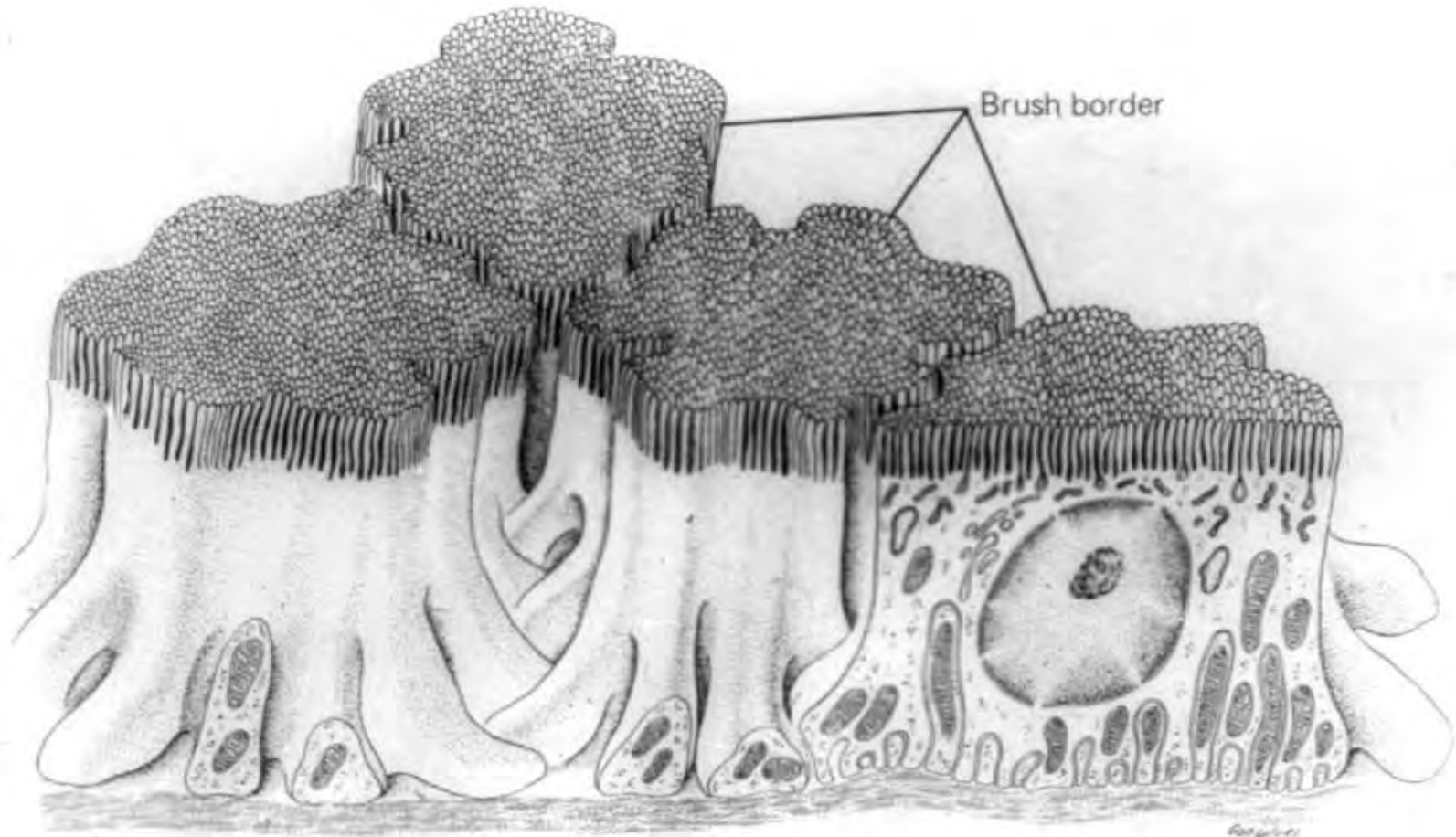
$\text{Na}^+/\text{K}^+\text{ATPase}$
(Natrium/kalium ATPase)

Cell junction

Membrane interdigitation



Proximal convoluted tubule



Membrane interdigitation

Proximal convoluted tubule

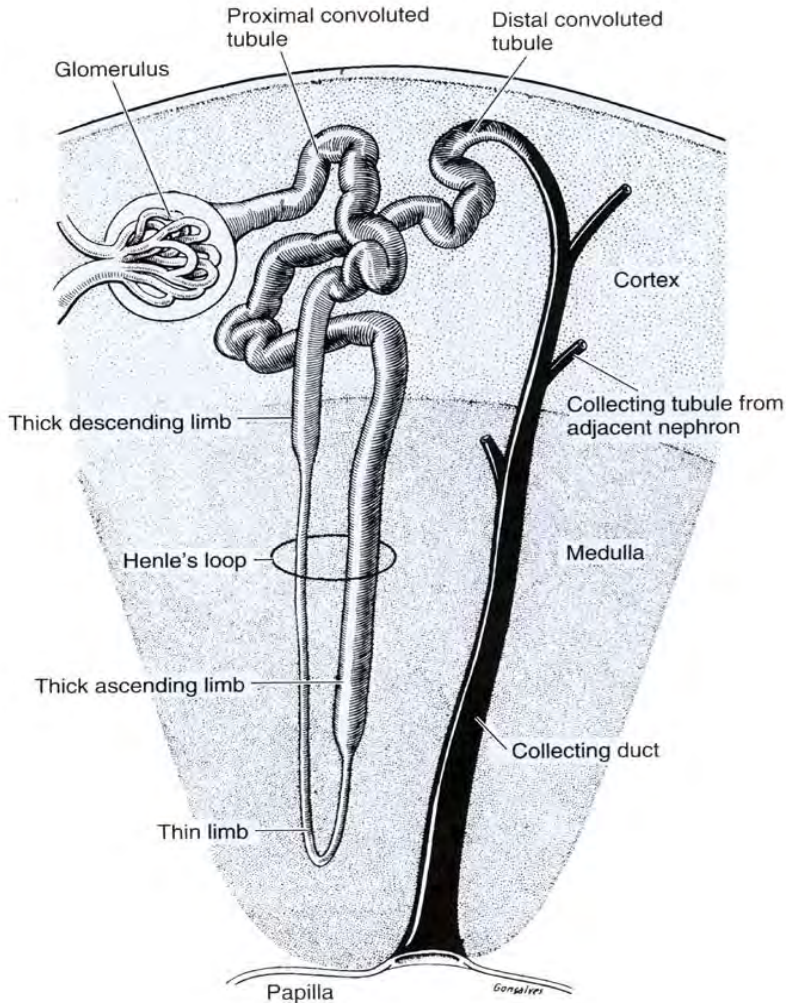
Functions:

Urine absorption

Secrete Hydrogen, Ammonia, creatinine

Transfer and release the substance in the blood

Henle's loop



Henle's loop

Thick descending limb

Proximal straight tubule

Thin descending limb

Thin segment

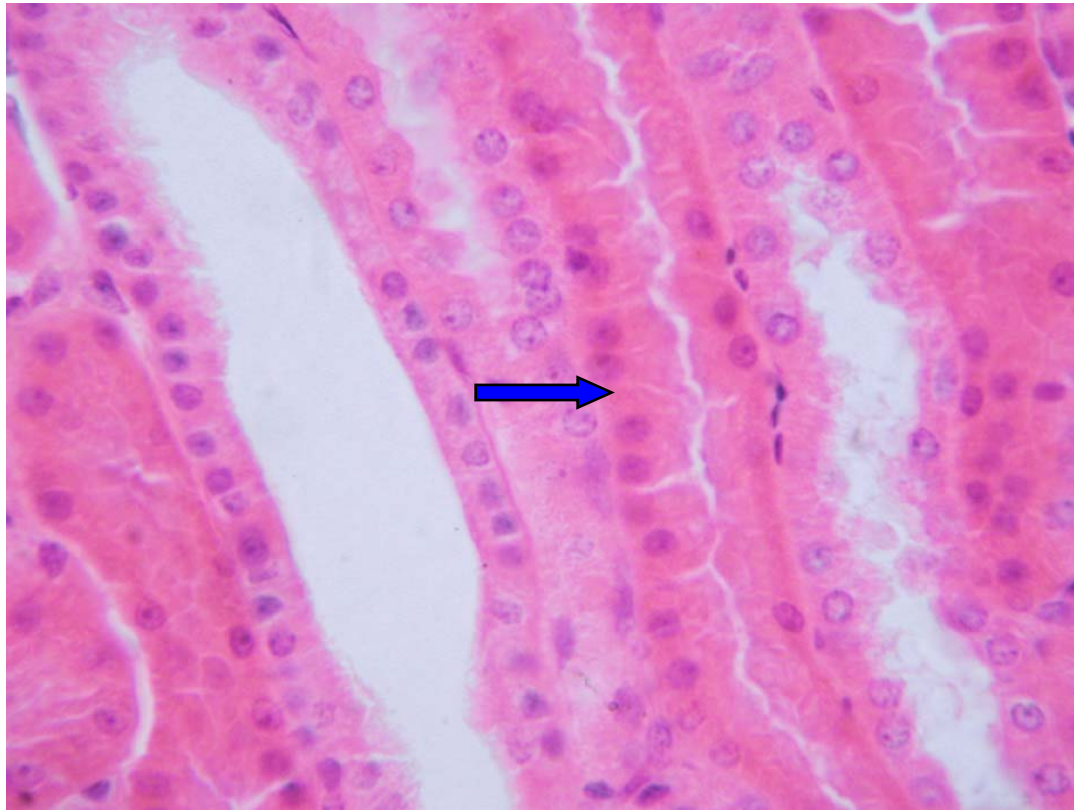
Thin ascending limb

Thick ascending limb

Distal straight tubule

Thick descending limb (proximal straight tubule)

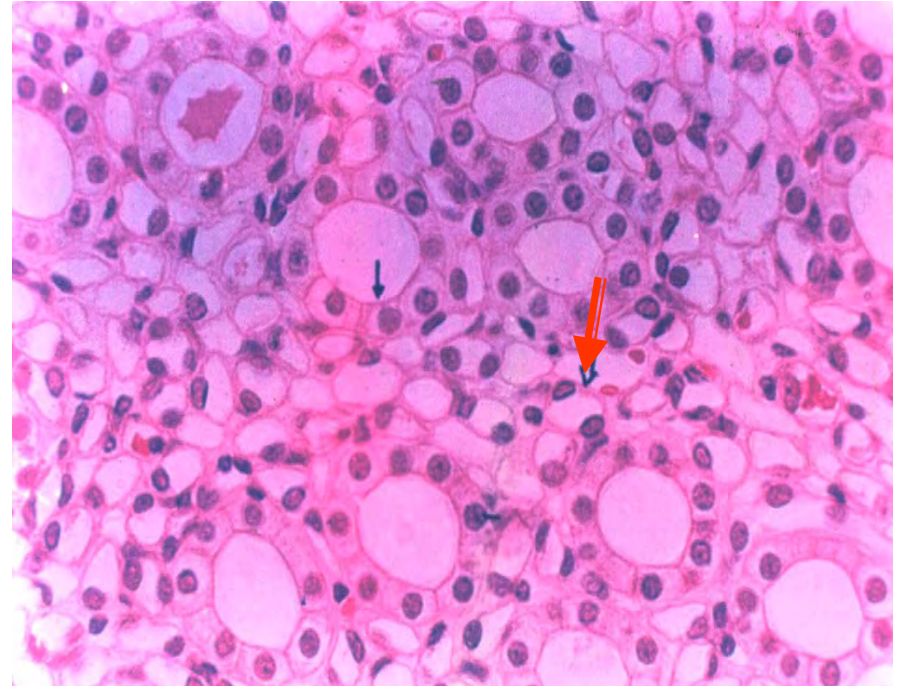
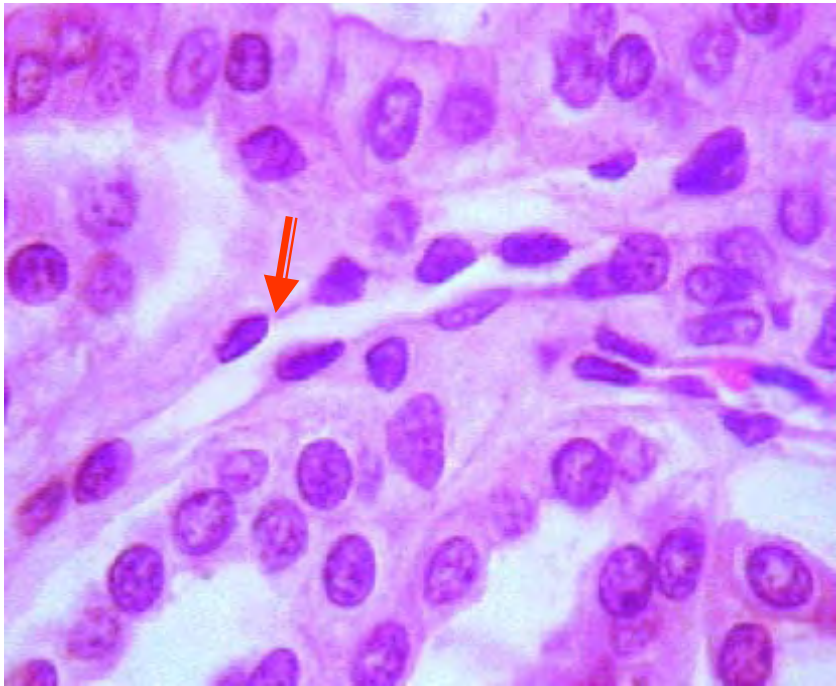
The proximal straight tubule is very similar in structure to the convoluted portion, but has less microvilli, basal membrane invaginations and lateral interdigitations



Thin segment

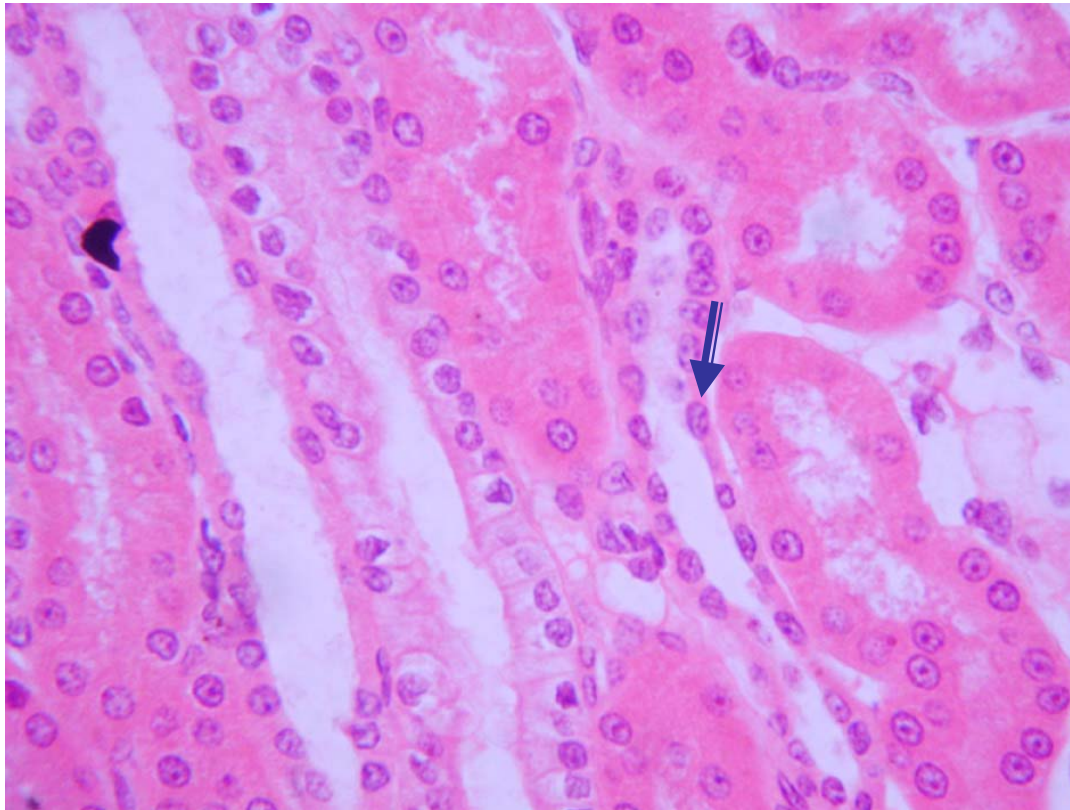
A simple squamous epithelium

Function: water, and ions pass through easily



Thick ascending limb (distal straight tubule)

The distal straight tubule is very similar in structure to the convoluted portion. A simple cuboidal epithelium



Distal convoluted tubule

A simple cuboidal epithelium

Cell shape:

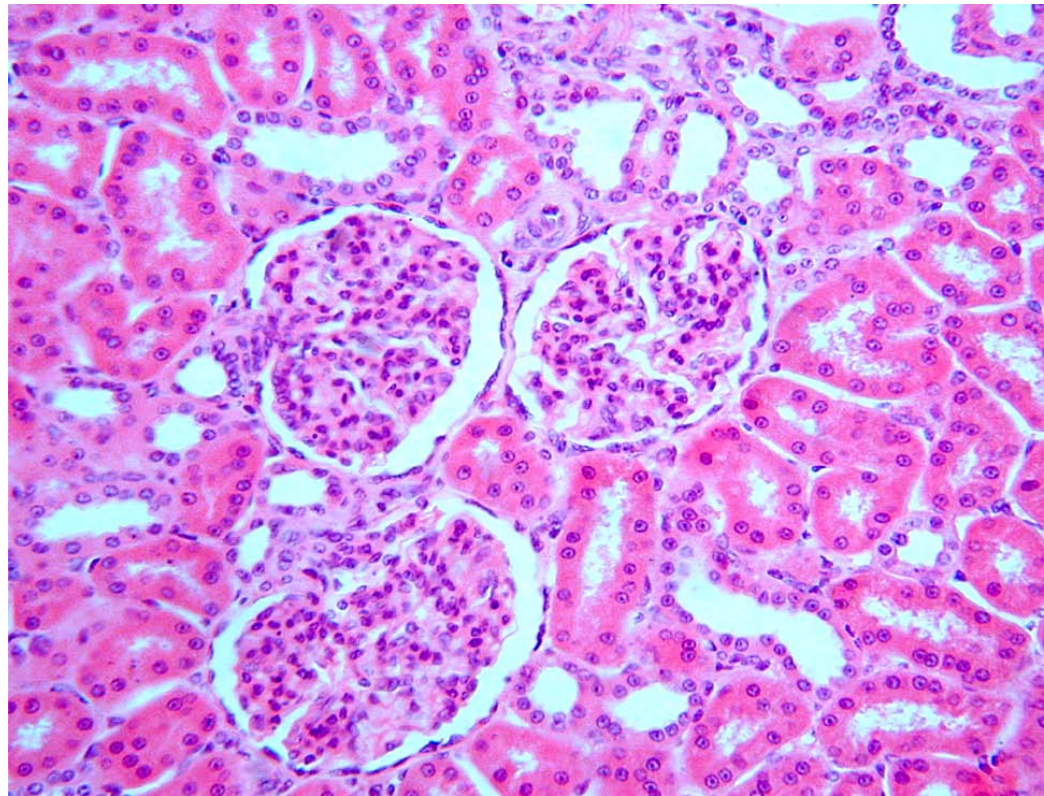
small cuboidal cell lacking
brush border

Nucleus:

small, round, located in medium

Cytoplasm:

less acidophilic



Distal convoluted tubule cell

ultrastructure

Few microvilli

Few canaliculi and vesicles

Few interdigitation

Extensive membrane folds

Numerous mitochondria



Distal convoluted tubule

functions

Absorb Na^+ and secrete K^+

Secrete Hydrogen and Ammonium into tubular urine

Hormone regulation

Aldosterone: increase the absorption of Na^+ and water

increase the secretion of K^+

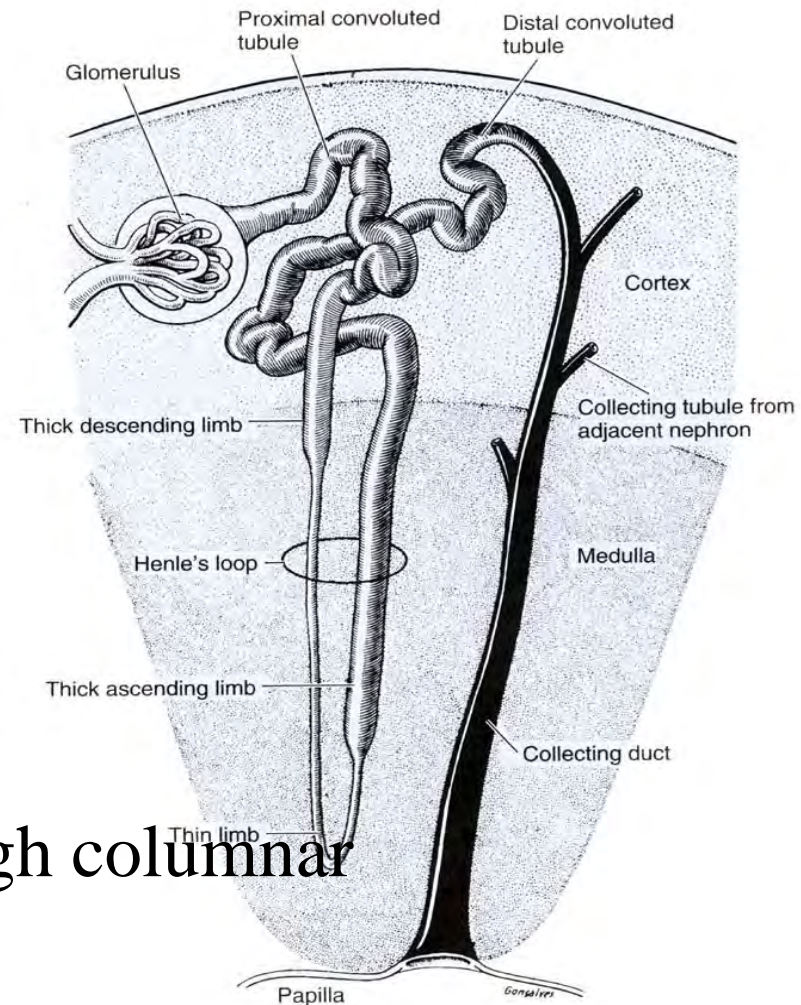
Antidiuretic hormone: increase the absorption of water

Collecting tubule and duct

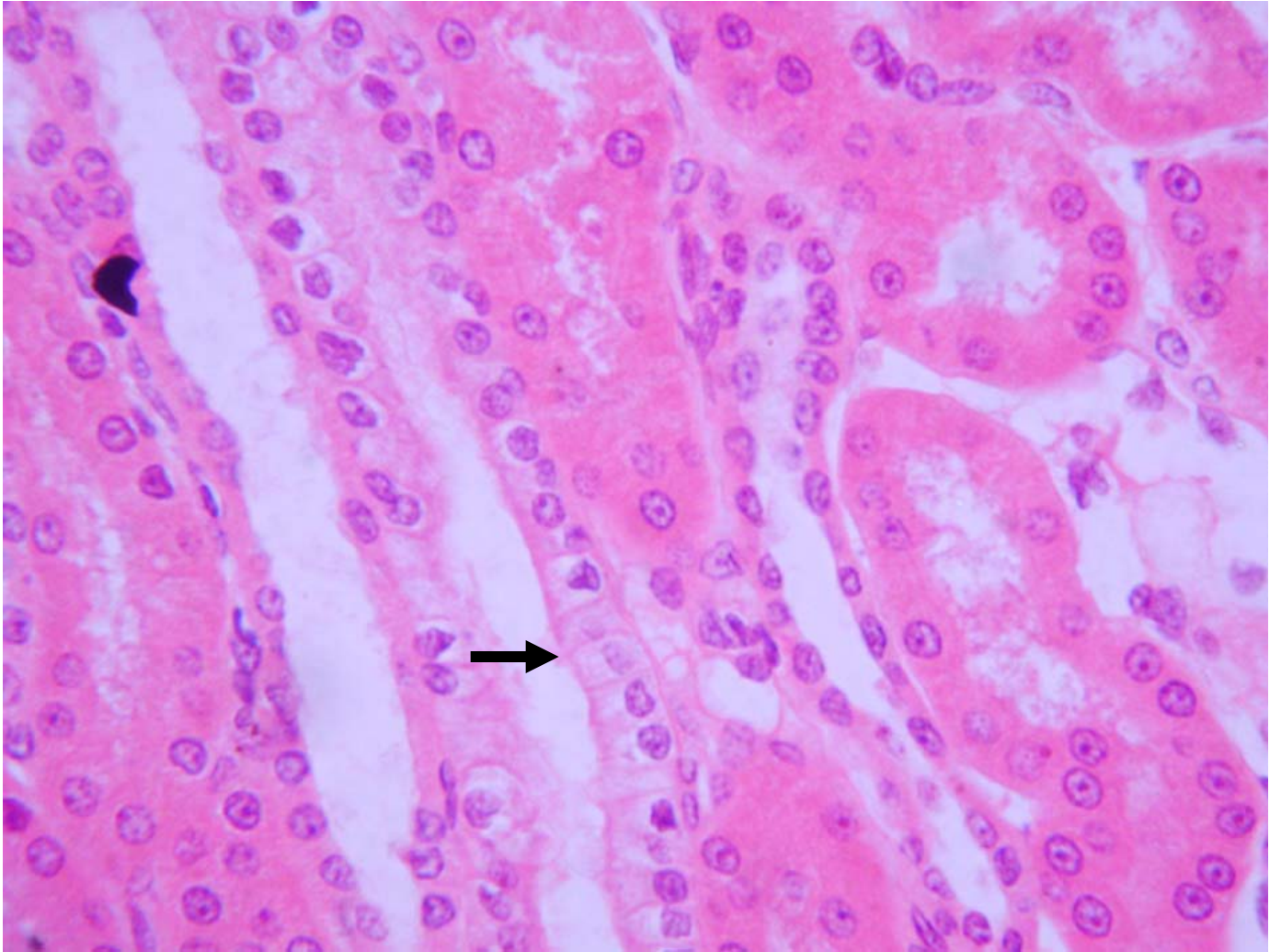
Arched collecting tubule
Cortical collecting tubule
Medullary collecting tubule
Papillary duct

A simple epithelium:

Squamous → cuboidal → columnar → high columnar



Cortical collecting tubule



Collecting tubule cell

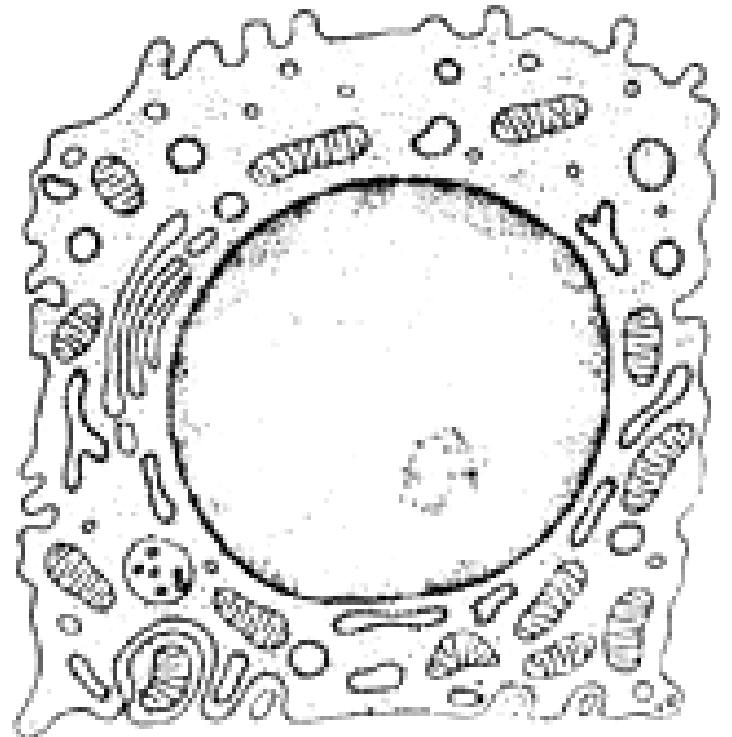
ultrastructure

Few microvilli

Few organelles

No interdigitation

No membrane fold



Collecting tubule

Function

Absorb Na_+ and water

Secrete K_+

The activity is controlled by the aldosterone and ADH

Proximal convoluted tubule

Cell shape:

cuboidal cell with brush border

Nucleus:

small, round, located in the base

Cytoplasm:

strong acidophilic

Ultrastructure:

Microvilli; Canaliculi and vesicles; lysosomes;
Membrane folds; Mitochondria; Na / K ATPase
(Natrium/kalium ATPase); Cell junction ; Membrane
interdigitation

Function:

Urine absorption; Secrete Hydrogen, Ammonia,
creatinine; Transfer and release the substance in the blood

Distal convoluted tubule

Cell shape:

small cuboidal cell lacking
brush border

Nucleus:

small, round, located in medium

Cytoplasm:

less acidophilic

Ultrastructure:

Few microvilli; Few canaliculi and vesicles; Few interdigitation; Extensive membrane folds; Numerous mitochondria

Function:

Absorb Na⁺ and secrete K⁺; Secrete Hydrogen and Ammonium into tubular urine

Collecting tubule

A simple epithelium:

Squamous cuboidal columnar high columnar

Ultrastructure:

Few microvilli

Few organelles

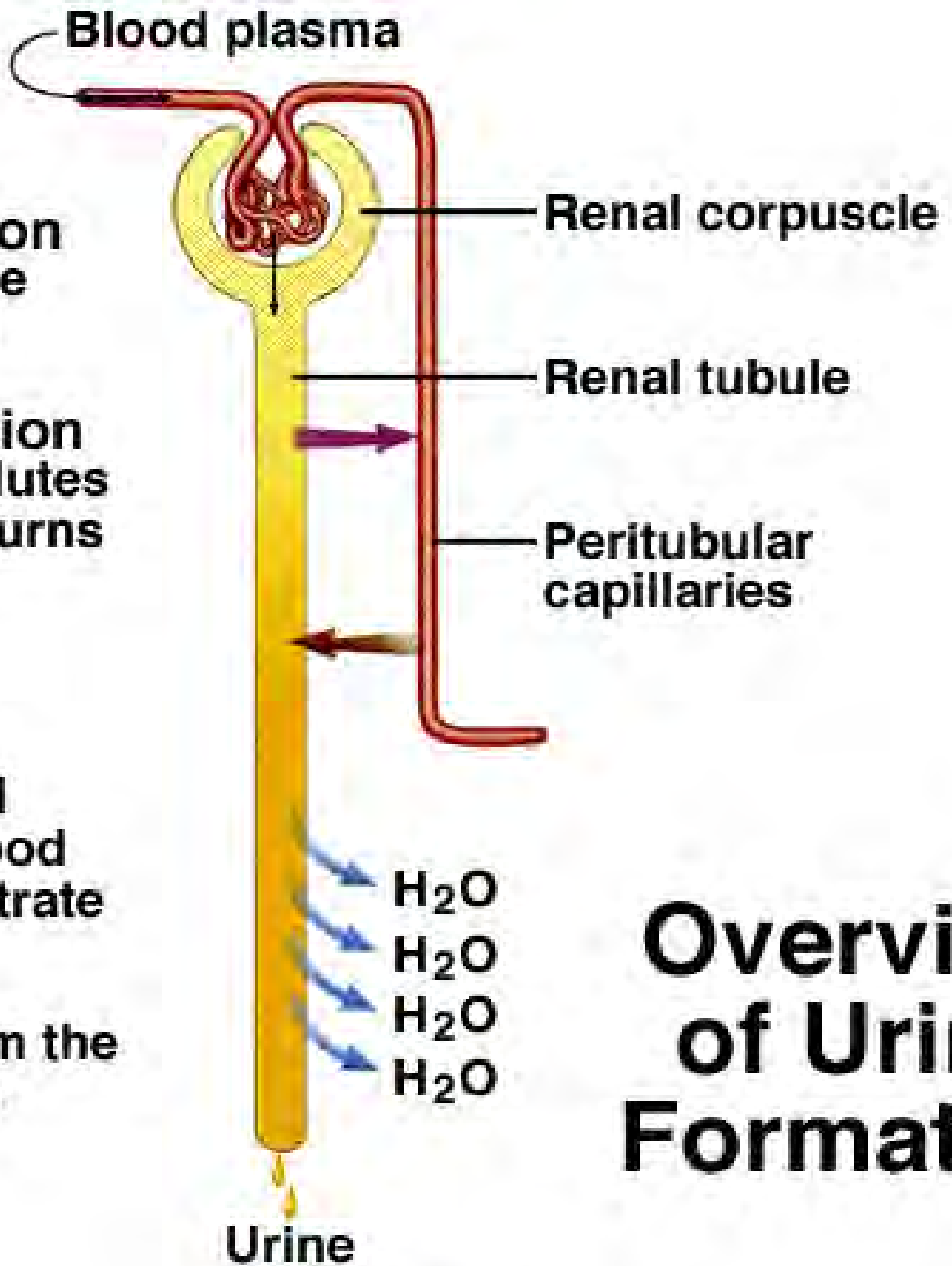
No interdigititation

No membrane fold

Function:

Absorb Na and water

Secrete K

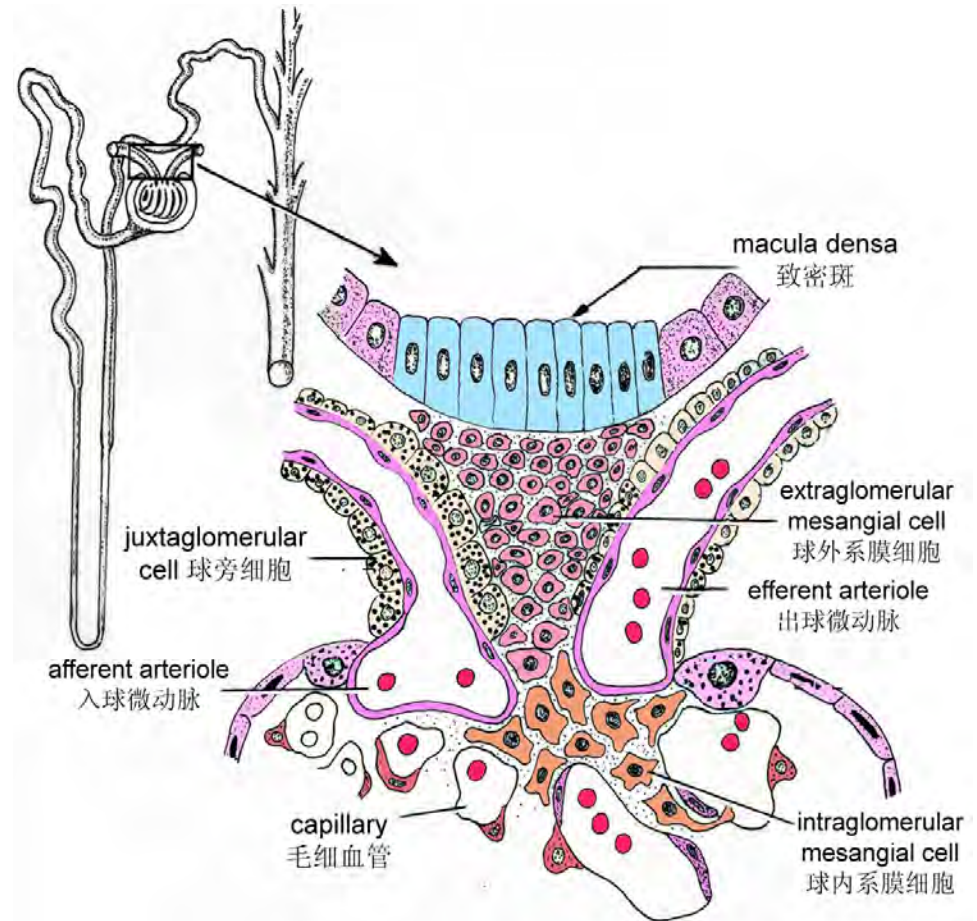


- ① **Glomerular filtration**
Creates a plasmalike filtrate of the blood
- ② **Tubular reabsorption**
Removes useful solutes from the filtrate, returns them to the blood
- ③ **Tubular secretion**
Removes additional wastes from the blood adds them to the filtrate
- ④ **Concentration**
Removes water from the urine, concentrates wastes

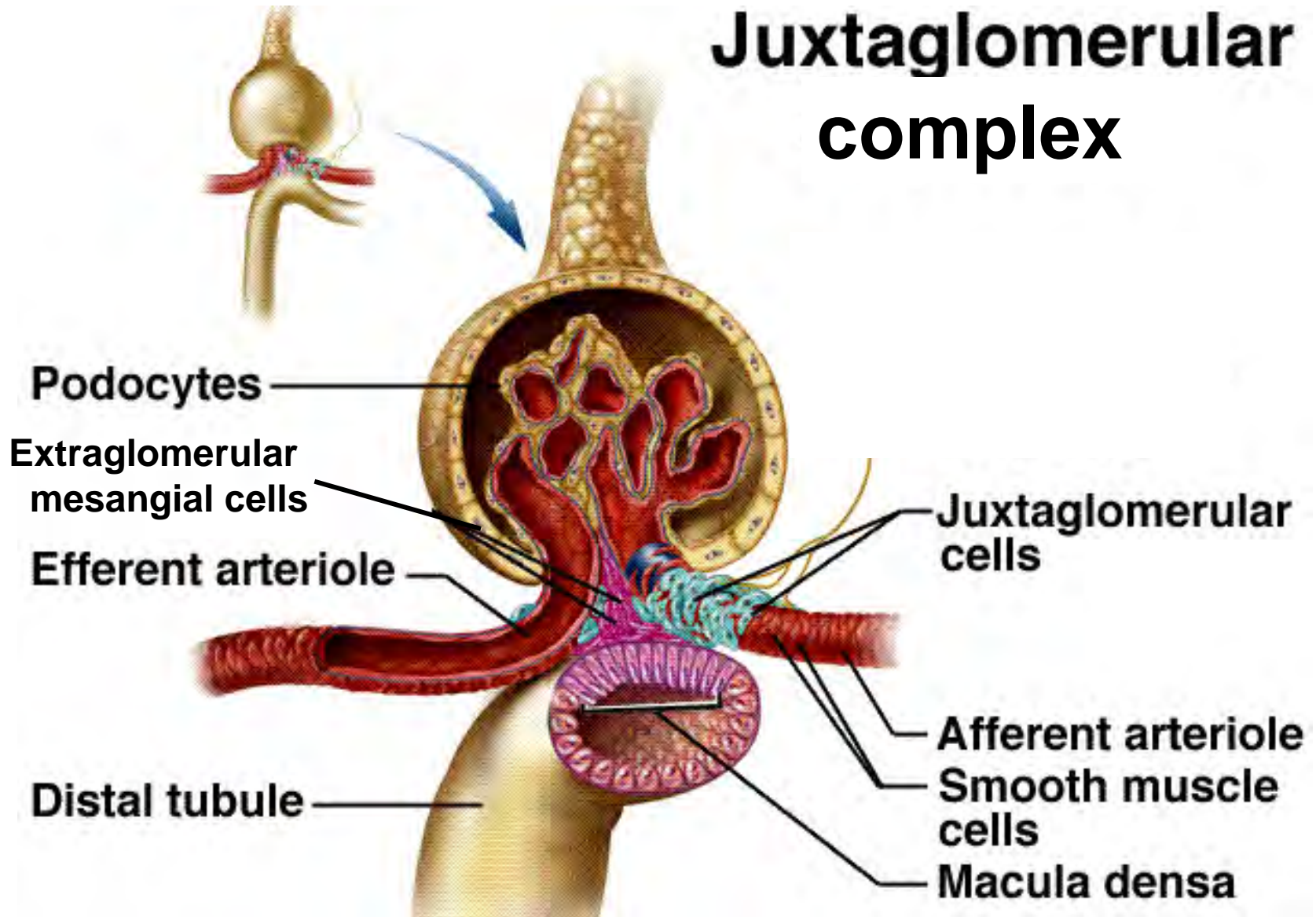
Overview of Urine Formation

Juxtaglomerular complex

1. juxtaglomerular cell
2. Extraglomerular mesangial cell
3. Macula densa



Juxtaglomerular complex



Juxtaglomerular complex

Juxtaglomerular cell

Origin:

smooth muscle cell of
the afferent arteriole

Secretion:

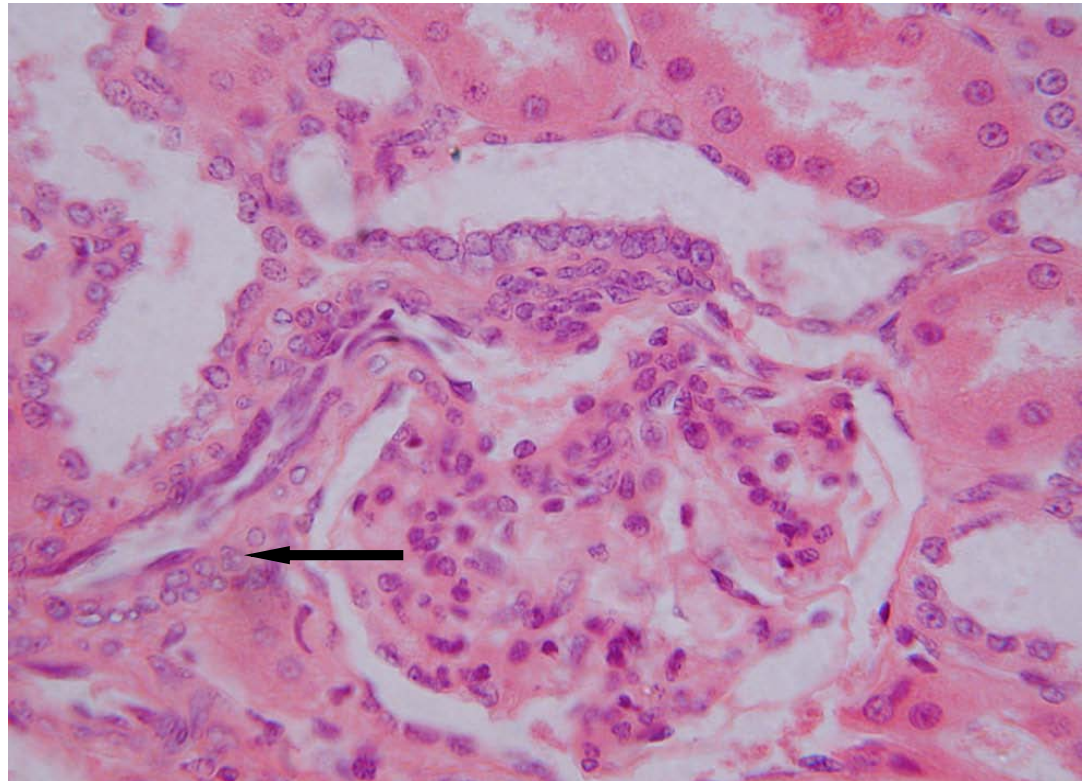
renin (hormone)



Angiotensinogen → angiotensin I → angiotensin II



aldosterone ↑



Juxtaglomerular complex

macula densa

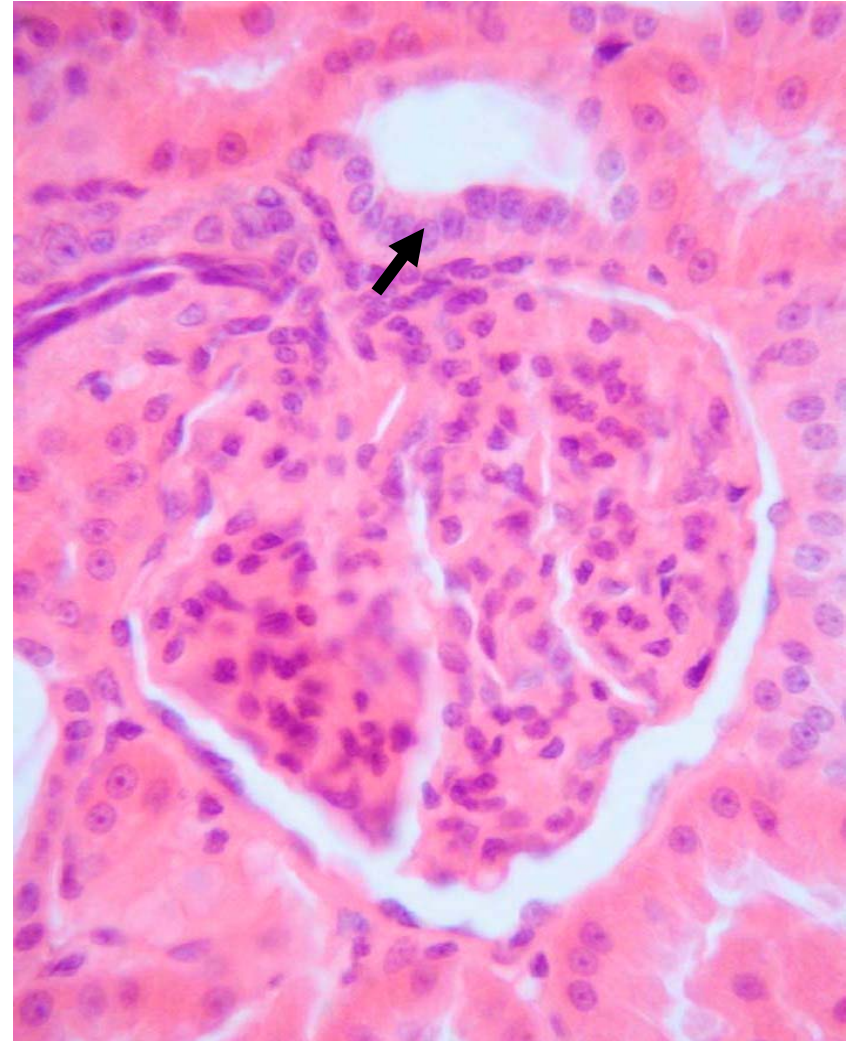
Origin:

part of the distal tubule wall

Function:

a chemical sensor _

monitoring sodium concentration



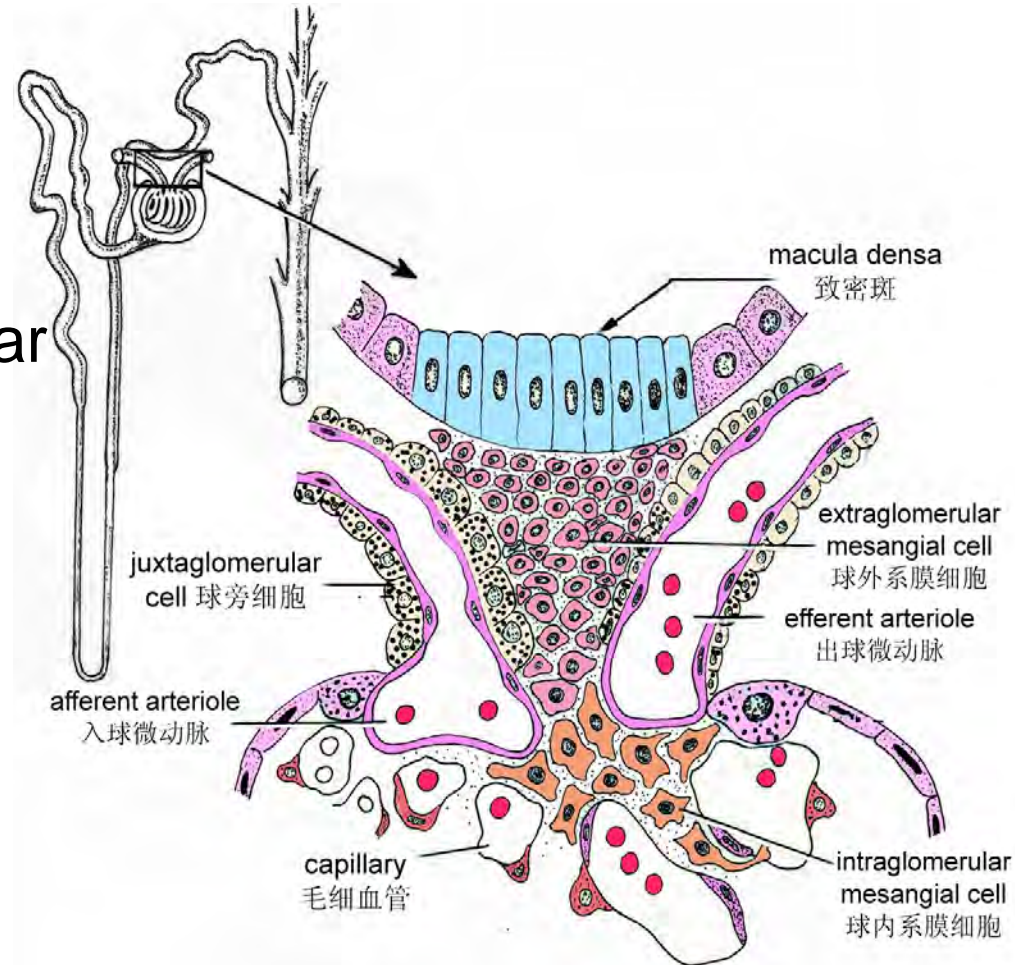
Juxtaglomerular complex

Extraglomerular mesangial cell

resemble the intraglomerular
mesangial cells

Function:

gap junctions between the
component of the
juxtaglomerular apparatus
transmit information



Blood supply of kidney

1 blood flow is large

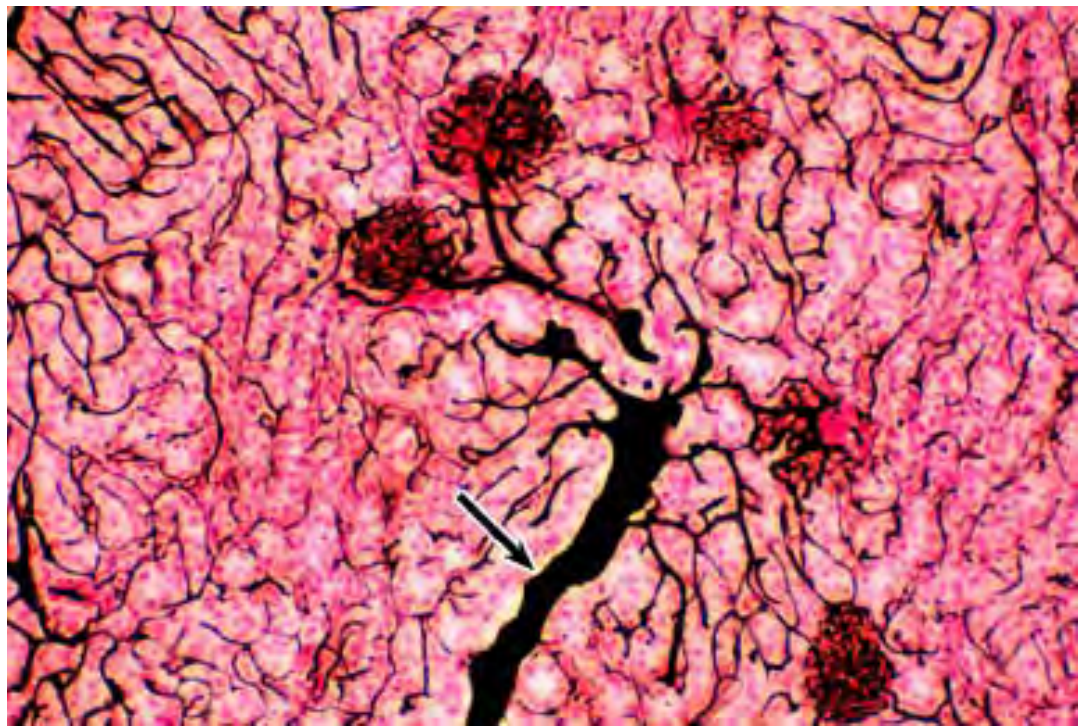
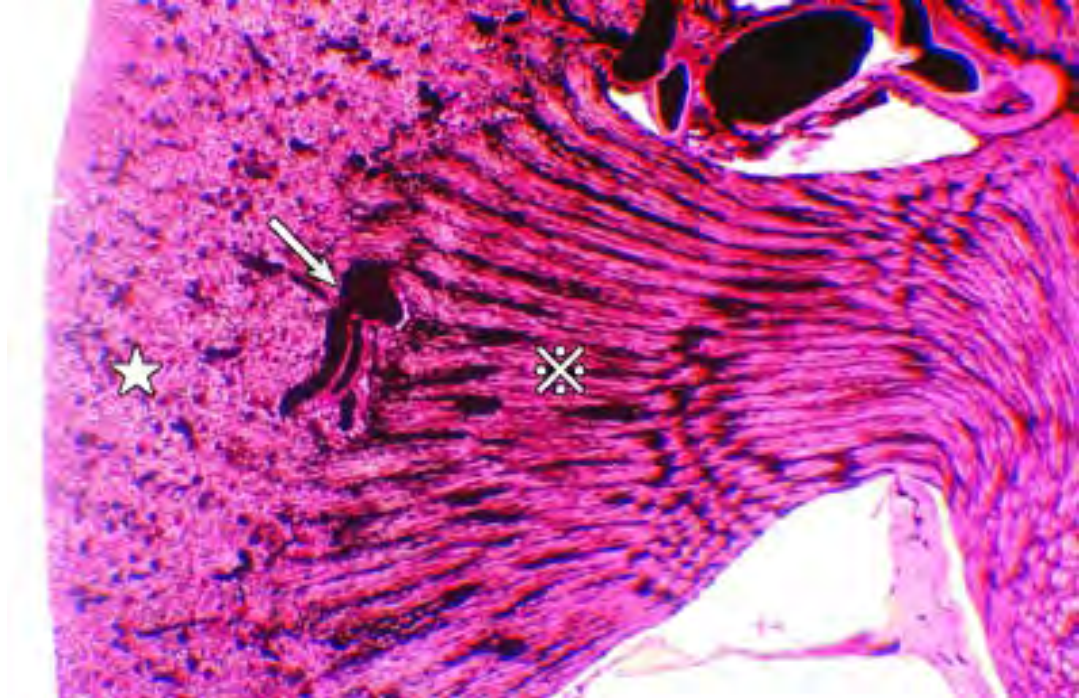
2 two sets of capillary network

3 the diameter of afferent arterioles is larger

**than that of efferent arterioles, so as to facilitate
filtration**

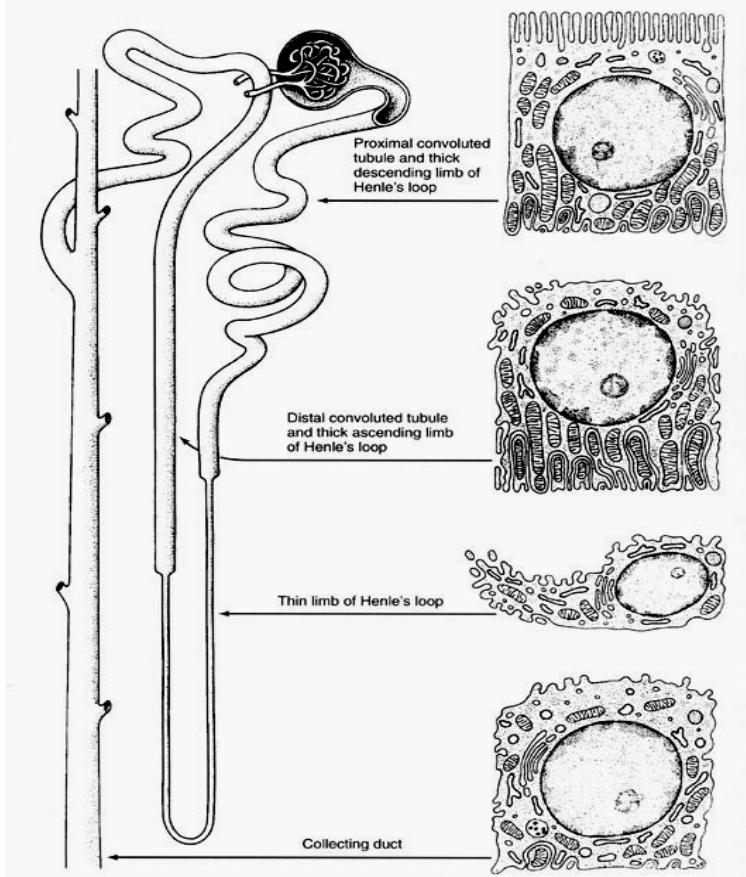
**4 the vasa recta are parallel to the Henle's loop,
so aid water reabsorption and urine
concentration**

Blood vessels of kidney



review

Renal tubules



Henle's loop {
Proximal straight tubule
Thin segment
Distal straight tubule

Uriniferous tubule

Nephron

Collecting tubule

Renal corpuscle {
glomerulus
renal capsule

Cortical labyrinth **Renal columns**

Proximal convoluted tubule

Cortical labyrinth
Renal columns

Renal tubule {
Henle's loop

Medullary ray
renal pyramids

Distal convoluted tubule

Cortical labyrinth
Renal columns

Medullary ray
renal pyramids

Filtration barrier

The filtration barrier includes the fenestrated endothelium of the glomerular capillary, The basement membrane and The filtration slit membrane of the podocytes.

The filtration barrier is to filter the blood plasma.this barrier permits water and small molecules to enter the capsular.

Proximal tubule: convoluted tubule straight tubule

LM:A simple cuboidal epithelium

Cell shape: cuboidal cell with brush border

Nucleus: small, round, located in the base

Cytoplasm: strong acidophilic

EM:Microvilli;Canaliculi and vesicles;lysosomes;Membrane folds

Mitochondria;Na / K ATPase (Natrium/kalium ATPase);Cell junction ;Membrane interdigitation

Function:Urine absorption;Secrete Hydrogen, Ammonia; creatinine
Transfer and release the substance in the blood

Distal tubule : distal straight
convoluted tubule

LM:A simple cuboidal epithelium

Cell shape: small cuboidal cell lacking, brush border

Nucleus: small, round, located in medium

Cytoplasm: less acidophilic

EM:Few microvilli; Few canaliculi and vesicles;

Few interdigitations; Extensive membrane folds

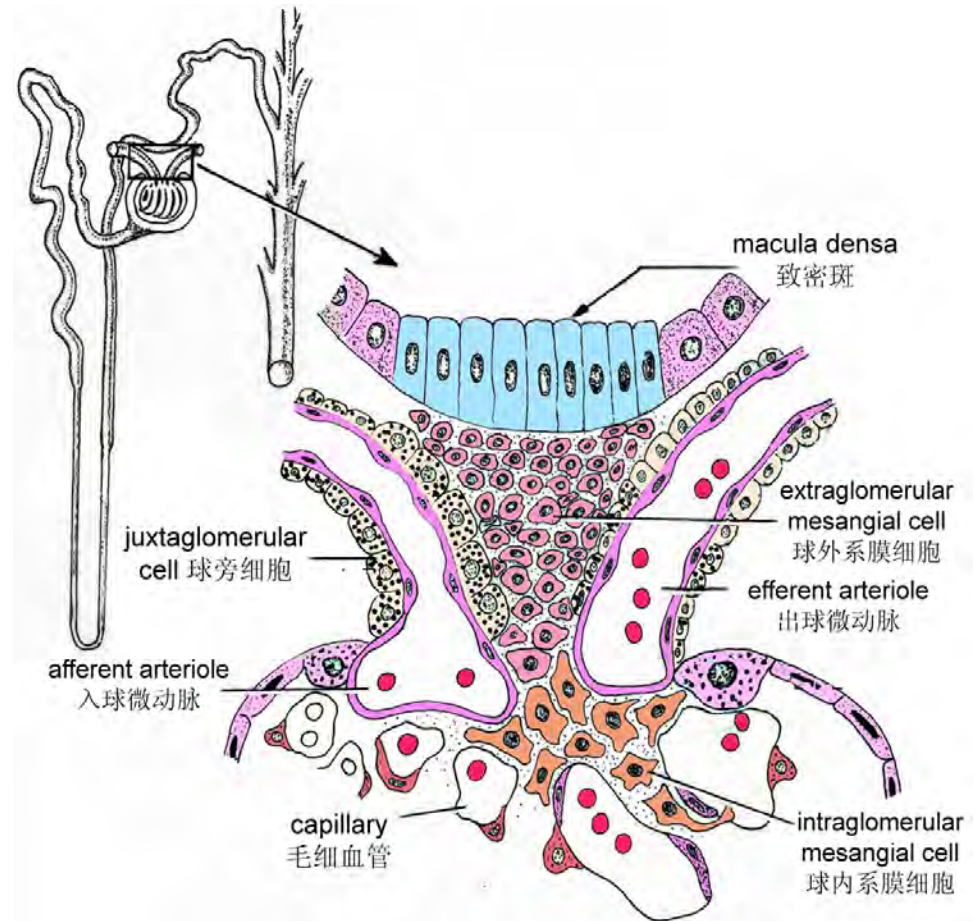
Numerous mitochondria

Function: Absorb Na and secrete K

Secrete Hydrogen and Ammonium into tubular urine

Juxtaglomerular complex

1. juxtaglomerular cell
2. Extraglomerular mesangial cell
3. Macula densa



1 juxtaglomerular cell

smooth muscle cells of the afferent arteriole transform into the epithelial cells.

Function: secrete **renin** and erythropoietin

2 macula densa

transformed from the cells of distal tubule which near the vascular pole of the renal corpuscle the cells become taller and narrow, arranged compactly; pale cytoplasm; nuclei located at the apex
Function: a chemical sensor

3 extraglomerular mesangial cell

resemble the intraglomerular mesangial cells ; gap junctions between the component of the juxtaglomerular apparatus
Function: transmit information

Questions

- 1、 What is Filtration barrier, please describe its structure and function?**
- 2、 What are differences of structure and function between proximal and distal tubule?**
- 3、 Please describe the components and functions of Juxtaglomerular complex**



bye!