NORMAL HISTOLOGY OF KIDNEY

- ANAMIKA GUPTA

INTRODUCTION

- Bean shaped, reddish brown.
- Located *retroperitoneally* between T12 – L3 vertebral level.
- Size approx 10 x 6.5 x 3 cms.
- Weighs around 135-150 grams.
- Highly vascular organ.
- Receives 25 % of cardiac output.
- Kidney produces urine - ultrafiltrate of blood, which is then modified by selective resorption and specific secretion by cells of kidney.

FUNCTIONS OF KIDNEY

1. Regulates and maintains composition and volume of extracellular fluid.
2. Maintains acid base balance by excreting H^+ ions or $HCO3^-$ ions.
3. Endocrine organ –

   a) Synthesis of acid protease **RENIN** –

   - enzyme involved in control of blood pressure and blood volume.

Angiotensinogen → Angiotensin I

Renin

b) Erythropoietin synthesis –

- glycoprotein hormone

- regulates RBCs formation in response to decrease O_2 concentration.

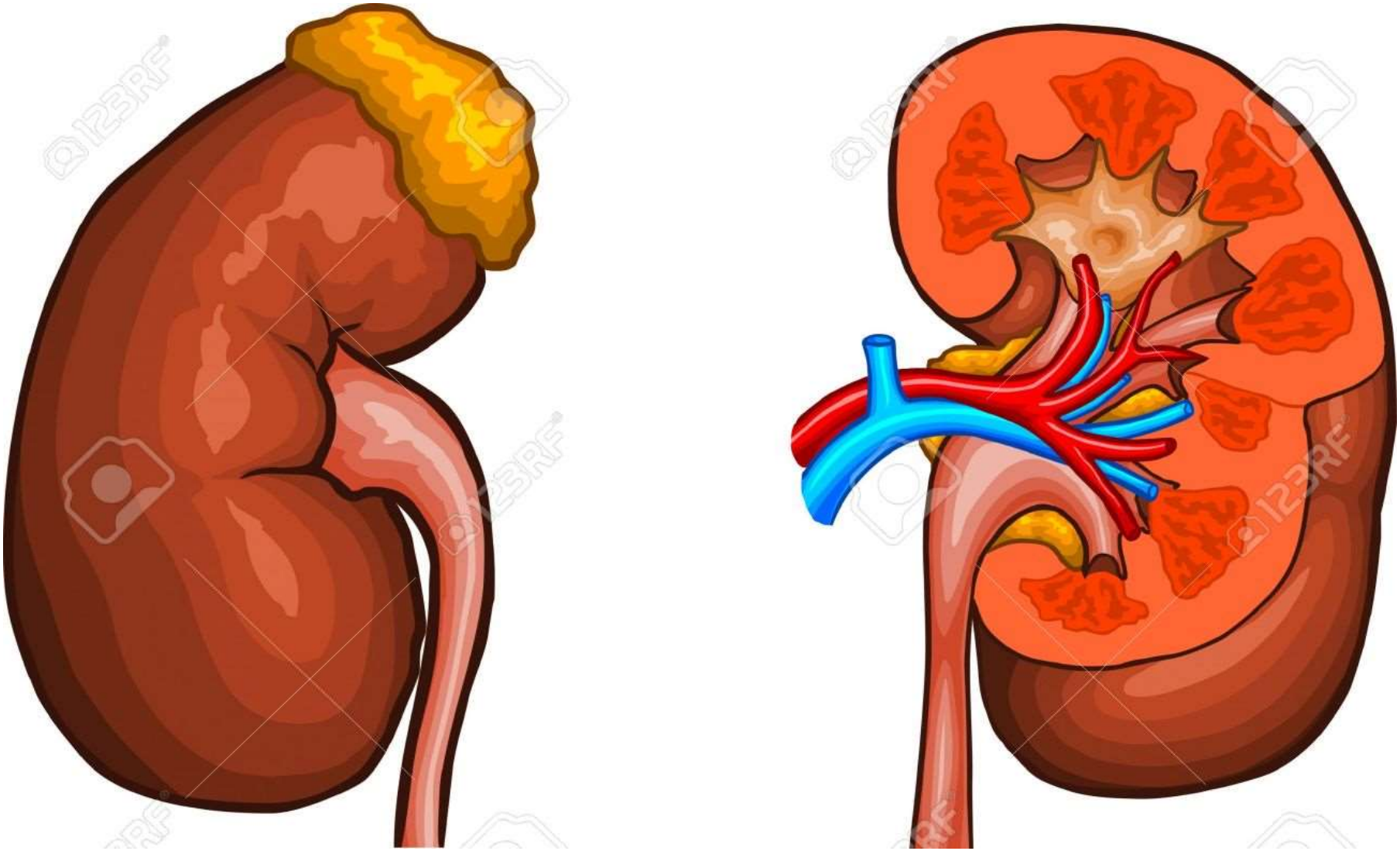
- erythropoietin acts on specific receptors expressed on surface of CFU for erythrocytes in bone marrow.

c) Hydroxylation of 25-OH vitamin D3 –

- a steroid precursor produced in liver.

- converted to 1,25 (OH)2 vitamin D3, hormonally active.

ANATOMY OF KIDNEY

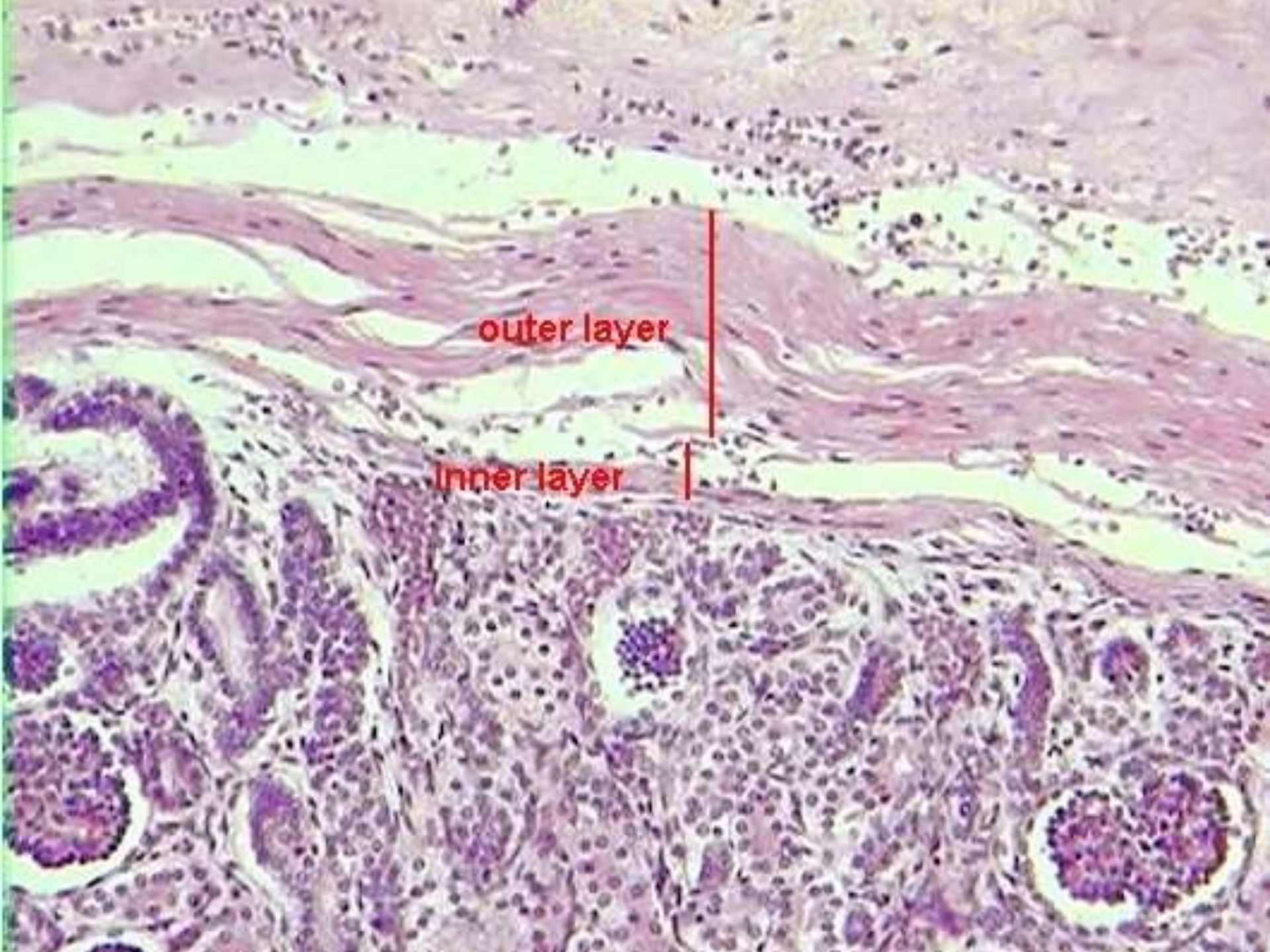


Capsule

- Connective tissue capsule.

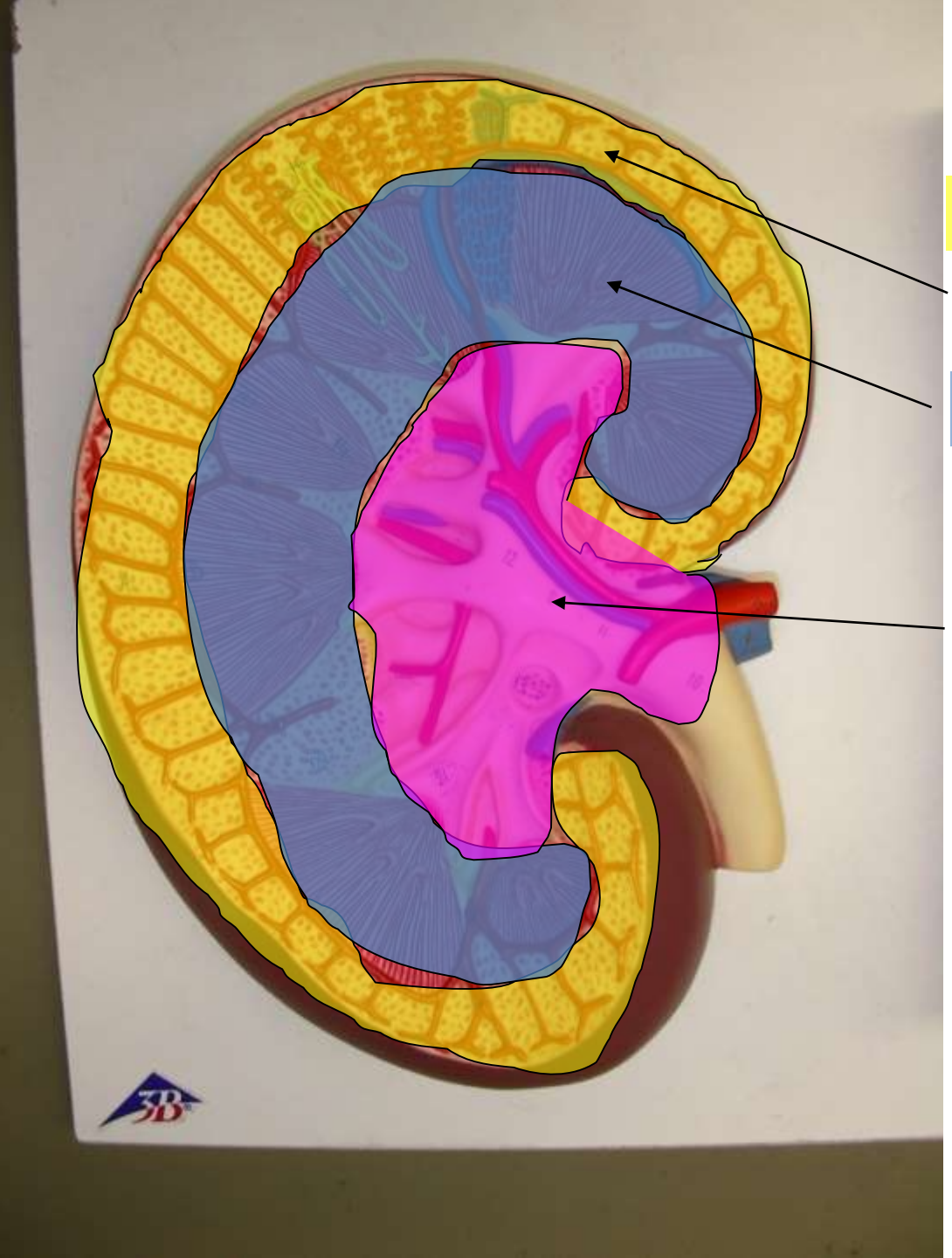
- Outer layer – fibroblasts and collagen fibres

  Inner layer – myofibroblasts


outer layer
inner layer

- Myofibroblasts resist volume and pressure variation that accompany variation in kidney function.

Parts of kidney

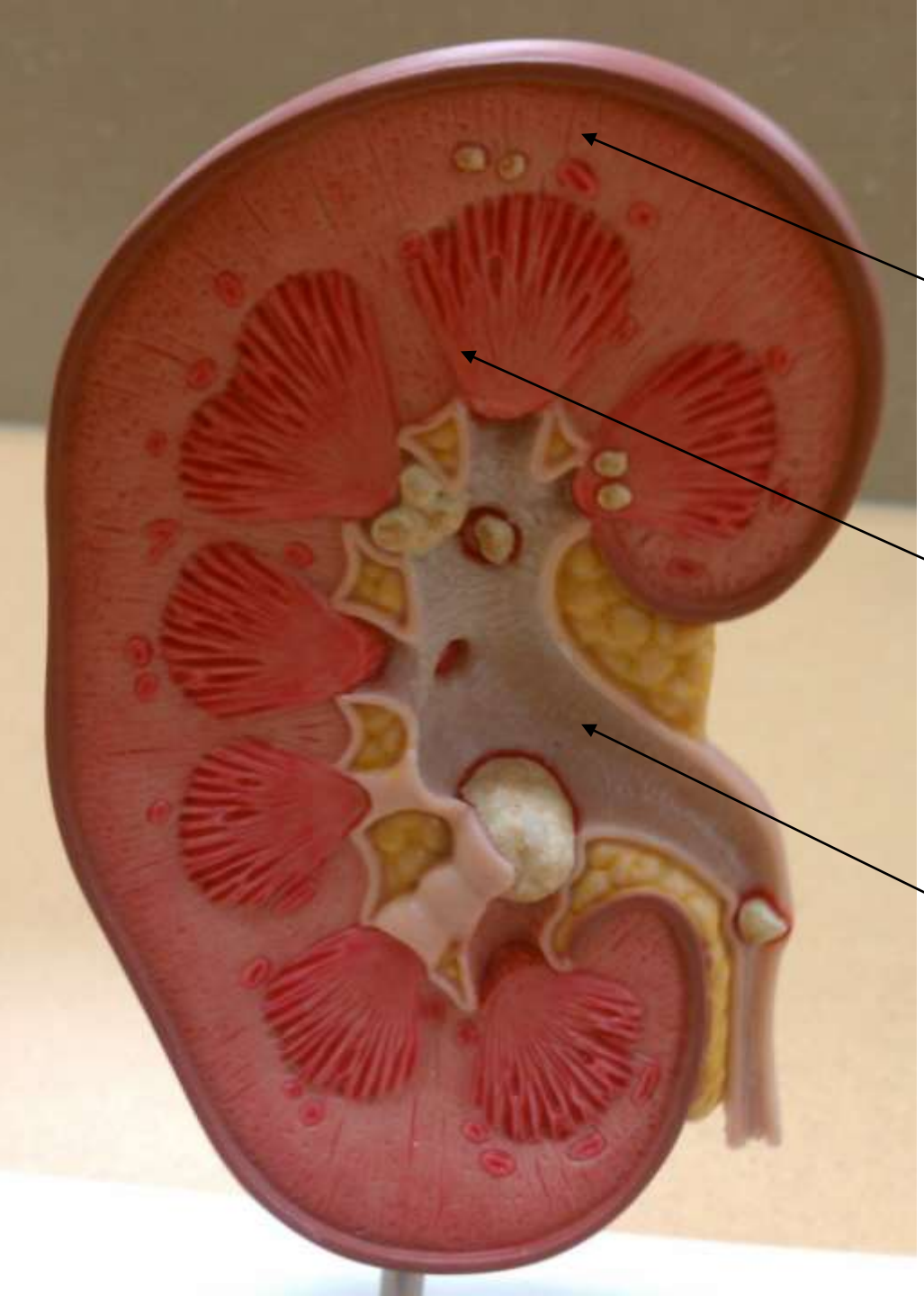


Cortex

Medulla

Renal Pelvis

- 90-95 % of blood passing through kidney is in cortex, and
- 5-10 % is in medulla.



Cortex

Medulla

- Pyramids

(triangular areas of renal tissue)

Renal pelvis

- Medullary pyramids have striped appearance due to presence of many collecting tubules.

- Tissue between pyramids is also a part of cortex and is known as **RENAL COLUMNS.**

- Tissue between base of pyramid and surface of kidney is known as **CORTICAL LOBULE.**

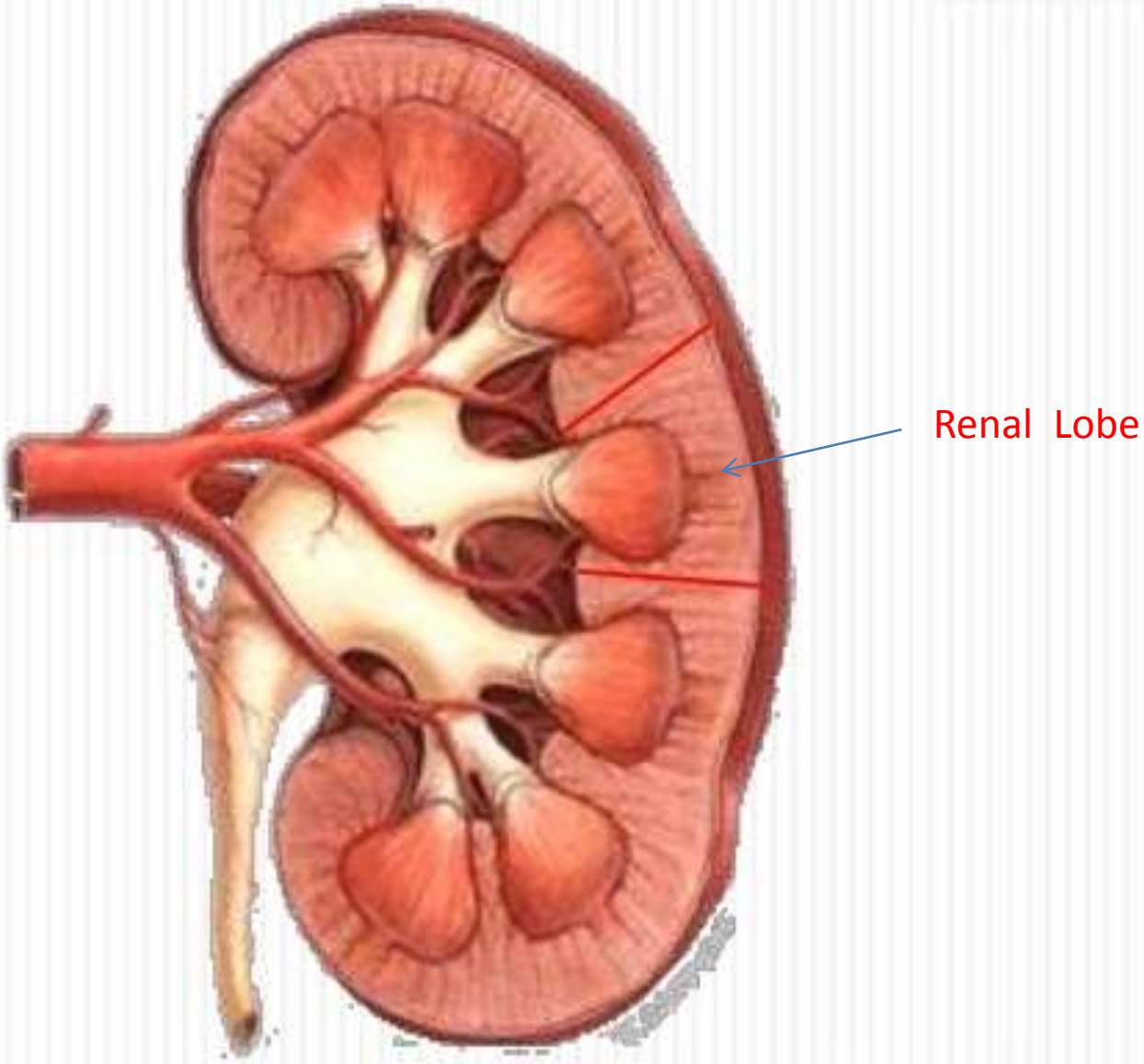
- Cortical lobules show light and dark striations, light lines are called **MEDULLARY RAYS.**

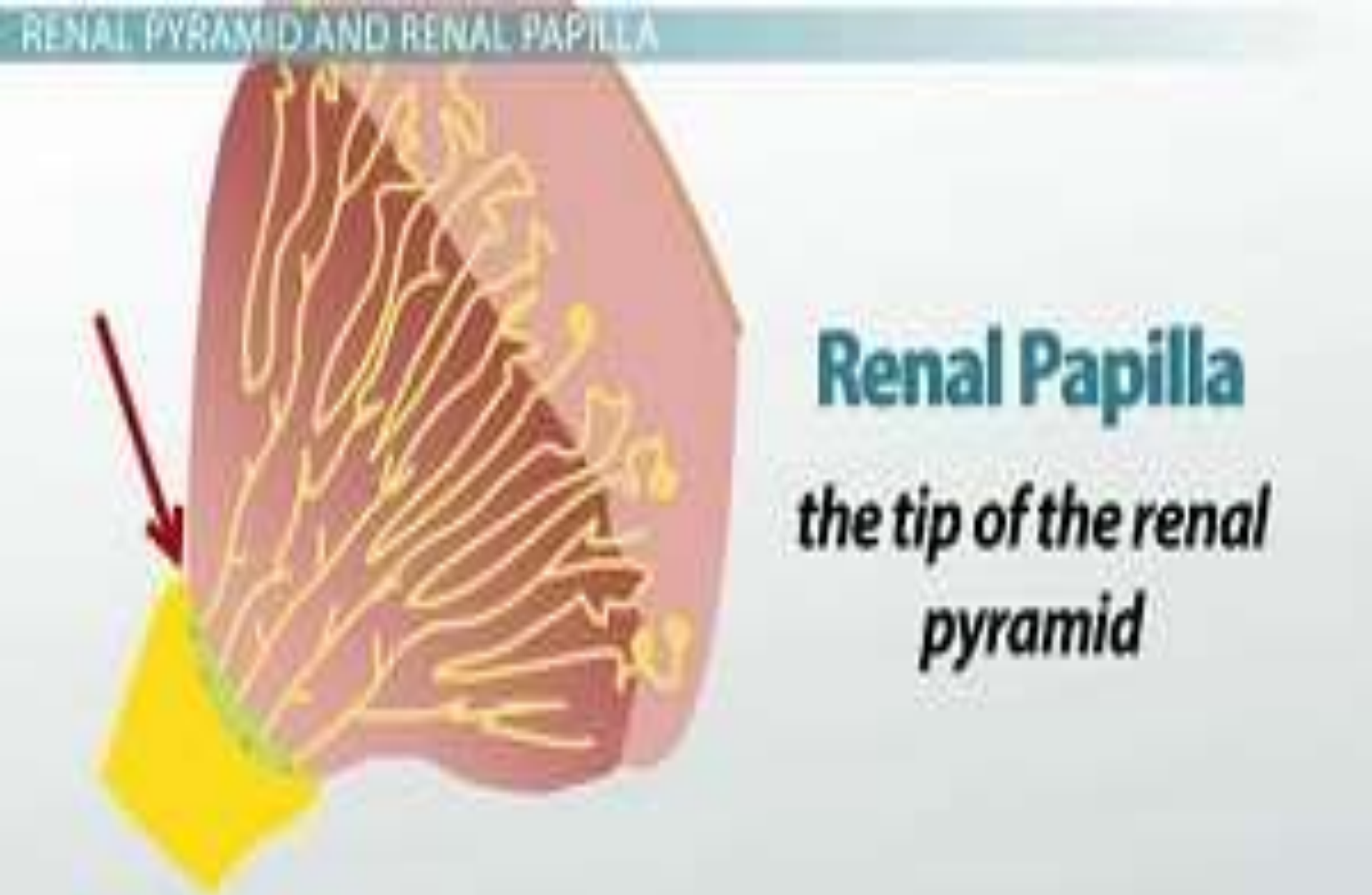
  Contains straight tubules and collecting ducts.

- Pyramid and the cortex around it constitute **LOBE OF KIDNEY.**

  Each kidney has *8-18 lobes.*

RENAL LOBE



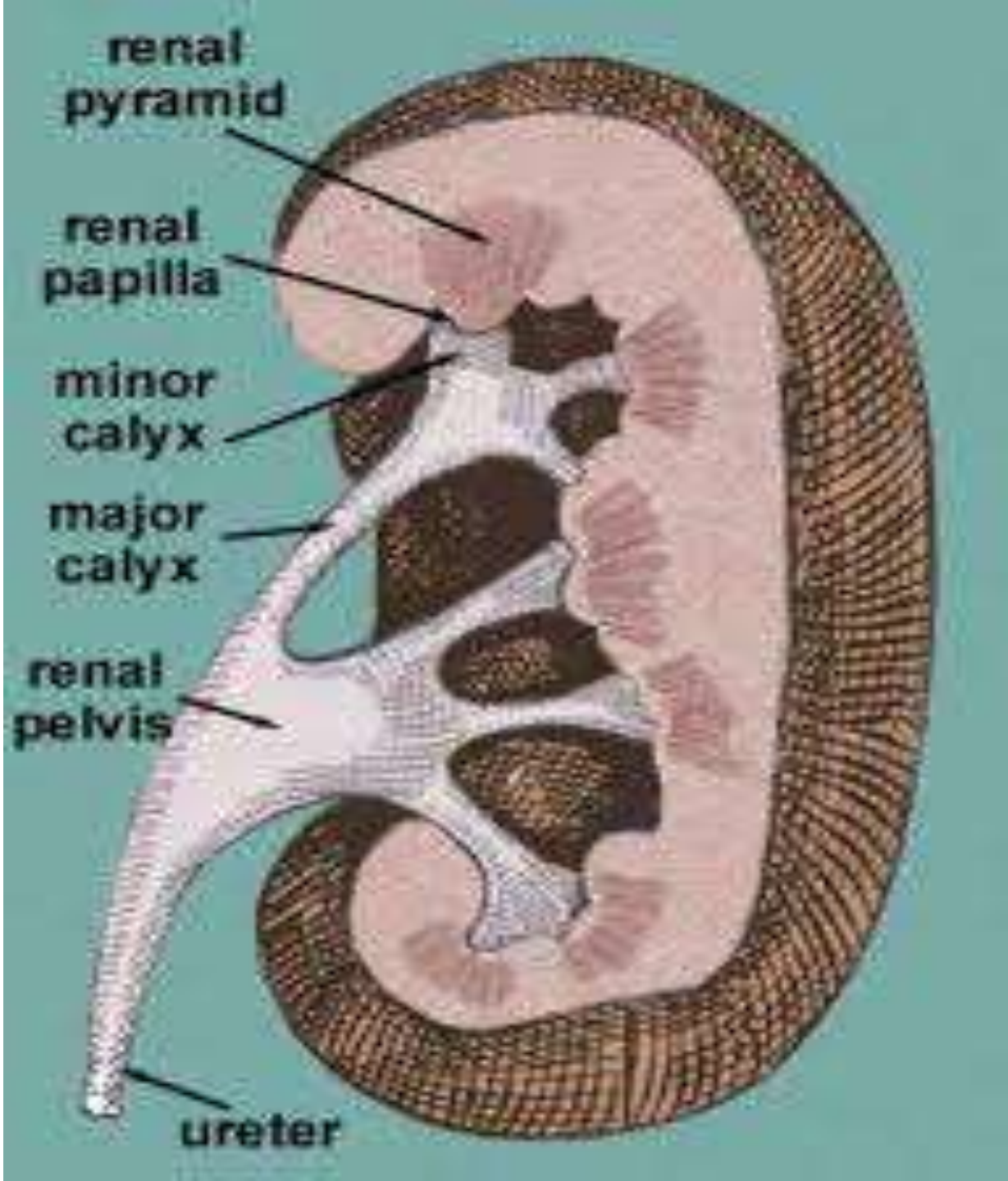


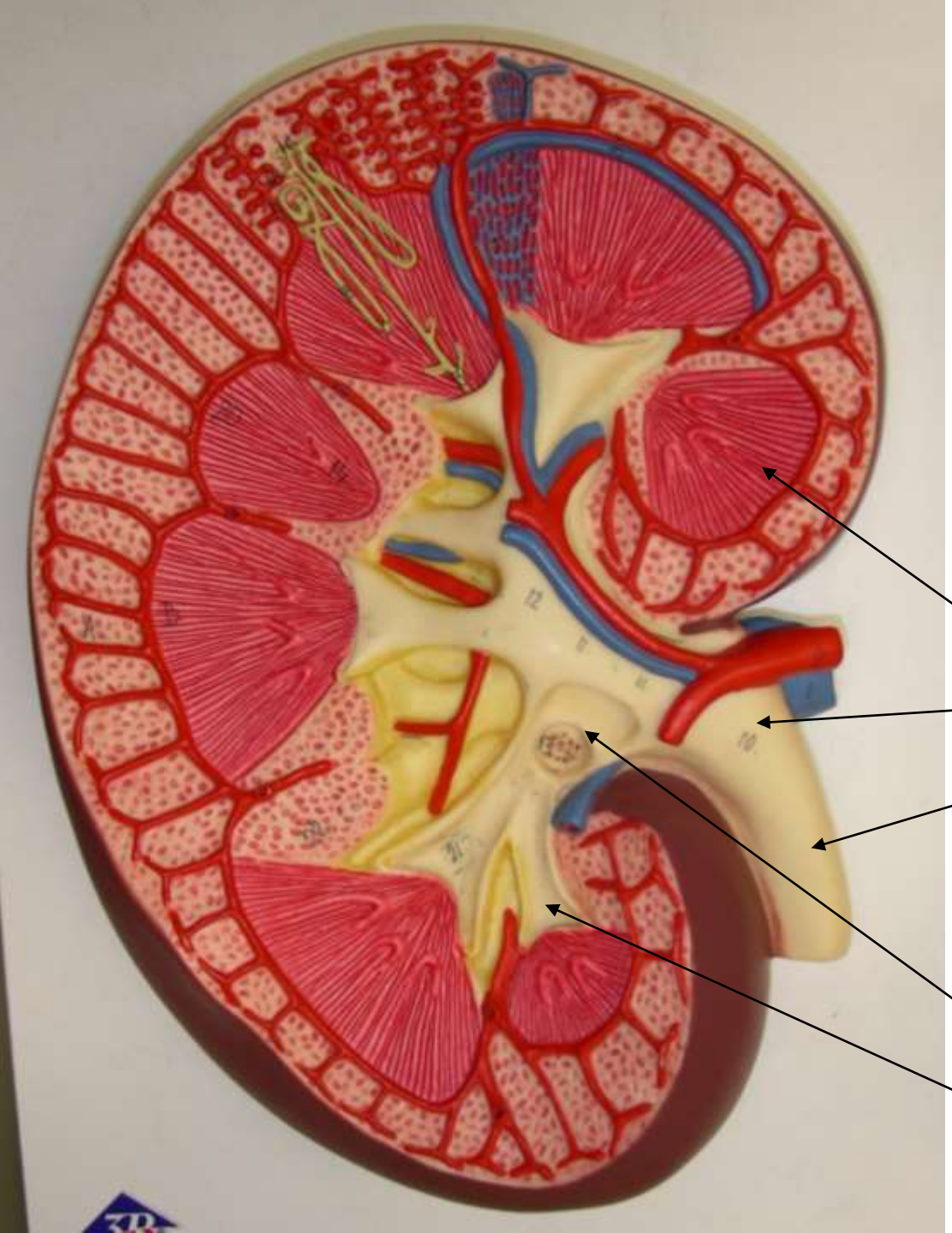
Apex of each pyramid extends downwards into renal pelvis and forms Renal Papilla

- Papilla is surrounded by funnel shaped Minor Calyx

- Minor calyces join to form Major Calyx

- Major Calyces join to form Renal Pelvis



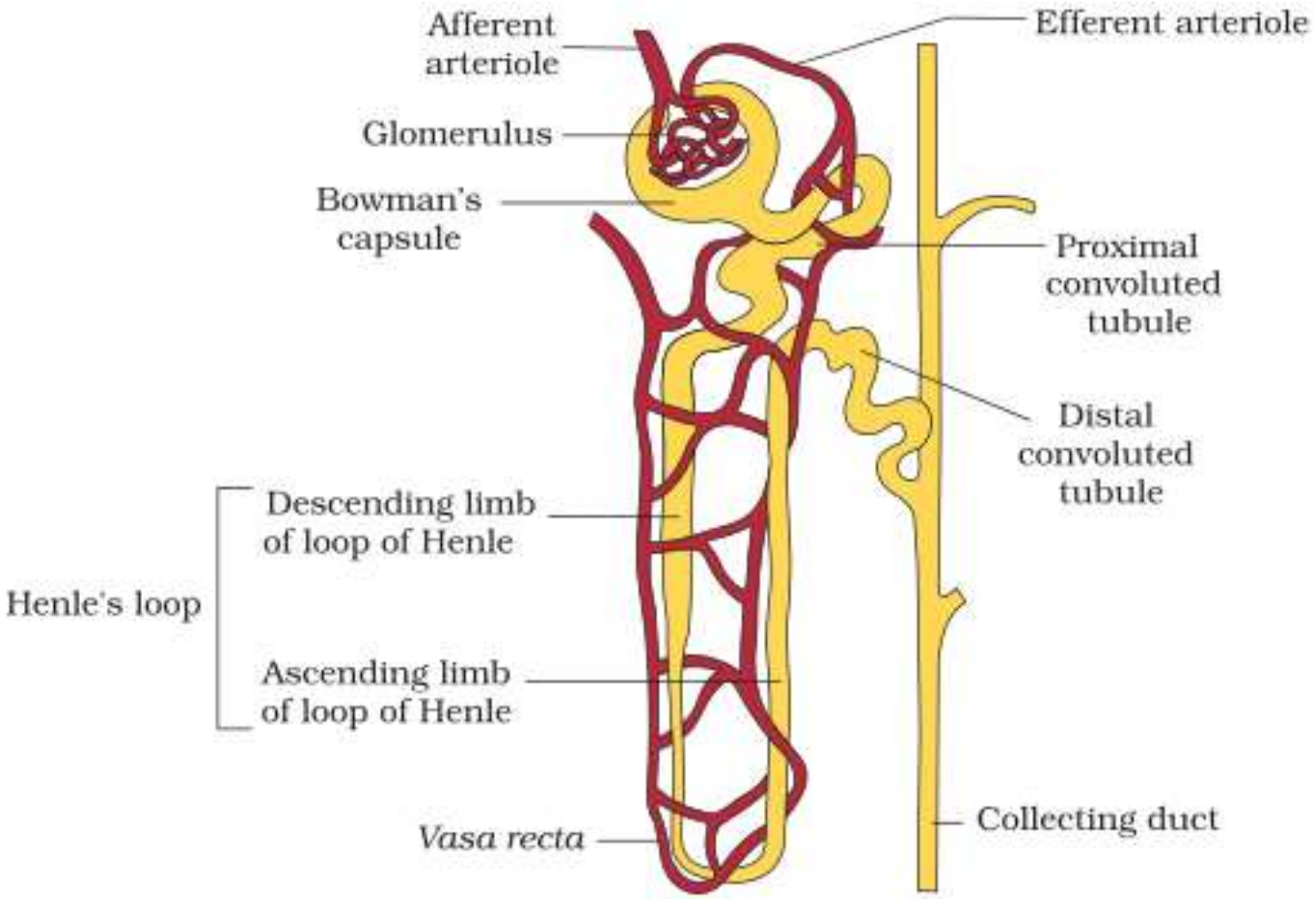

Pyramids
Hilus
Ureter
Major calyx
Minor calyx

- Kidney consists of collection of numerous Uriniferous tubules.

- Uriniferous tubule = Nephron + Collecting Duct.

- Accompanied by capillary network called **VASA RECTA**, that runs parallel with tubules.

  - represent vascular part of countercurrent exchange system that regulates concentration of urine.


Afferent arteriole
Efferent arteriole
Glomerulus
Bowman's capsule
Proximal convoluted tubule
Distal convoluted tubule
Henle's loop
Descending limb of loop of Henle
Ascending limb of loop of Henle
Vasa recta
Collecting duct

- *Structural and functional unit of each kidney is Nephron.*

- There are 1 million nephrons in each kidney.

URINIFEROUS TUBULE

NEPHRON + COLLECTING DUCTS

1. NEPHRON

- distributed throughout cortex and various zones of medulla

a) RENAL CORPUSCLE

BOWMAN'S CAPSULE + GLOMERULUS

b) PROXIMAL TUBULE

CONVOLUTED AND STRAIGHT PORTIONS

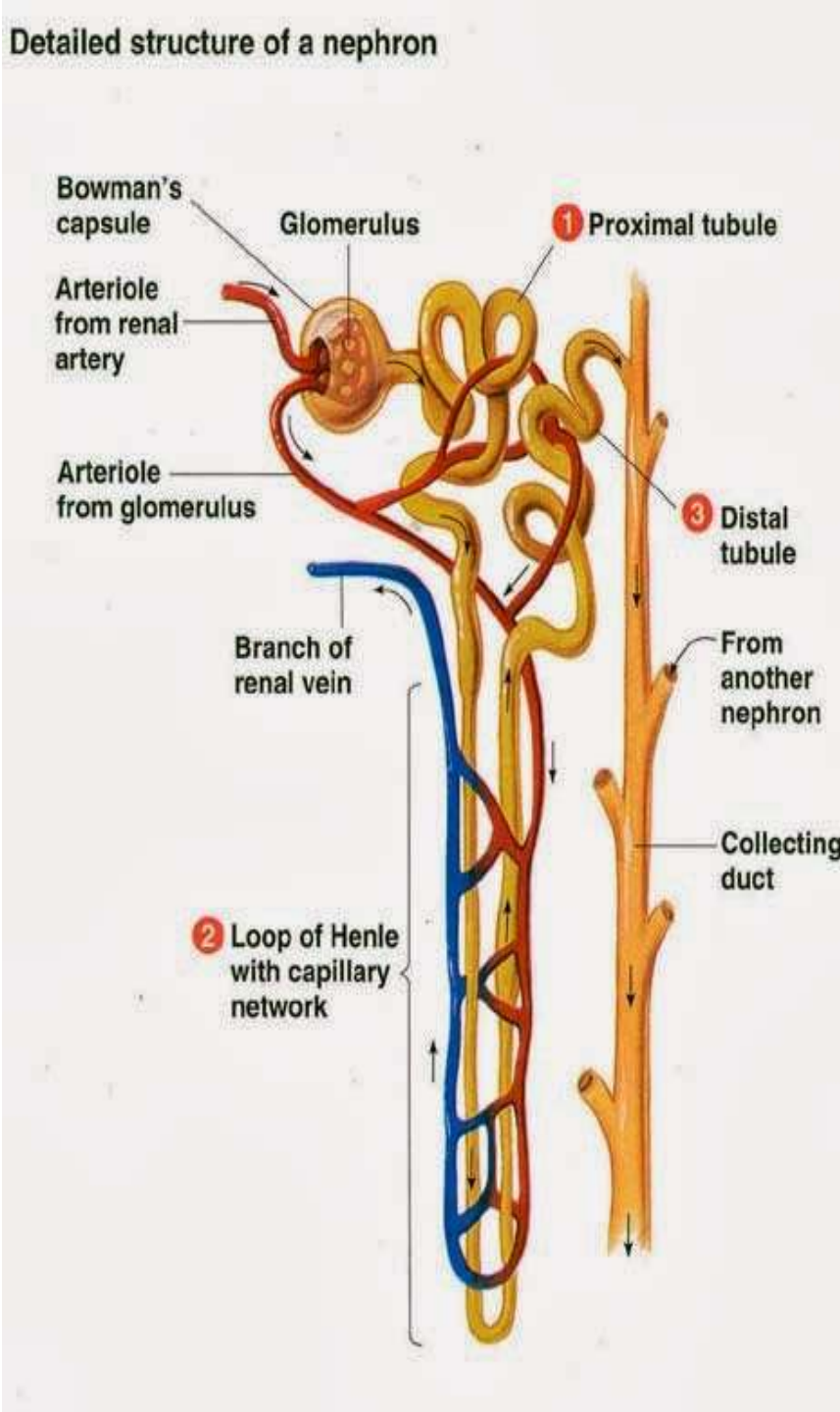
c) HENLE'S LOOP

THICK AND THIN PORTIONS

d) DISTAL TUBULE

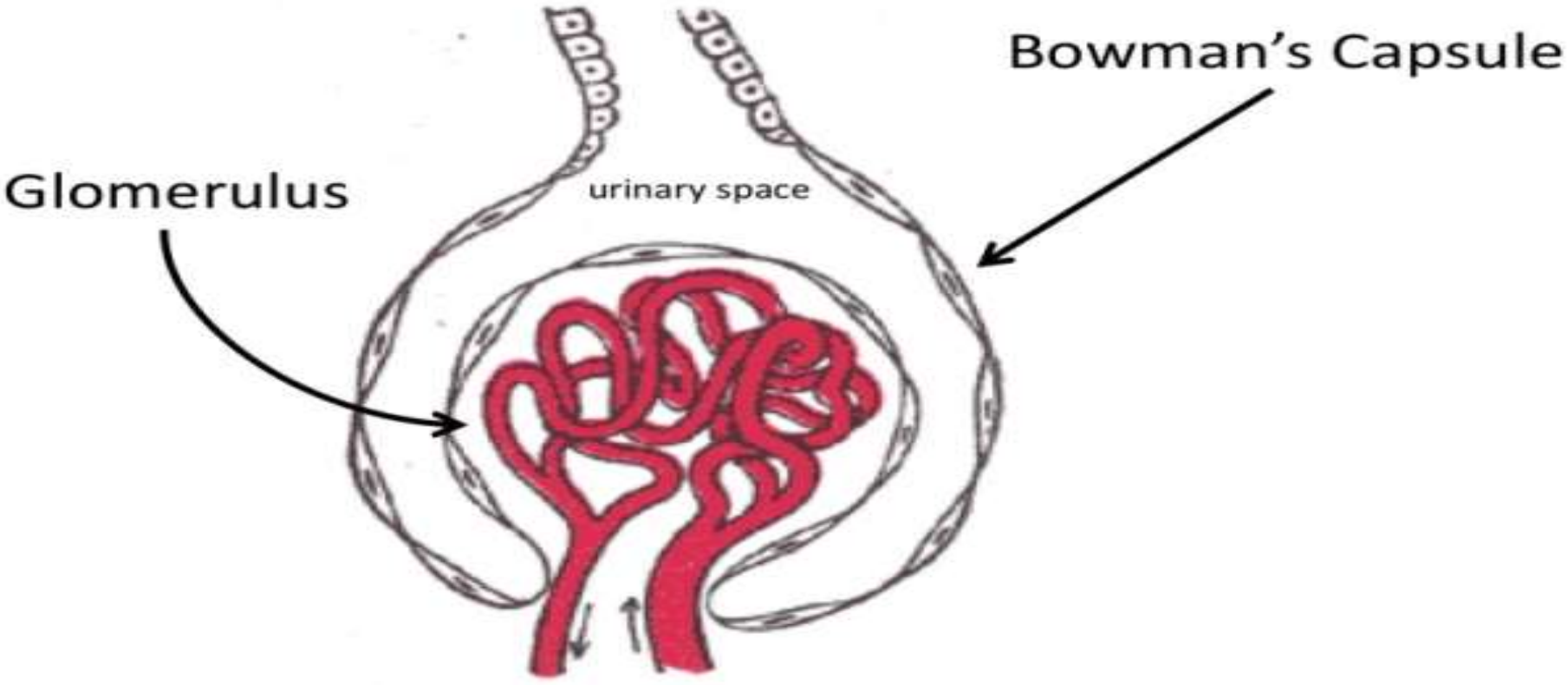
STRAIGHT AND CONVOLUTED PORTIONS

2. COLLECTING DUCTS



Glomerulus + Bowman's capsule

Renal Corpuscle



Renal Corpuscle has-

1- **Vascular Pole** : Afferent arteriole enters and efferent arteriole leaves.

2- **Urinary Pole** : Proximal convoluted tubule begins.

Marcello Malpighi - discovered renal corpuscles.

Father of microscopic anatomy and histology.

Discovered by Sir William Bowman.

Bowman's Capsule has 2 layers:

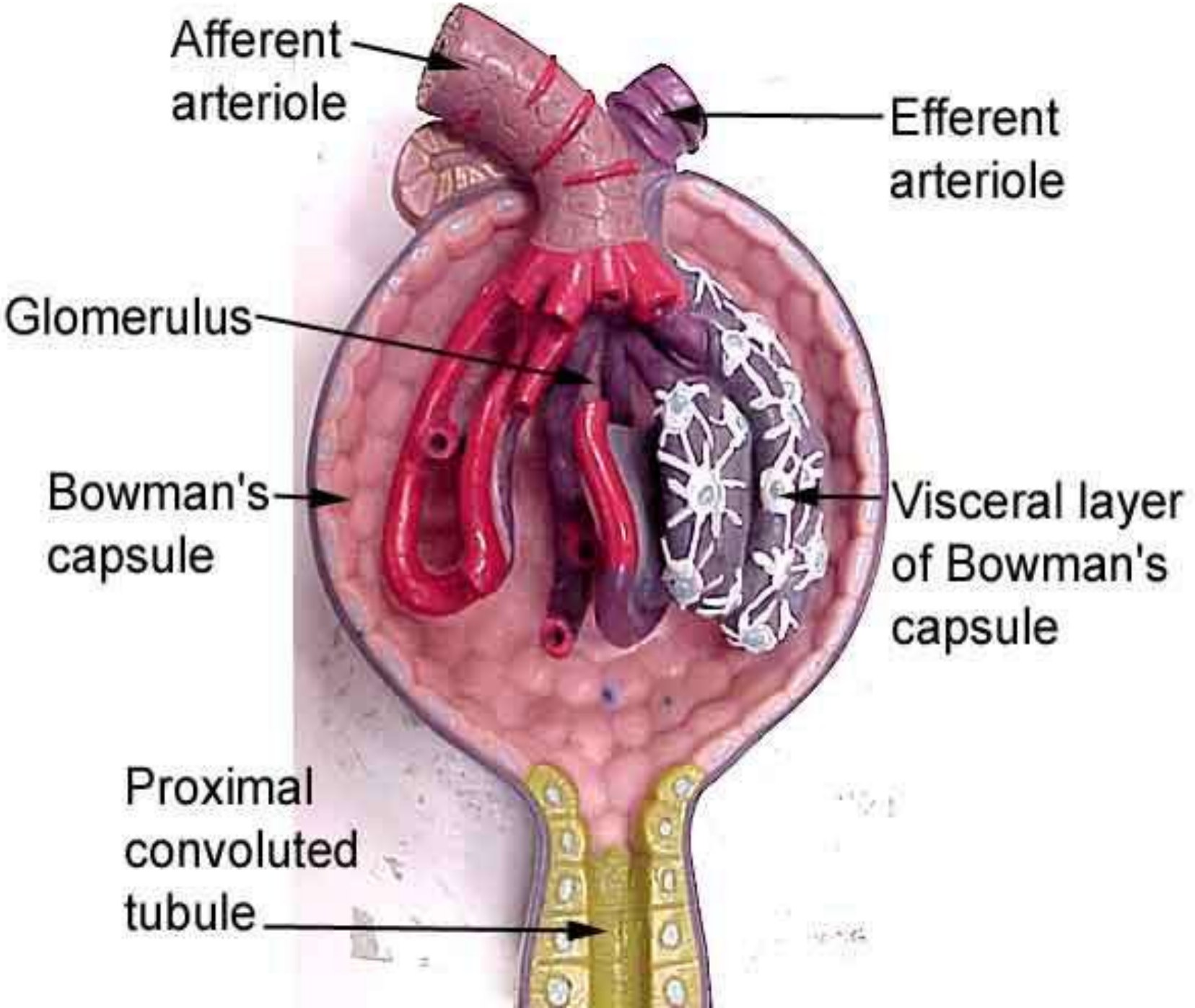
1- **Visceral Layer** - Inner

- Contains podocytes.

Podocytes extend processes around glomerular capillaries.

2- **Parietal Layer** - Contains parietal epithelial cells.

-simple squamous epithelium.


Afferent arteriole
Efferent arteriole
Glomerulus
Bowman's capsule
Visceral layer of Bowman's capsule
Proximal convoluted tubule

GLOMERULAR CAPILLARIES

Glomerular endothelium has numerous fenestrations.

Fenestrations – larger

more numerous

more irregular

Endothelial cells in glomerular capillaries has large number of aquaporin-1 water channels that allows fast movement of water through epithelium.

Glomerular Basement membrane

- Principal component of filtration barrier.
- Prominent in sections stained with PAS procedure.

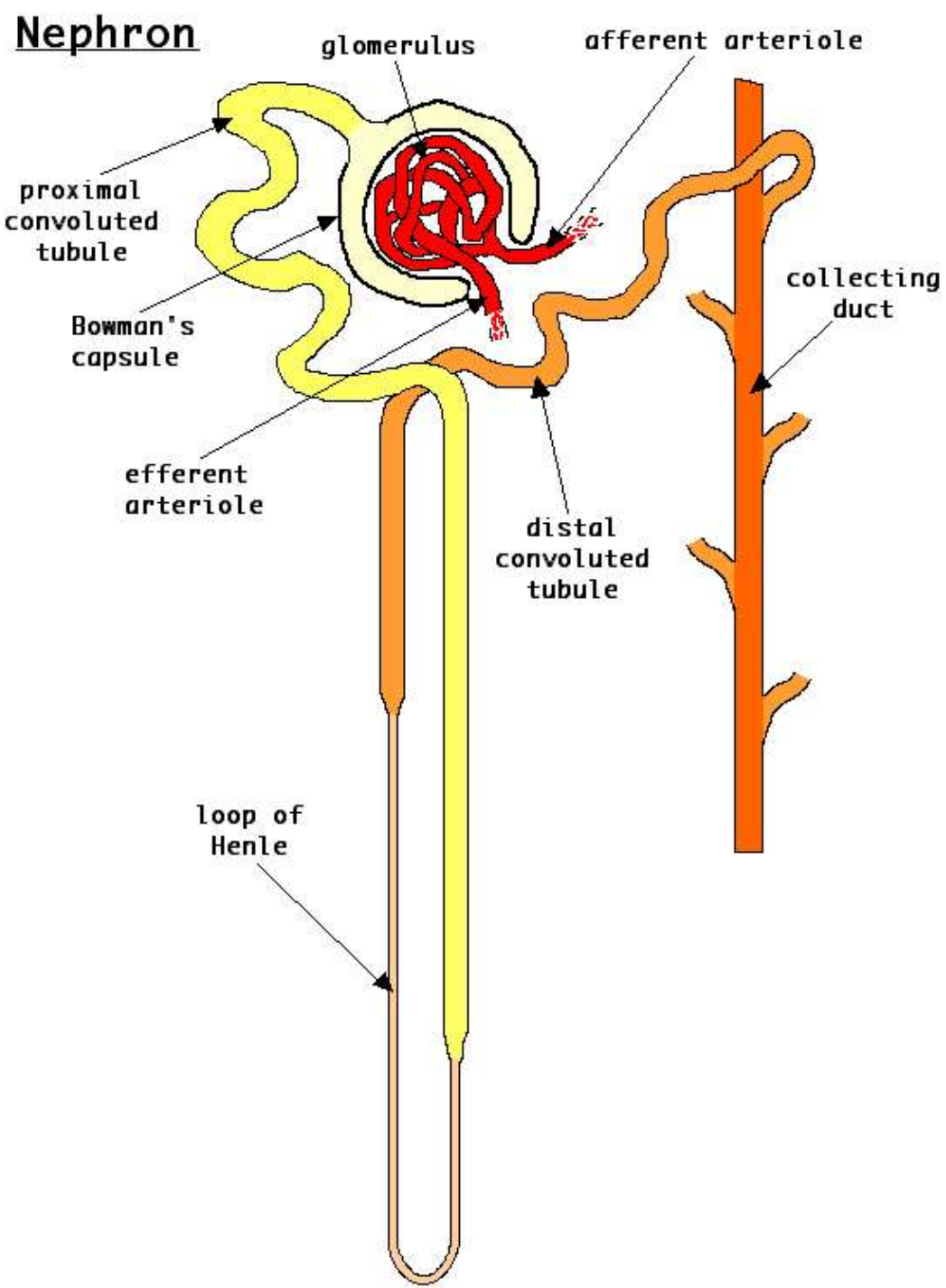
RENAL TUBES

Renal tubes are named according to –

A) Course they take – Convoluted
or
Straight

B) Location – Proximal
or
Distal

C) Wall thickness – Thick
or
Thin


Nephron
glomerulus
afferent arteriole
proximal convoluted tubule
Bowman's capsule
collecting duct
efferent arteriole
distal convoluted tubule
loop of Henle

Proximal convoluted tubule –

- originates from urinary pole of corpuscle.
- tortuous.
- located in cortex.

Proximal straight tubule –

- Known as **THICK DESCENDING LOOP OF HENLE.**
- descends into medulla.
- *Discovered by Jacob Henle.*

Thin descending limb –

- makes hairpin turn and returns towards cortex.

Thin ascending limb

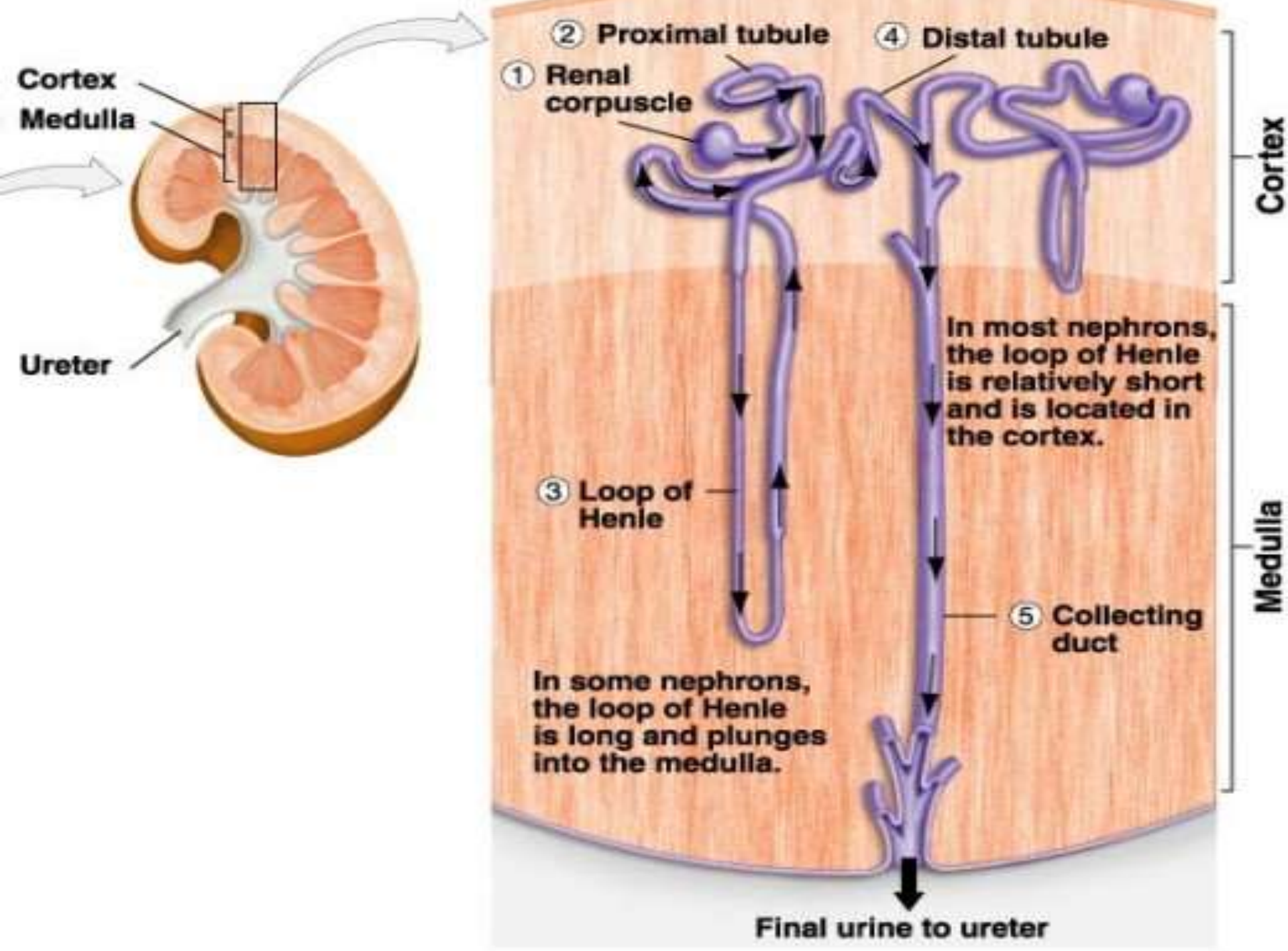
Thick ascending limb –

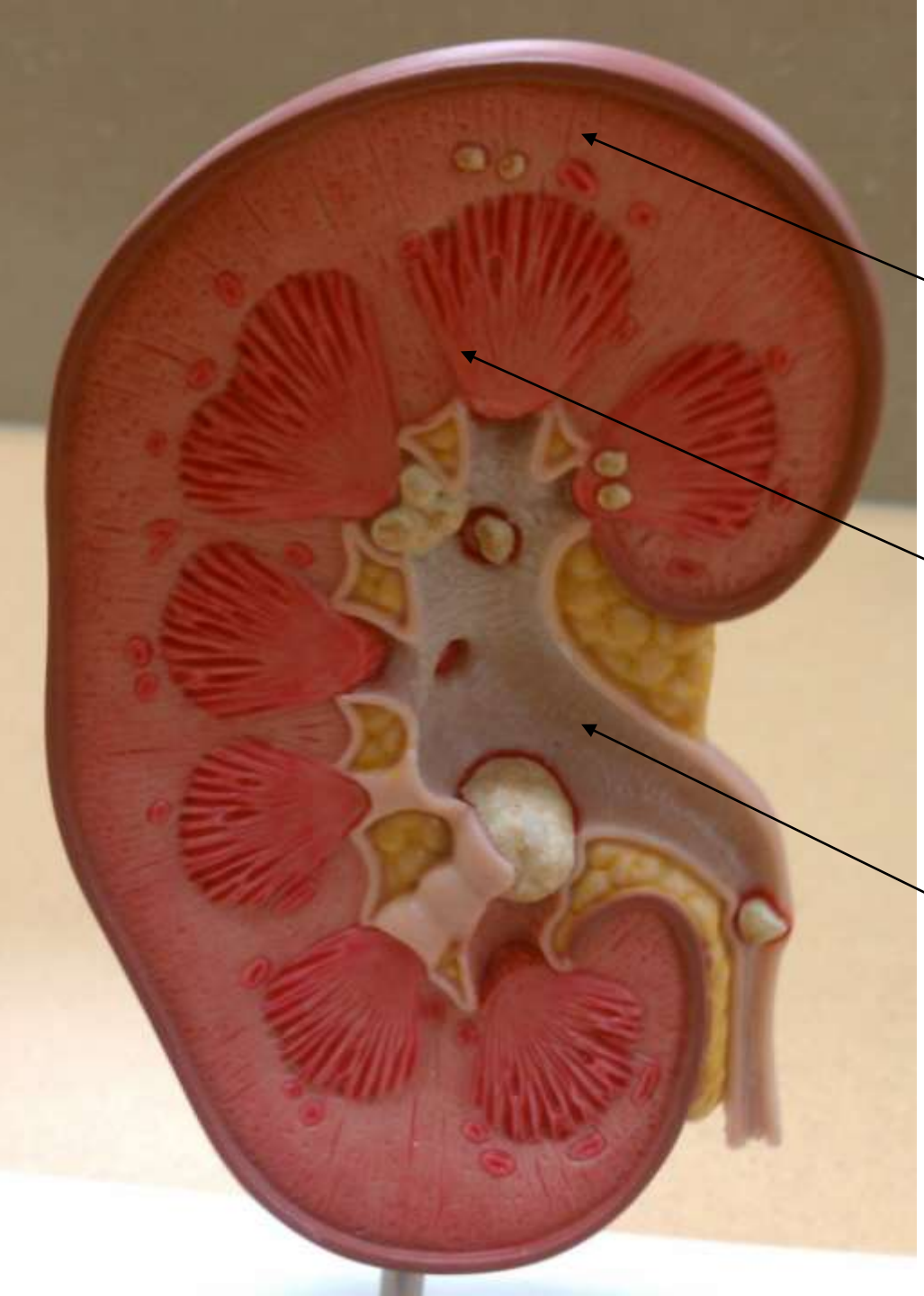
- known as **DISTAL STRAIGHT TUBULE.**
- ascends through medulla into cortex.

Distal Convoluted Tubule

Collecting Tubule

Collecting Duct


Cortex
Medulla
Ureter
2 Proximal tubule
4 Distal tubule
1 Renal corpuscle
Cortex
In most nephrons, the loop of Henle is relatively short and is located in the cortex.
3 Loop of Henle
5 Collecting duct
Medulla
In some nephrons, the loop of Henle is long and plunges into the medulla.
Final urine to ureter



Cortex:

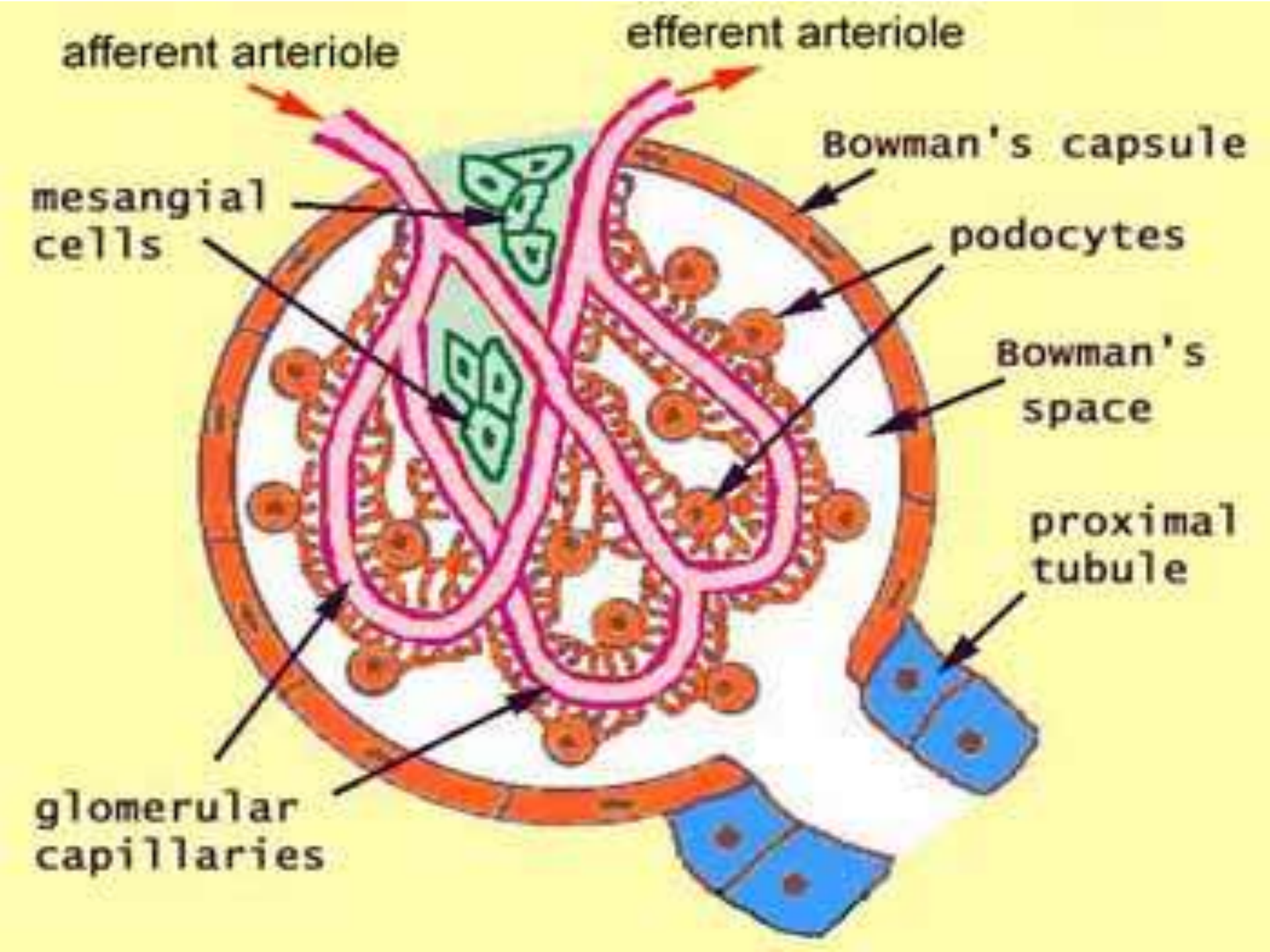
- Glomerulus
- Proximal and Distal convoluted tubules

Medulla:

- Loops of Henle
- Collecting duct
- Pyramids

Renal pelvis:

- Hilum
- Major calyxes
- Minor calyxes


afferent arteriole
efferent arteriole
Bowman's capsule
mesangial cells
podocytes
Bowman's space
proximal tubule
glomerular capillaries

MESANGIAL CELLS

- Specialised cells in glomerulus.
- Also attached to capillaries.
- Mesangial cells with their extracellular matrix is called **MESANGIUM.**

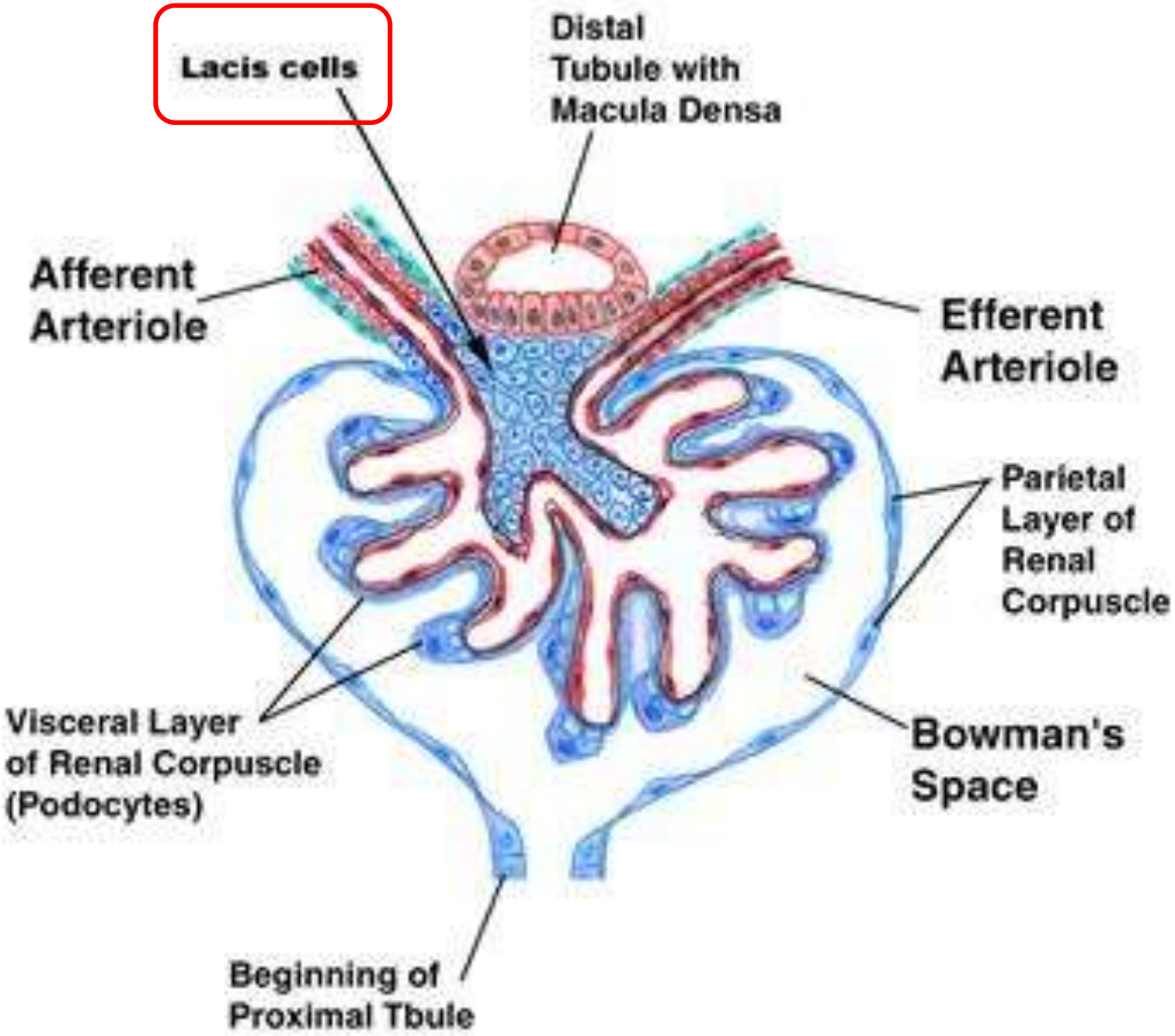
- Functions as macrophages in intraglomerular regions and phagocytose material that accumulates on glomerular filter.
- Structural support for podocytes.
- Secretes IL1 and platelet derived growth factor.
- Regulates glomerular blood flow.

- Some mesangial cells are located outside corpuscle along the vasular pole, and are known as **LACIS CELLS.**

- Flat cells with fine cytoplasmic processes.

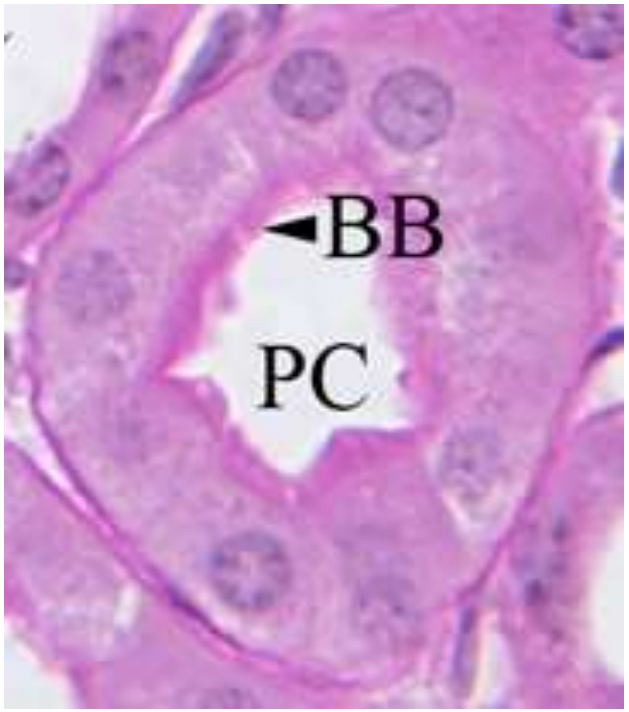
- Form part of Juxtaglomerular apparatus.

- Controls glomerular blood flow.


Lacis cells
Distal
Tubule with
Macula Densa
Afferent
Arteriole
Efferent
Arteriole
Parietal
Layer of
Renal
Corpuscle
Visceral Layer
of Renal Corpuscle
(Podocytes)
Bowman's
Space
Beginning of
Proximal Tbule

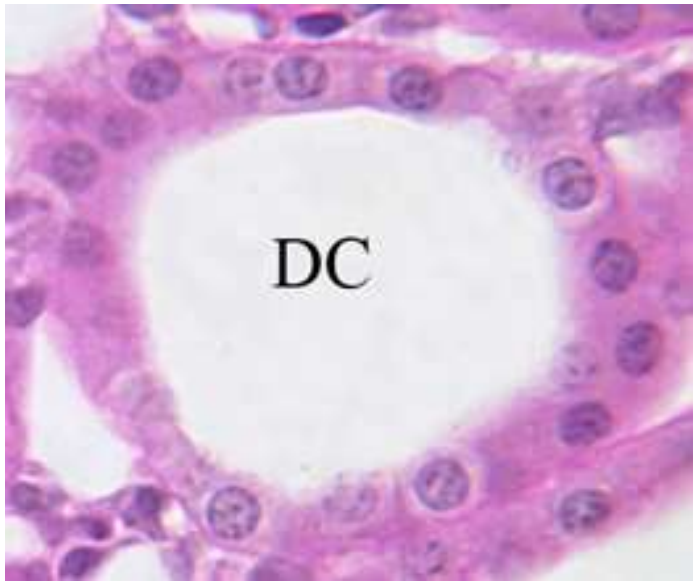
Proximal convoluted tubule

- Longer and hence, are more numerous in cortex.
- Have small and uneven lumen.
- Contains *single layer of cuboidal cells* with *eosinophilic granular cytoplasm*.
- Cell boundaries are not distinct because of extensive basal and lateral cell membrane *interdigitations* with neighbouring cells.
- Cells have microvilli on their luminal surface (*typical brush border*).

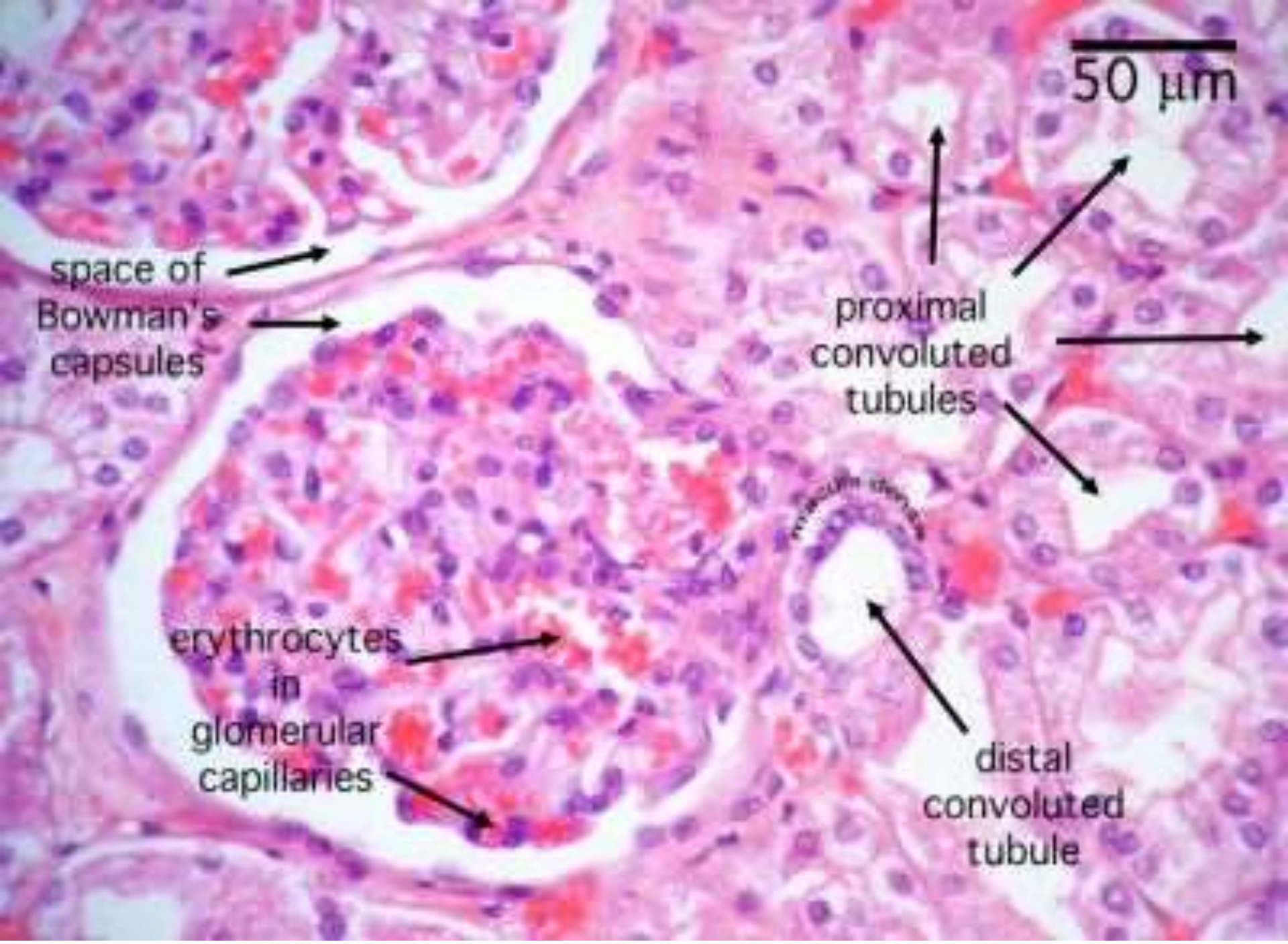


Distal convoluted tubule

- Shorter in length, therfore are few in number in cortex.
- Have larger lumen.
- Lined by *small, cuboidal cells.*
- Cytoplasm stains less intensely.
- Deep basal and lateral cell membrane infoldings and interdigitations are also present.
- Cells *lack microvilli.*



PCT	DCT
simple cuboidal epithelium	
PCTs have nuclei spaced some what farther apart than those of DCTs	DCTs have nuclei less spaced than those of PCTs
more intensely eosinophilic than those comprising distal tubules	less intensely eosinophilic than those comprising proximal tubules
brush border of microvilli (apical ends less distinct than those of DCT).	not have a brush border, although there may be scattered microvilli (apical ends more distinct than those of PCT).
may be occluded lumen	clearer lumen
Cells are extensively interdigitated → boundaries between adjacent cells are inconspicuous (i.e., in section the epithelium looks like a continuous band of cytoplasm with nuclei appearing at irregular intervals).	
Because the proximal convoluted tubule is considerably longer than the distal convoluted tubule, a typical section of the renal cortex includes many more profiles of proximal tubules than of distal tubules	


50 µm
space of Bowman's capsules
proximal convoluted tubules
erythrocytes in glomerular capillaries
distal convoluted tubule

Loop of Henle

- Thin limbs – *simple squamous epithelium.*
- Thick limbs – *cuboidal epithelium.*
- No brush border.

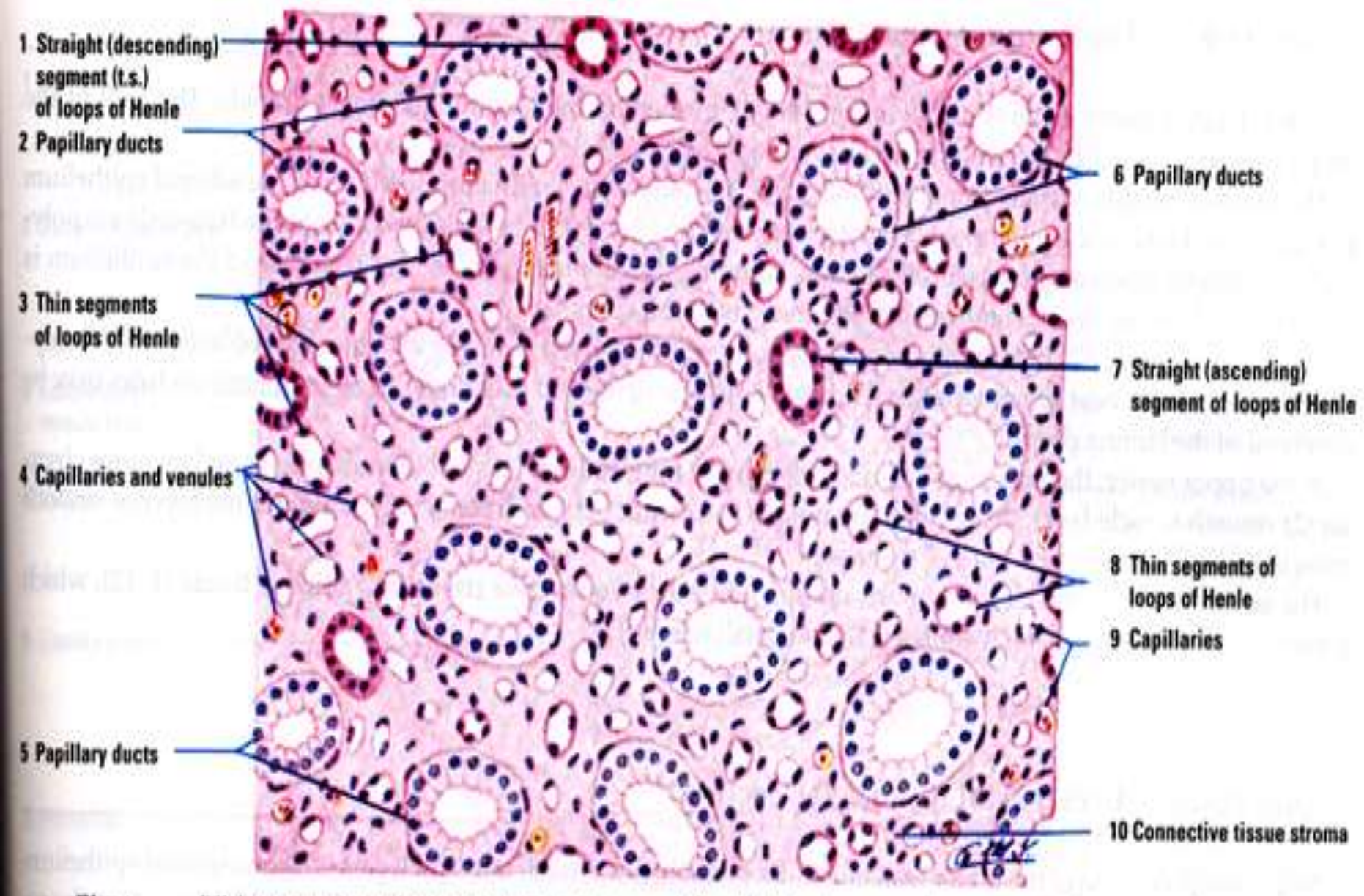


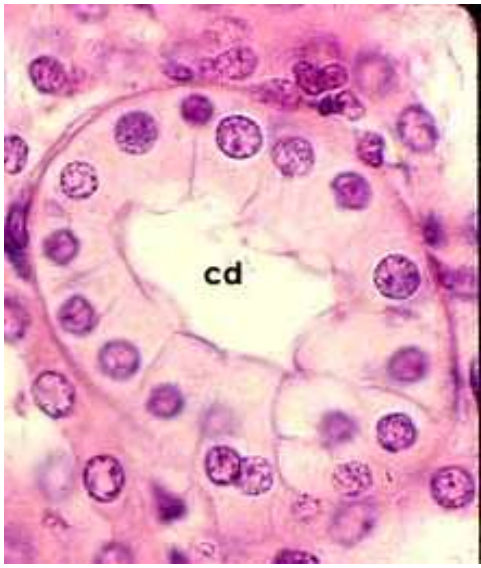
Fig. **Kidney Medulla: Papilla (transverse section).** Stain: hematoxylin-eosin. Medium magnification.

Collecting Tubule and Duct

- Drain urine from nephron to renal pelvis.

- Lie on medullary ray within cortex.

- Progressively increase in diameter towards medulla.



- Simple epithelium - *Squamous to cuboidal.*

- Cell boundaries are seen

- Two types of cells in collecting tubule and collecting duct –

  1) Light cells

  2) Dark cells

Light cells

- **Collecting duct or CD cells.**
- *Principal cells of system.*
- Pale staining cells.
- Basal infoldings present.
- Single primary cilium.
- Few short microvilli.
- Small, spherical mitochondria.
- Possess abundance of ADH regulated water channels AQP-2 → responsible for water permeability of colllecting duct.

Dark Cells

- Known as **Intercalated Cells or IC cells.**
- Less in number.
- Cytoplasm is denser.
- Many mitochondria.
- No basal infoldings.
- Basally located interdigitations with neighbouring cells.
- Numerous vesicles present in apical cytolplasm.
- Secretes H^+ or $HCO3^-$ ions.

JUXTAGLOMERULAR APPARATUS

- At the vascular pole, in tunica media of afferent glomerualr arteriole

Smooth Muscle Cells

Replaced by

Modified Epithelial Cells

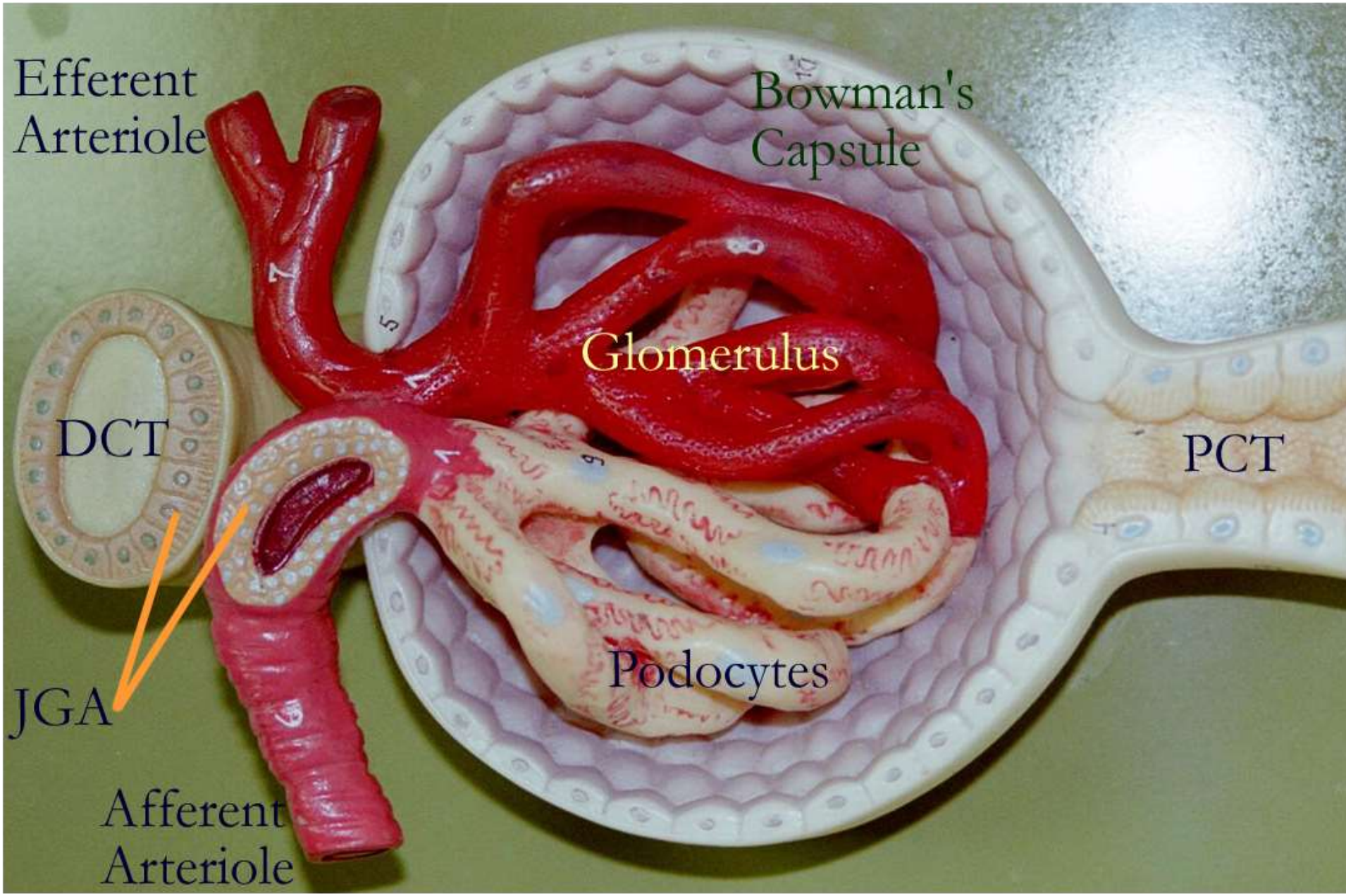
- The modified epithelial cells contains *spherical nuclei* and *cytoplasmic granules* , and are known as **JUXTAGLOMERULAR CELLS.**

In the adjacent DCT, the cells that border the J-G cells are *narrow* and *more columnar.*

This darker and more compact arrangement of cells is known as **MACULA DENSA.**

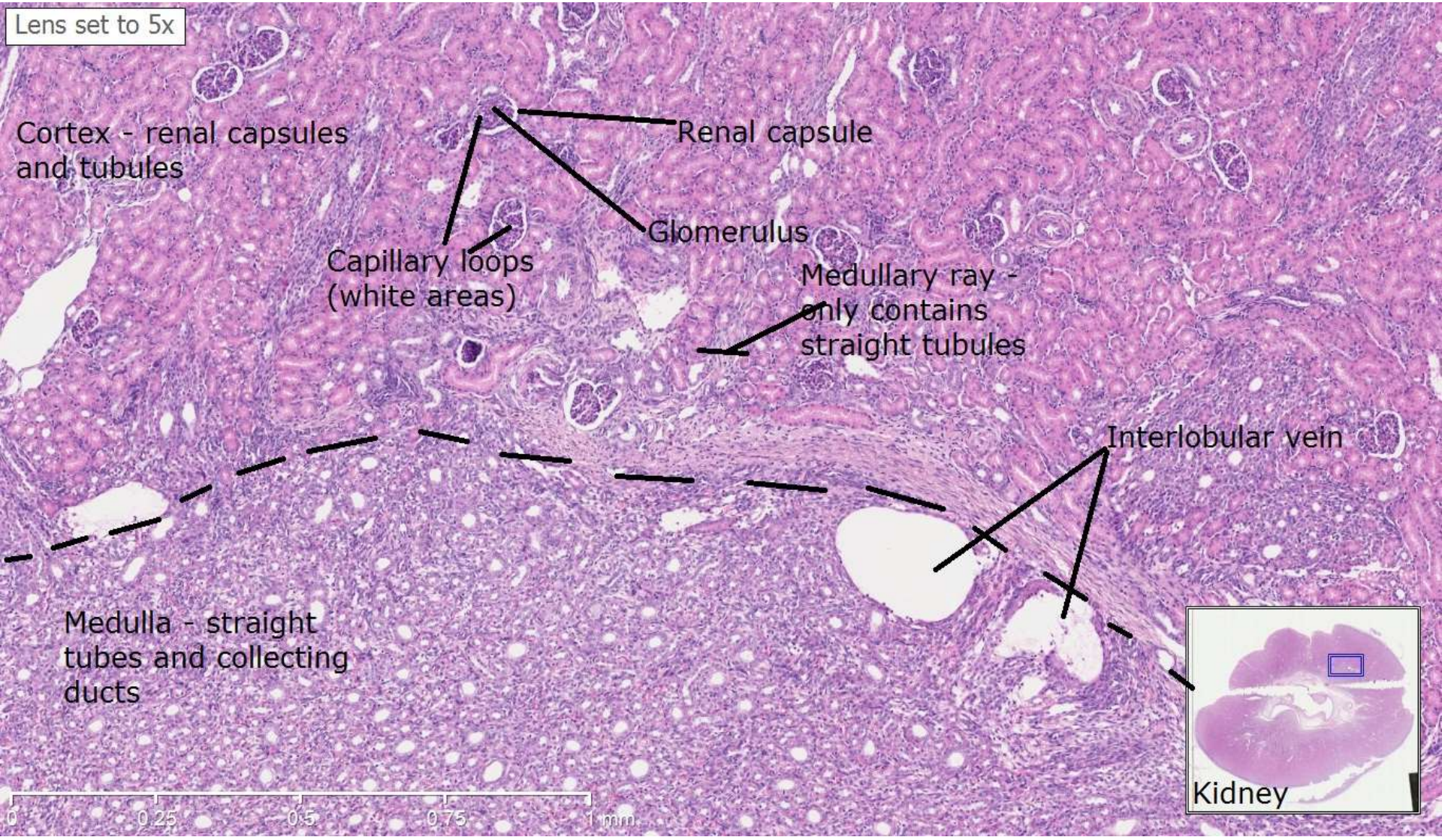
Juxtaglomerular cells + Macula densa = Juxtaglomerular Apparatus

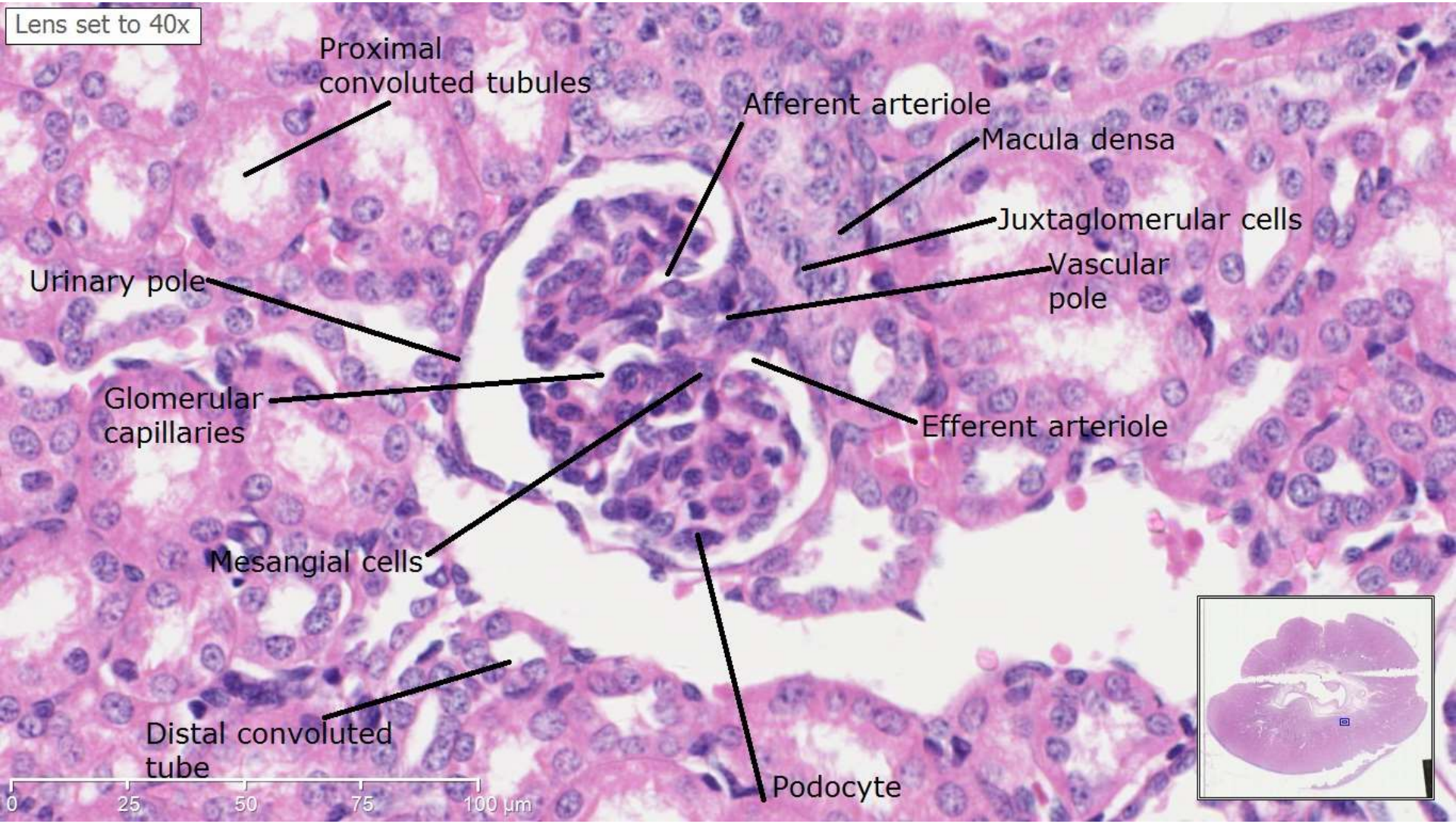
Renal Filtration: Renal Corpuscle

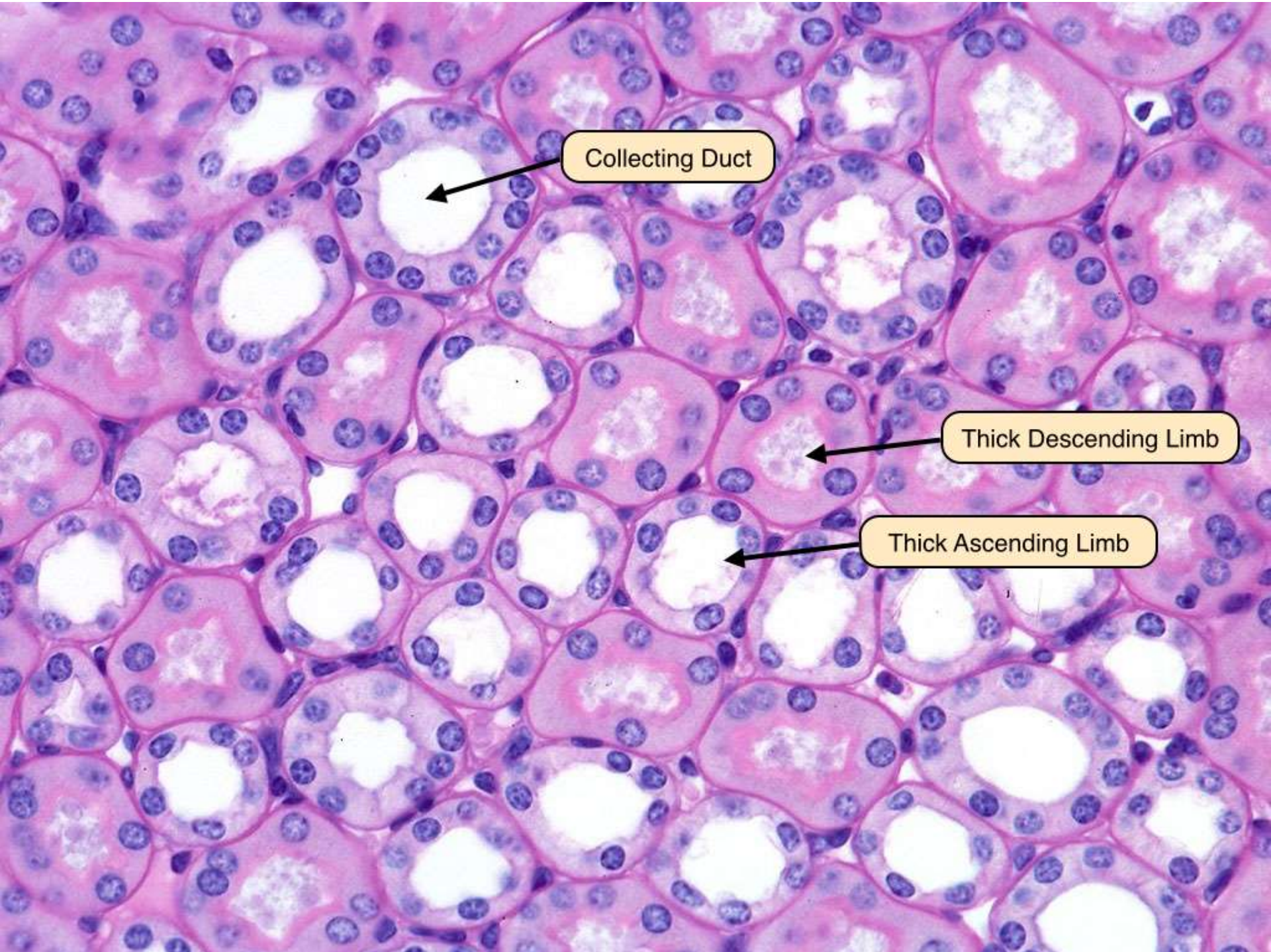


Importance of Juxtaglomerular Apparatus

- Cytoplasm of Juxtaglomerular cells contains membrane bound secretory granules of enzyme Renin.
- It maintains necessary Blood Pressure in kidney for glomerular filtration.
- Cells act as baroreceptors and chemoreceptors.


Lens set to 5x
Cortex - renal capsules and tubules
Renal capsule
Glomerulus
Capillary loops (white areas)
Medullary ray - only contains straight tubules
Interlobular vein
Medulla - straight tubes and collecting ducts
Kidney
0
0.25
0.5
0.75
1 mm


Lens set to 40x
Proximal convoluted tubules
Afferent arteriole
Macula densa
Juxtaglomerular cells
Vascular pole
Urinary pole
Glomerular capillaries
Efferent arteriole
Mesangial cells
Distal convoluted tube
Podocyte
0
25
50
75
100 µm


Collecting Duct
Thick Descending Limb
Thick Ascending Limb

References –

1) Wheater’s functional histology.

2) diFiore’s Atlas of histology.

3) Histology Atlas and Text-Ross and Pawlina.

4) Inderbir Singh’s Textbook of Histology.


thank
you!