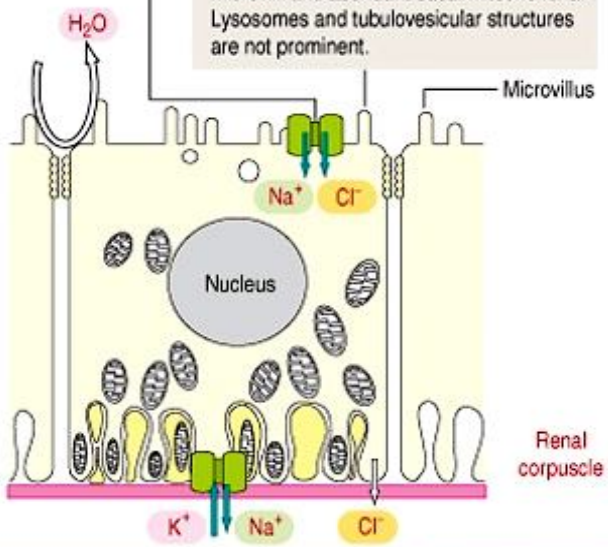
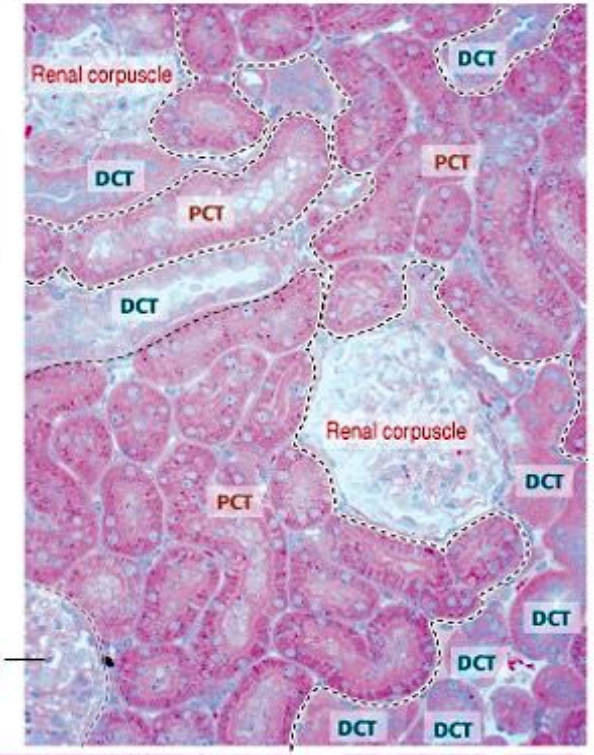
Distal convoluted tubule (DCT)

Simple Short cuboid epithelium
Large lumen
Short microvillus
No brush border
Base: basal ridge + mitochondria
Macula densa

A **symport mechanism** (coupled transport of two or more solutes in the same direction) enables the reabsorption of NaCl. The DCT is impermeable to water.

Distal convoluted tubular cells have short microvilli and abundant basal mitochondria. Lysosomes and tubulovesicular structures are not prominent.





Renal corpuscle

Identification parameters of PCTs and DCTs

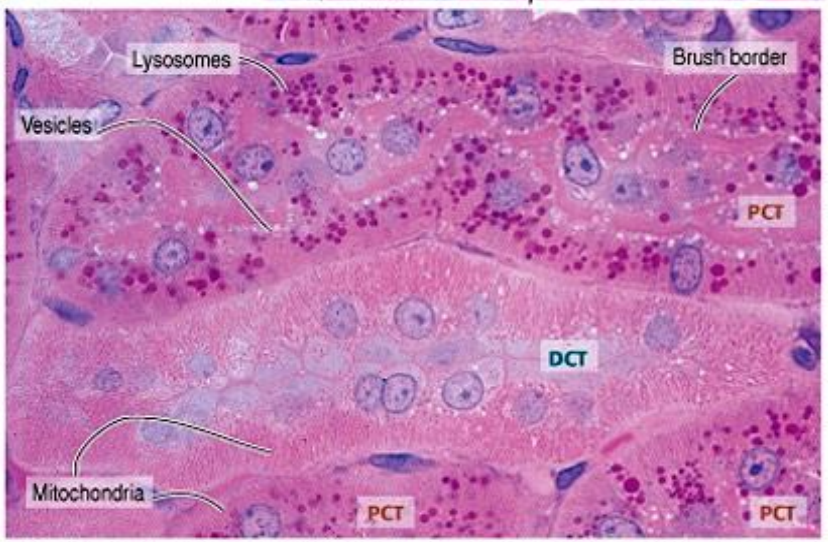
The identification of proximal convoluted tubules (PCTs) and DCTs is facilitated by the following parameters:

1. Both are adjacent to renal corpuscles.

2. PCTs contain cells with abundant **lysosomes** (stained dark in both light microscope illustrations).

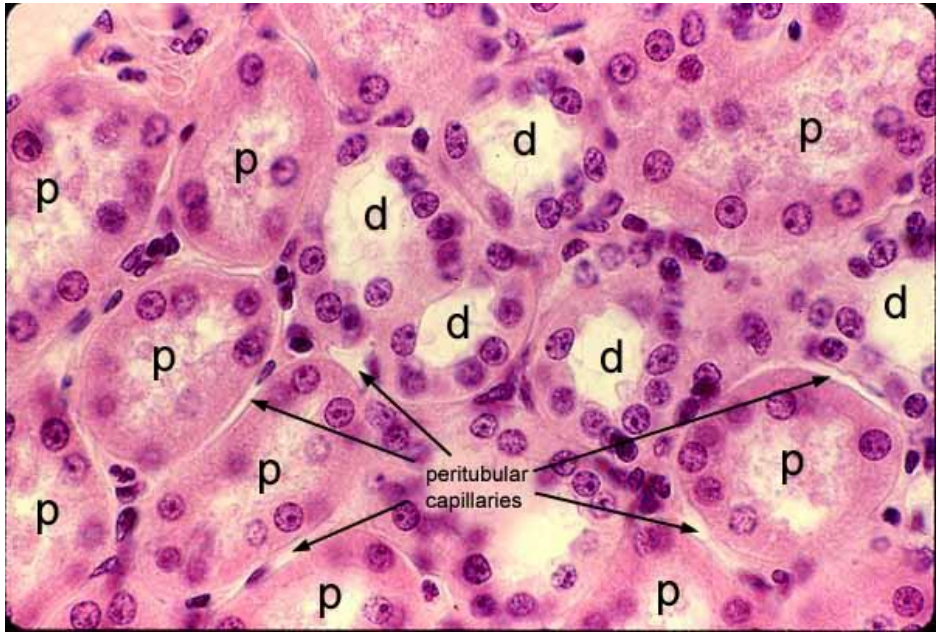
3. The **apical domain** of PCTs has a prominent **brush border (microvilli)** and **vesicles**. In contrast, the apical domain of DCTs has sparce microvilli and vesicles.

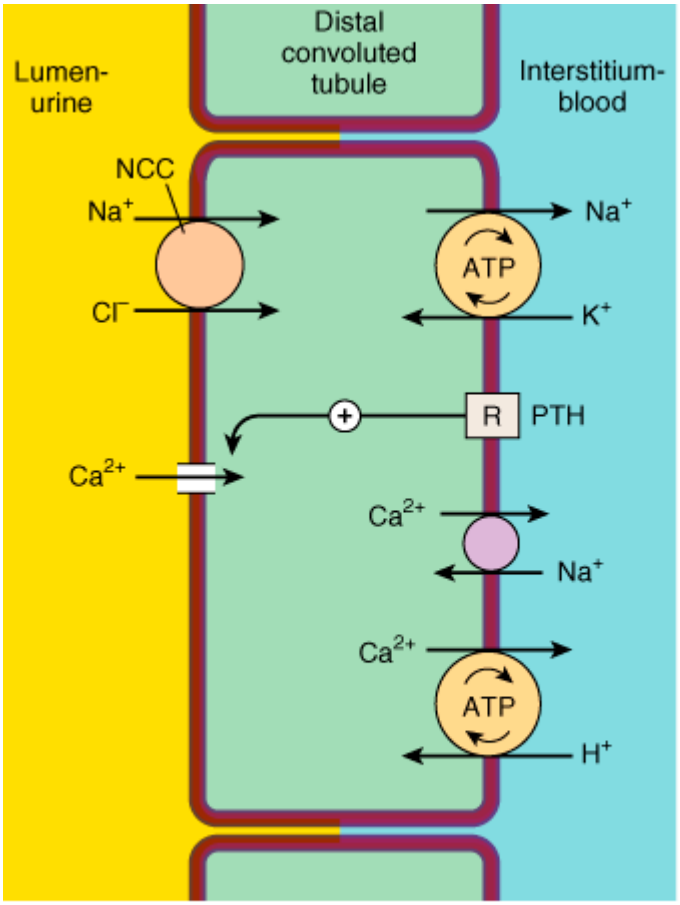
4. Cells lining the PCTs and DCTs contain abundant basally located **mitochondria**.



Distal convoluted tubule (DCT) functions:

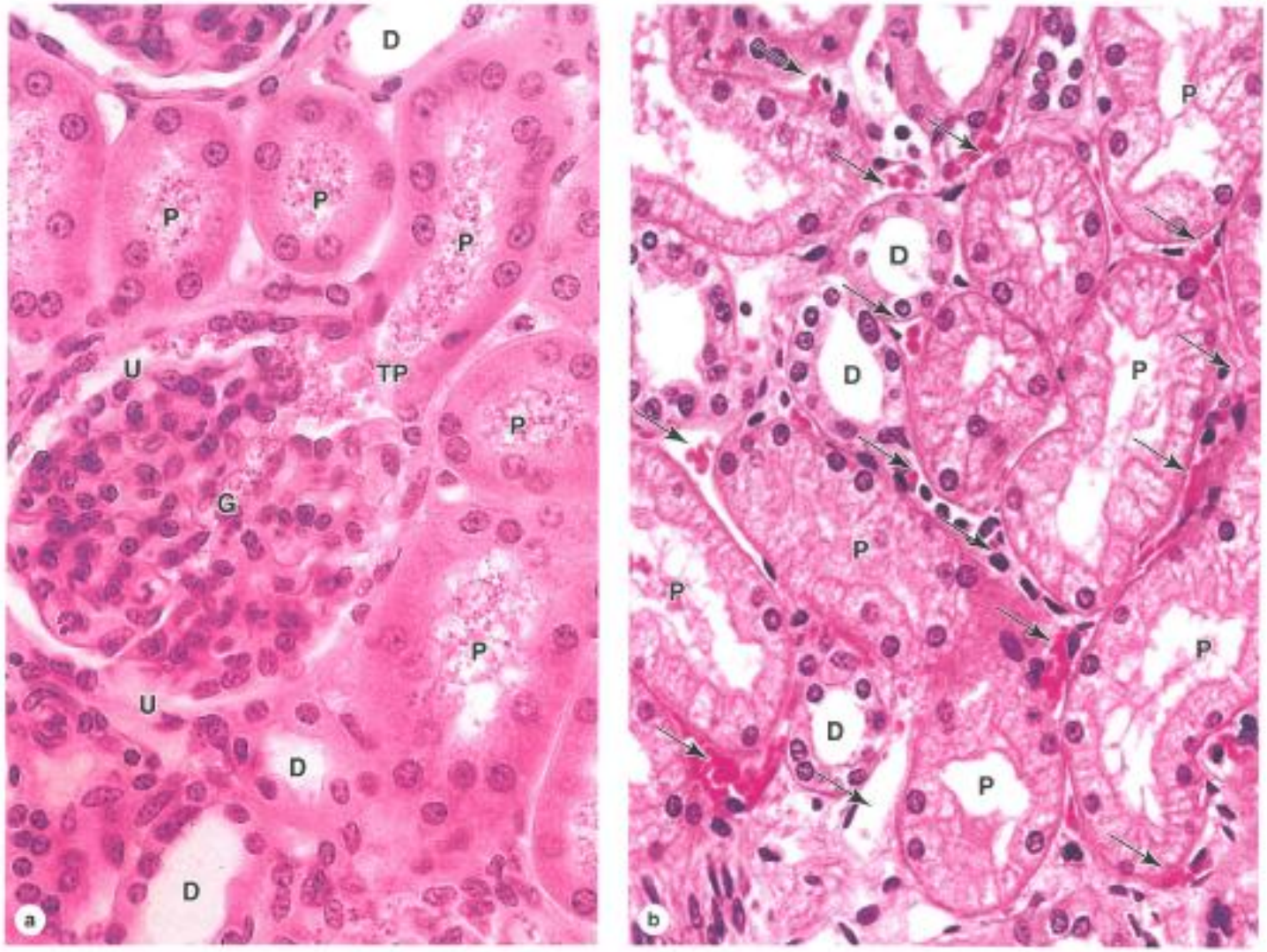
Reabsorbtion of Na+ / water (by aldestron)
Reabsorbtion of bicarbonate
Reabsorbtion of Ca+
Secretion of hydrogen / ammonium (acid-base balance)
Secretion K+





Source: Katzung BG, Masters SB, Trevor AJ: *Basic & Clinical Pharmacology, 11th Edition:* http://www.accessmedicine.com

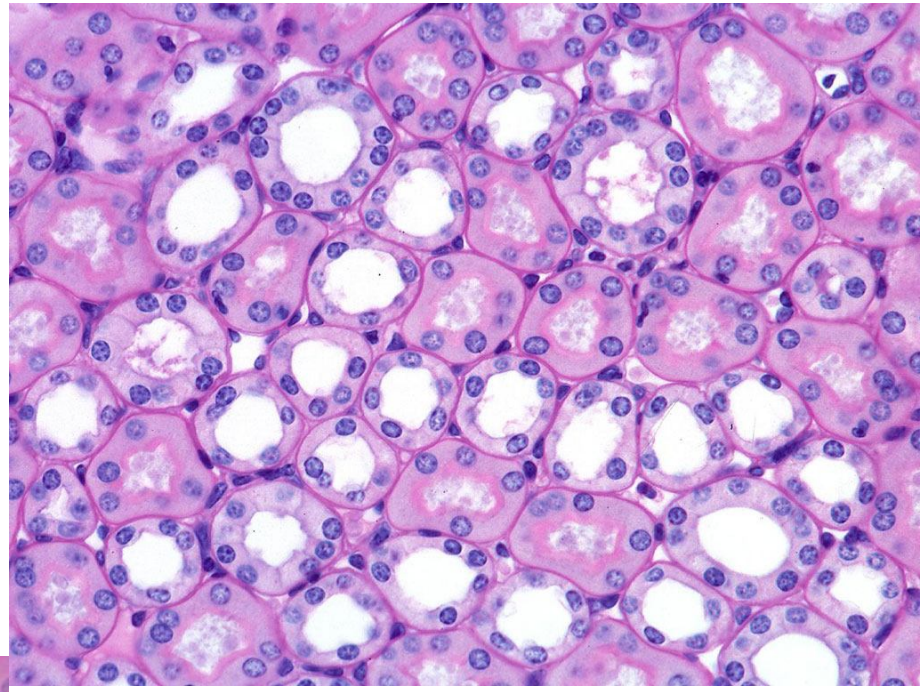
FIGURE **19–8** **Renal cortex: proximal and distal convoluted tubules.**

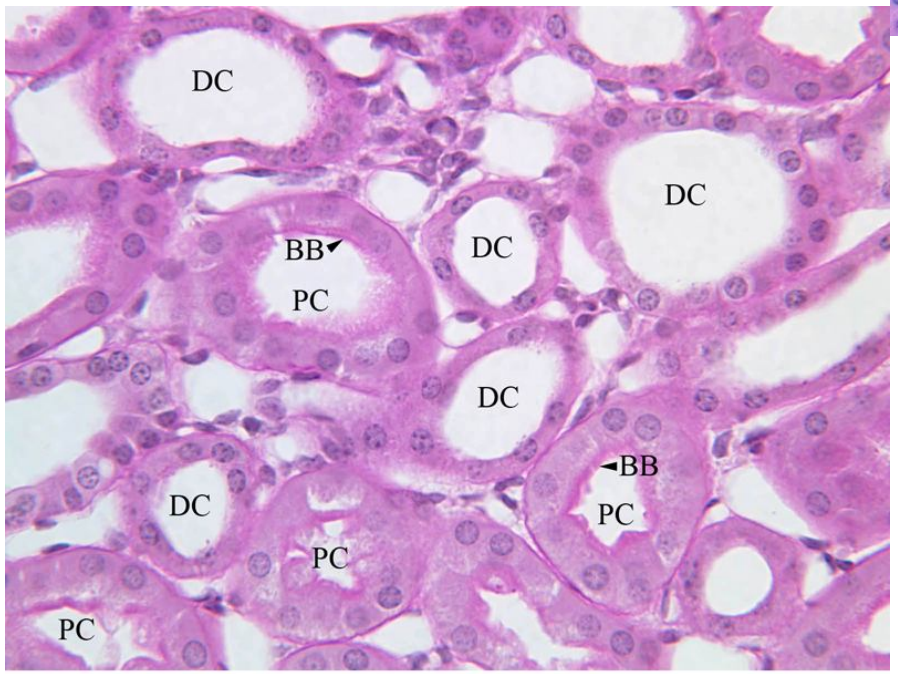


(a) The micrograph shows the continuity at a renal corpuscle's tubular pole (**TP**) between the simple cuboidal epithelium of a proximal convoluted tubule (**P**) and the simple squamous epithelium of the capsule's parietal layer. The urinary space (**U**) between the parietal layer and the glomerulus (**G**) drains into the lumen of the proximal tubule. The lumens of the proximal tubules appear filled, because of the long microvilli of the brush border and aggregates of small plasma proteins bound to this structure. By contrast, the lumens of distal convoluted tubules (**D**) appear empty, lacking a brush border and protein.

(b) Here the abundant peritubular capillaries and draining venules (arrows) that surround the proximal (**P**) and distal (**D**) convoluted tubules are clearly seen. Both X400. H&E.

PCT & DCT





DC - distal convoluted tubule PC - proximal convoluted tubule BB - brush border

Collecting tubule/duct

Chief cell:

Cuboid / light cytoplasm / basal ridge / apical single cilia /

Intercalated or dark cell:

Dark cuboid / apical microvillus / mitochondria

Collecting tube – collecting duct – duct of bellini (area cribrosa) – minor calyxes

Single cilia in chief cell:

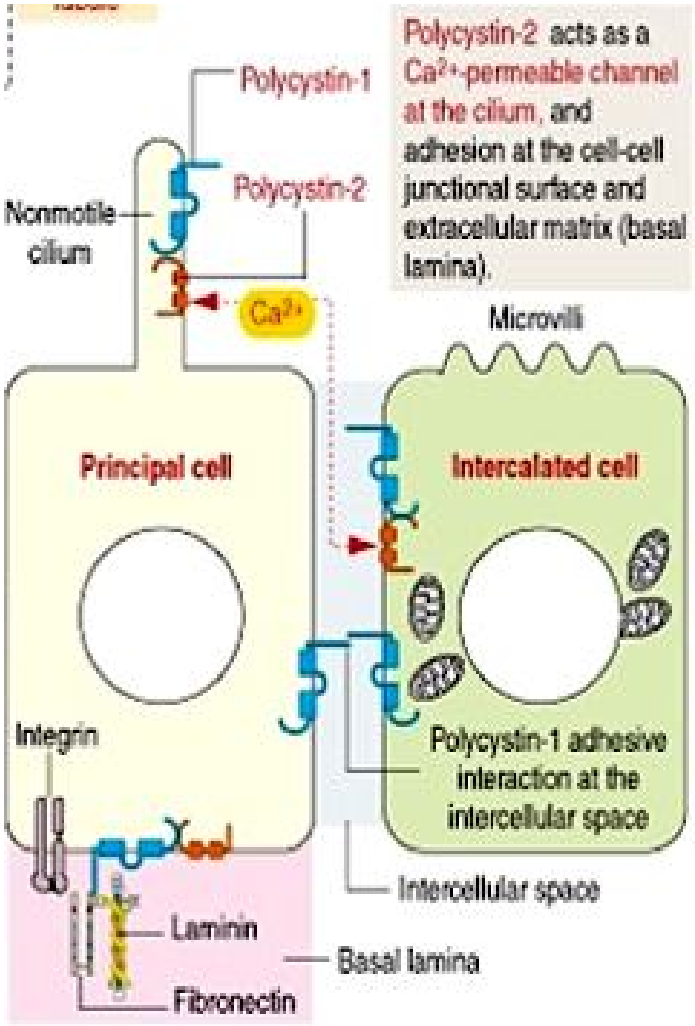
Have polycystin protein

Functions:

Ca+ channel

Adhesion protein in cell to cell junction

Attach cell to basal membrane

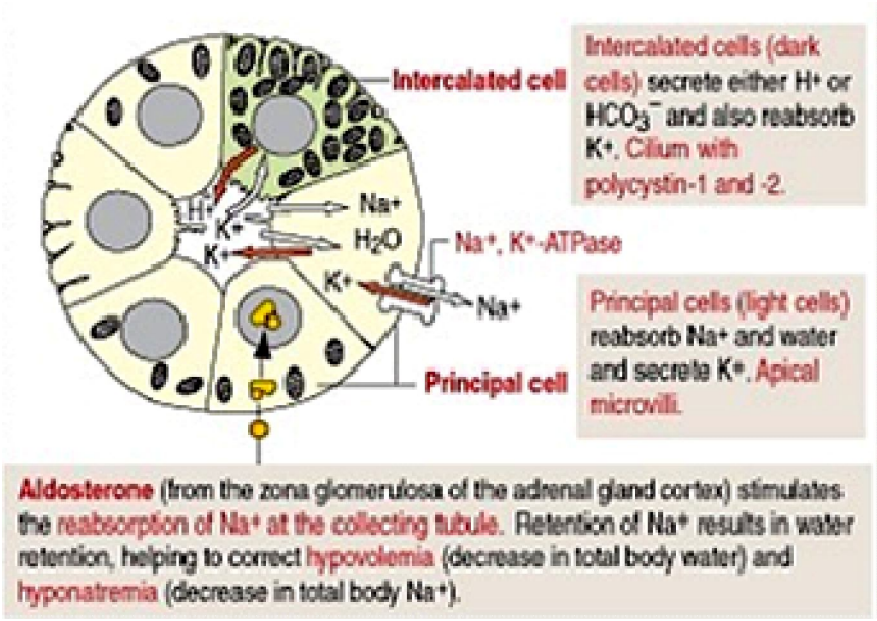


Chief cell :

Reabsorption Na+ / water
Secretion K+

Dark cell :

Reabsorption K
Secretion H+ / HCO3



Collecting tubule/duct

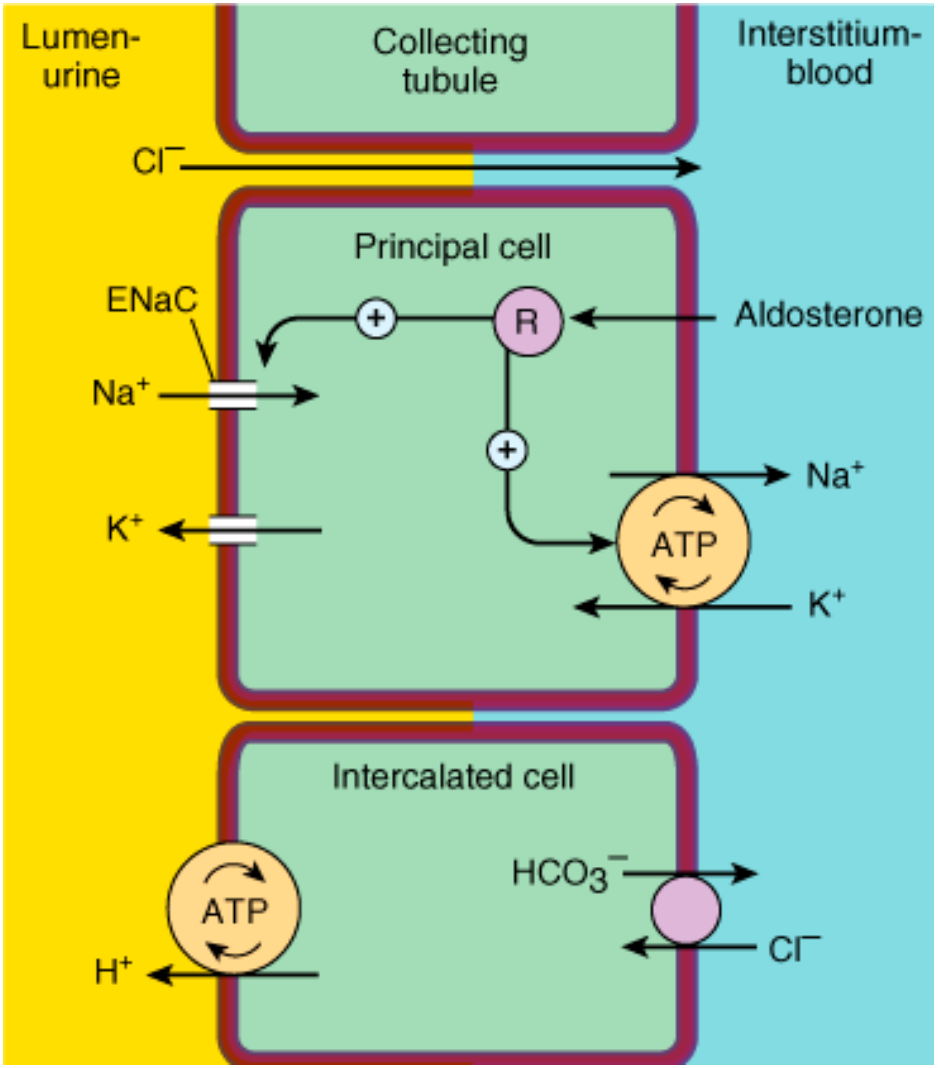


FIGURE **19–11** **Renal medulla: nephron loops and collecting ducts.**

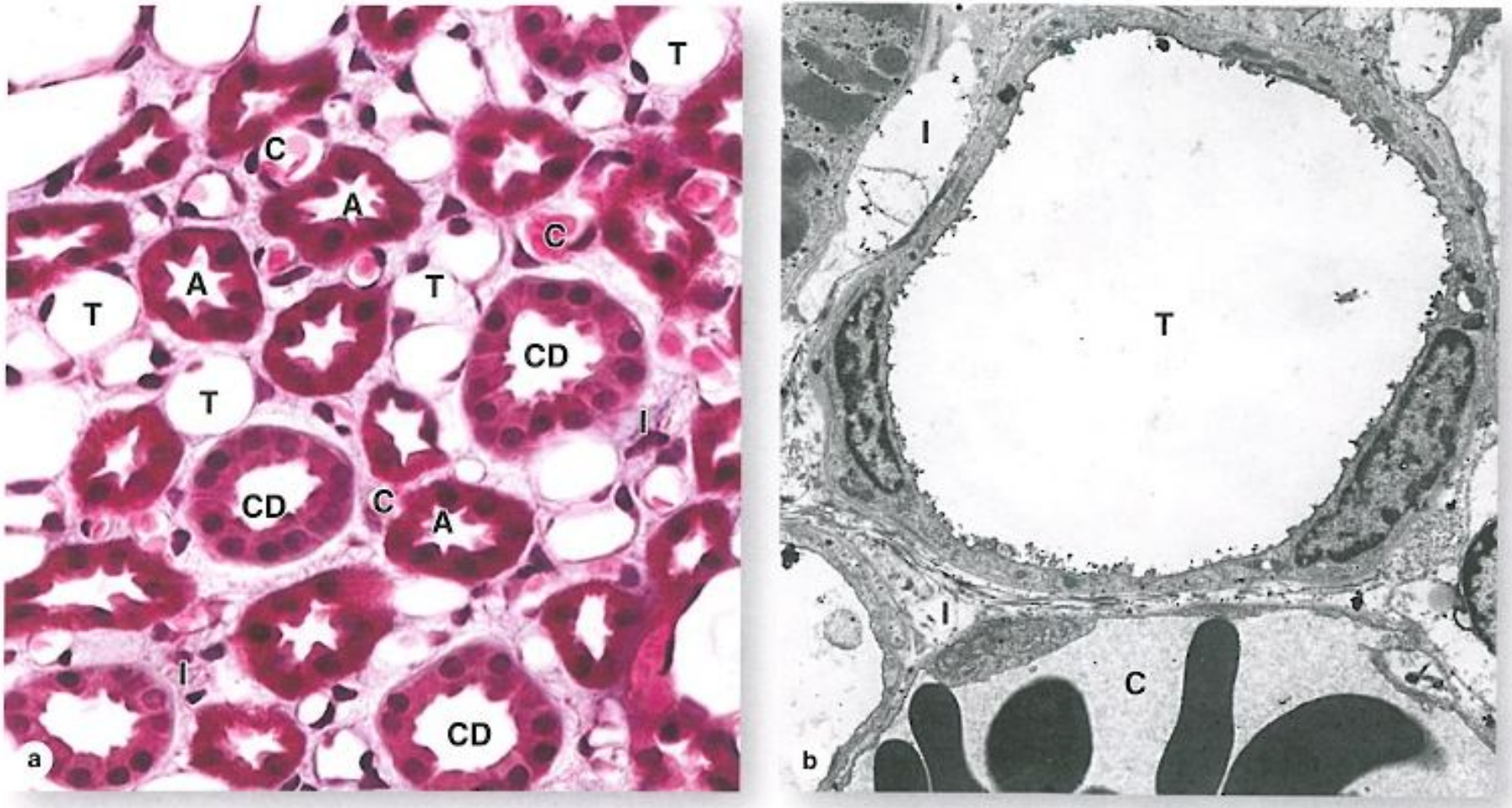


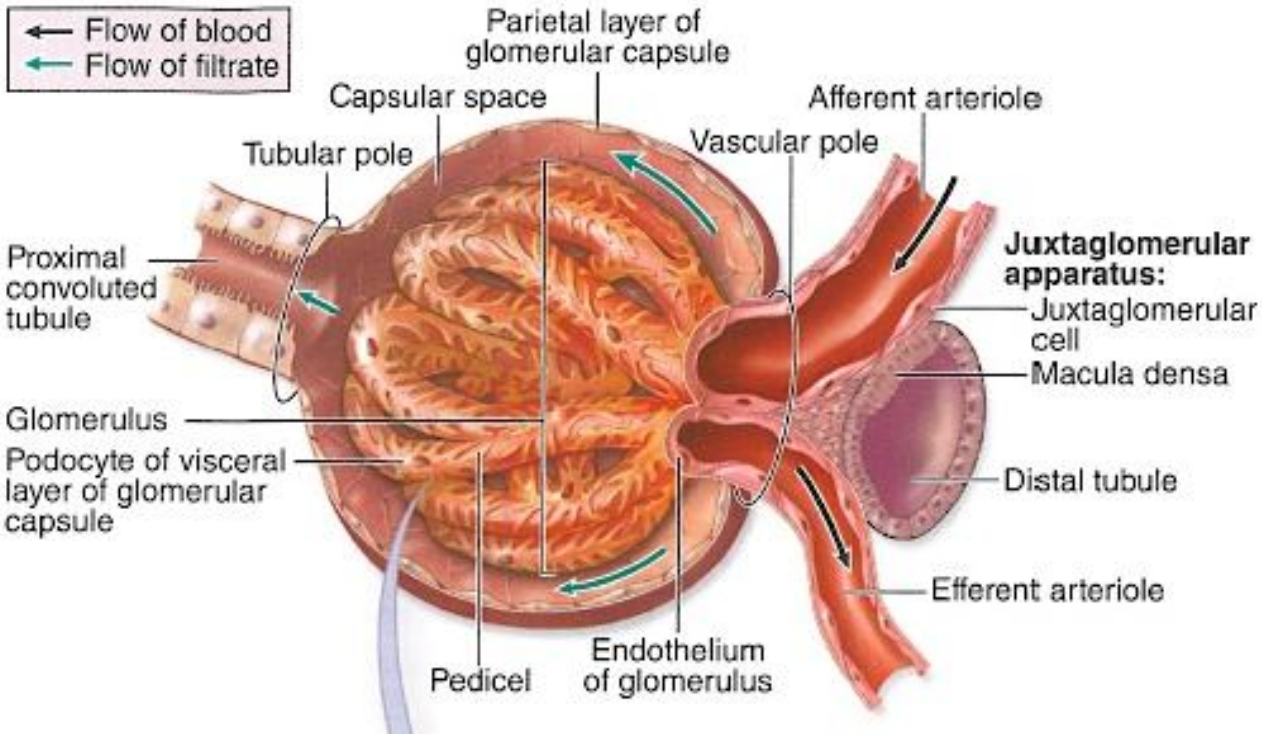
FIGURE **19–14** **Collecting ducts.**

Pale-staining columnar **principal cells**, in which ADH-regulated aquaporins of the cell membrane allow more water reabsorption, are clearly seen in these transversely sectioned collecting ducts (**CD**), surrounded by interstitium with vasa recta (**VR**). X600. PT.

Juxtaglomerular apparatus

Located in vascular pole
Consist of 3 parts:

Macula densa
Juxtaglomerular cell
External mesangial cell

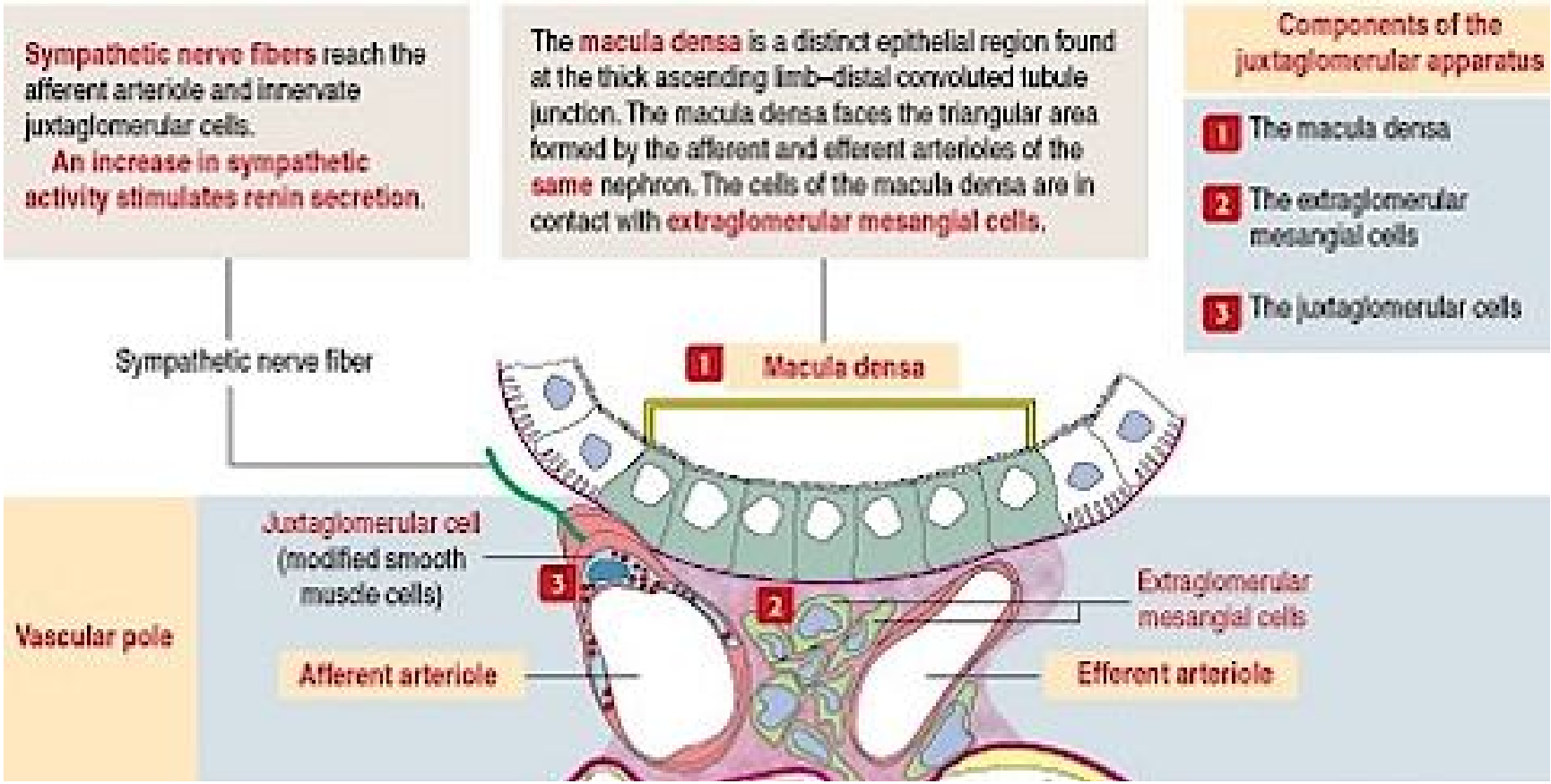


Juxtaglomerular apparatus

Macula densa:

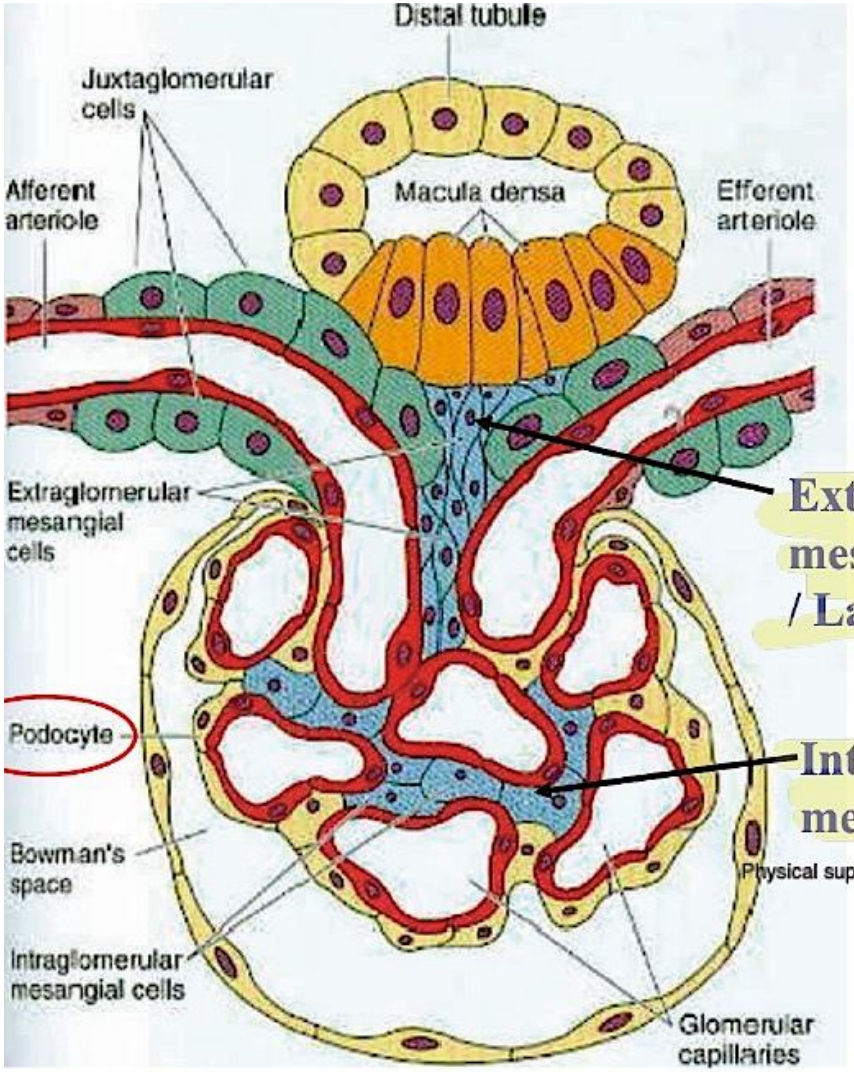
Modified cell of DCT
Located around afferent arteriole
Long / dark cell
Central or apical nucleus
Apical microvillus

susceptible to low Na+ concentration



Functions:

Renin secretion / angiotensin I to angiotensin II convertor enzyme



Juxtaglomerular cells:

Modified smooth muscle cells of afferent arteriole
Round nucleus
Secretory granules in cytoplasm
Rough ER / Golgi

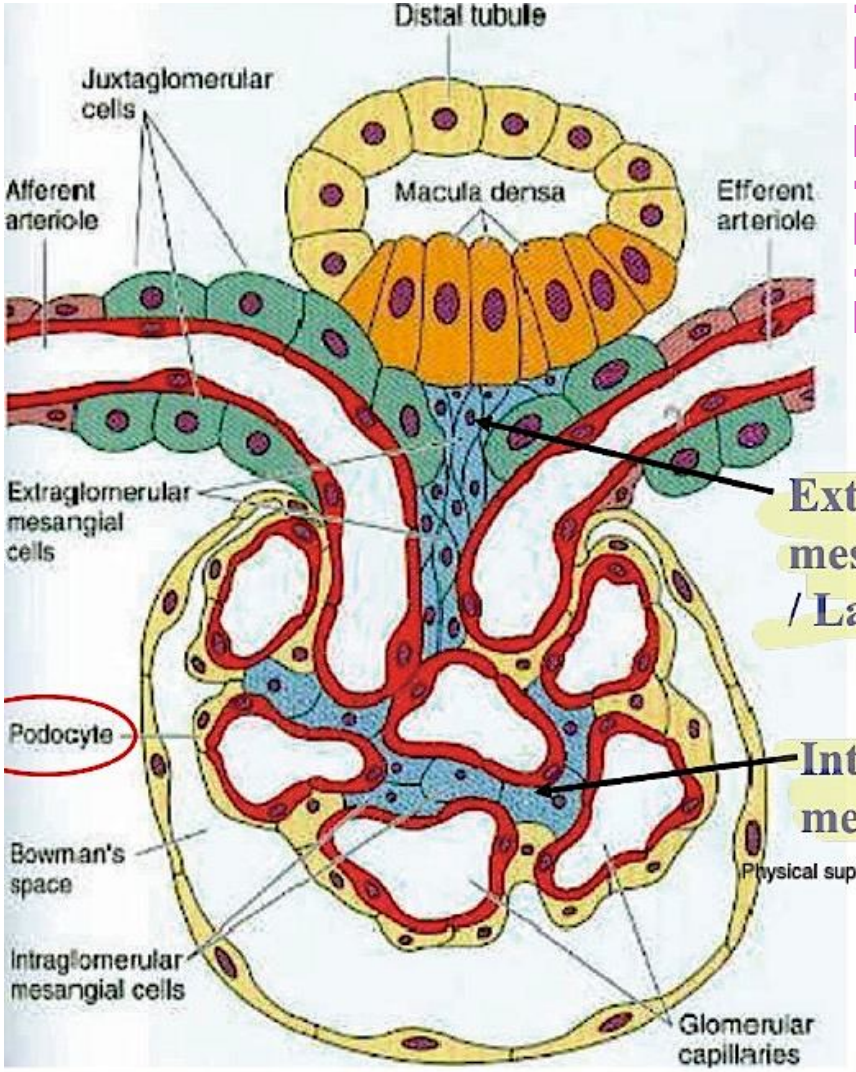
Juxtaglomerular apparatus

External mesangial cell: ***polkissen / lacis cells***

Occupied space between
afferent & efferent arterioles & macula densa

Functions:

Not clear / **external glomeruli mesangial** /
Secretion of **erythropoietin** probably /
Supporting + contractile



Extraglomerular mesangial cells / Lacis cells

Intraglomerular mesangial cells

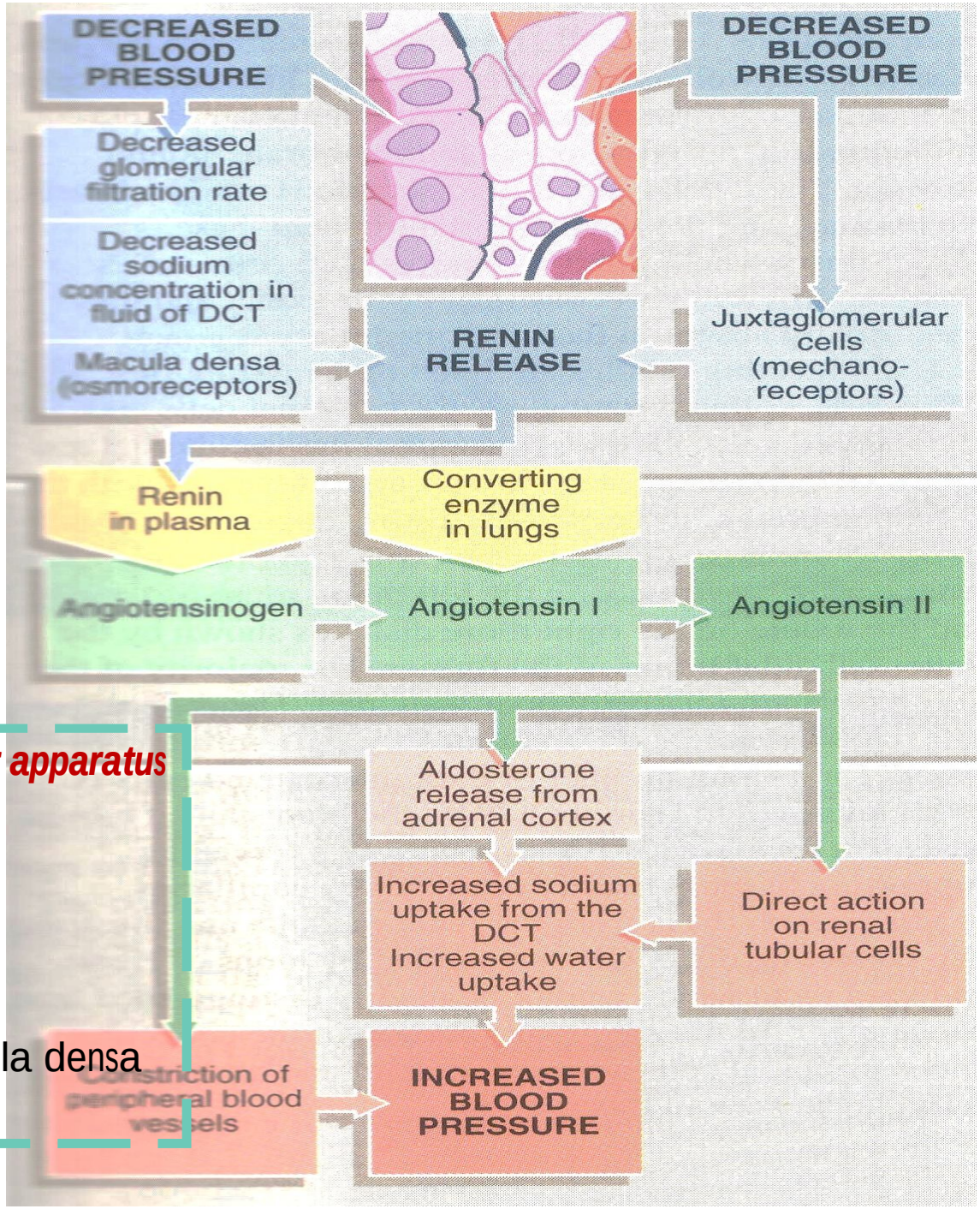
Physical support for the capillary loops

Stimulatory factors of Juxtaglomerular apparatus :

extracellular hypovolemic

↓ BP

decreased Na+ concentration in macula densa



Renin-angiotensin-aldosterone system

Angiotensin II functions:

➢Smooth muscle of arteriole = vasoconstriction
➢Adrenal gland = aldosterone secretion =
Reabsorption Na+ in 3 zones:

Thick segment of ascending loop of Henle
DCT
Collecting tubule

➢Hypothalamus = ADH secretion = water reabsorption
In Collecting tubule

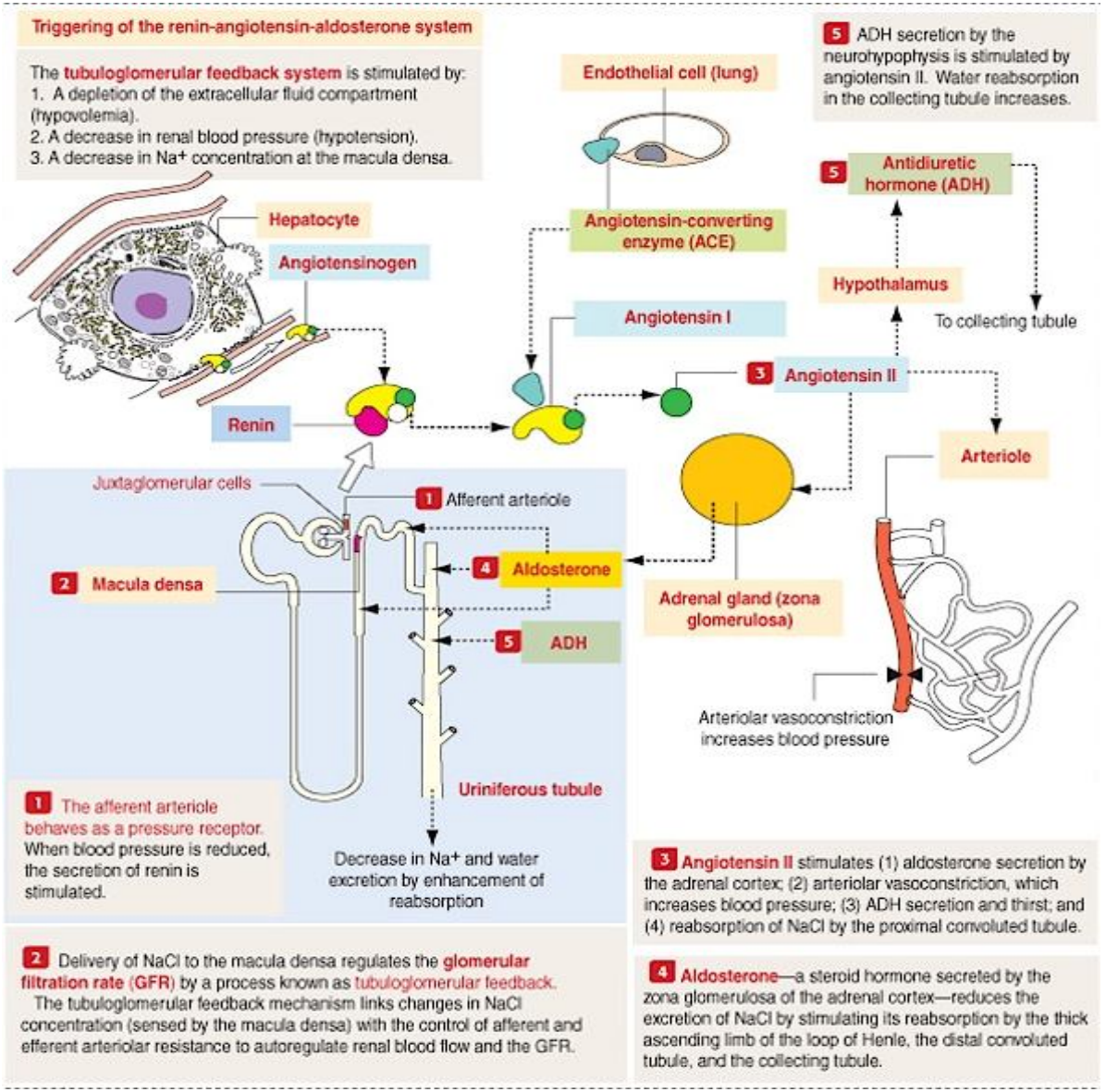
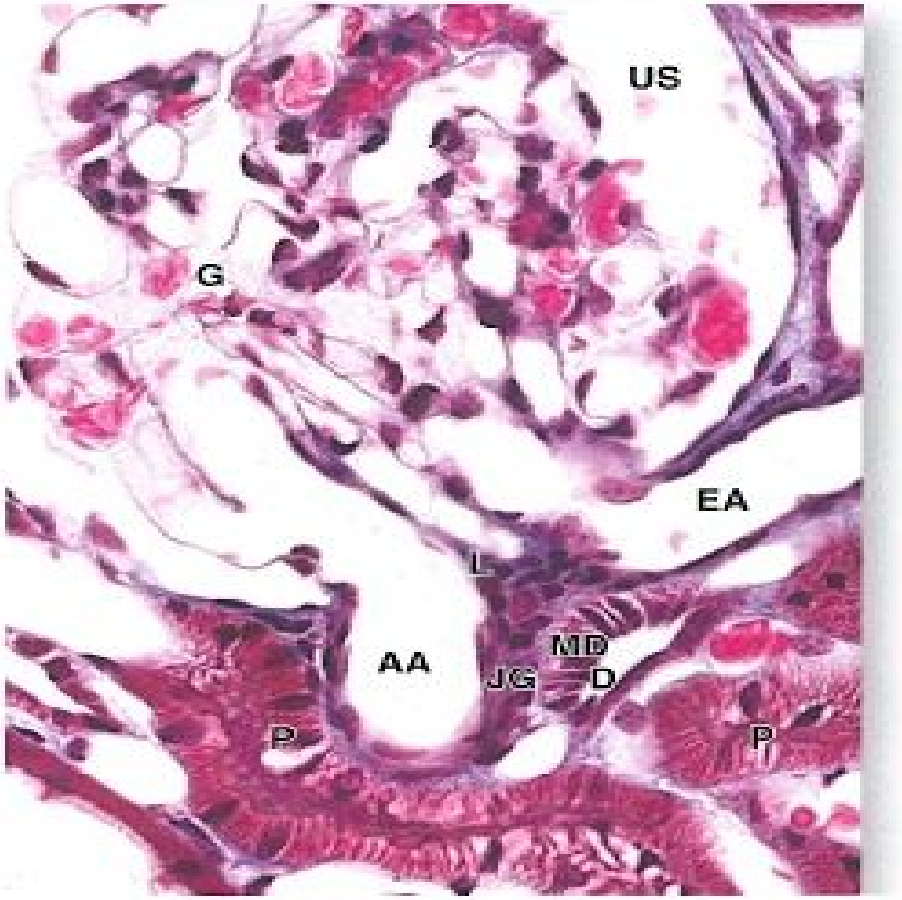


FIGURE 19–12 Juxtaglomerular apparatus (JGA).



The JGA forms at the point of contact between a nephron's distal tubule (**D**) and the vascular pole of its glomerulus (**G**). At that point cells of the distal tubule become columnar as a thickened region called the macula densa (**MD**). Smooth muscle cells of the afferent arteriole's (**AA**) tunica media are converted from a contractile to a secretory morphology as juxtaglomerular granule cells (**JG**). Also present are lacis cells (**L**), which are extraglomerular mesangial cells adjacent to the macula densa, the afferent arteriole, and the efferent arteriole (**EA**). In this specimen the lumens of proximal tubules (**P**) appear filled and the urinary space (**US**) is somewhat swollen. X400. Mallory trichrome.

Renal interstitium:

Located between tubules / ducts / vessels in cortex and medulla

In cortex:

✓Fibroblast like cell (renal architecture / secretion erythropoietin)

✓Macrophage

In medulla:

❖Fibroblast

❖Macrophage

❖Interstitial cell: long nucleus / fat droplet /
secretion medullipin I (vasodilator) / convert to medullipin II in liver

Renal circulation

Vasa recta (artery) = continues epithelium
Vasa recta (vein) = fenestrated epithelium

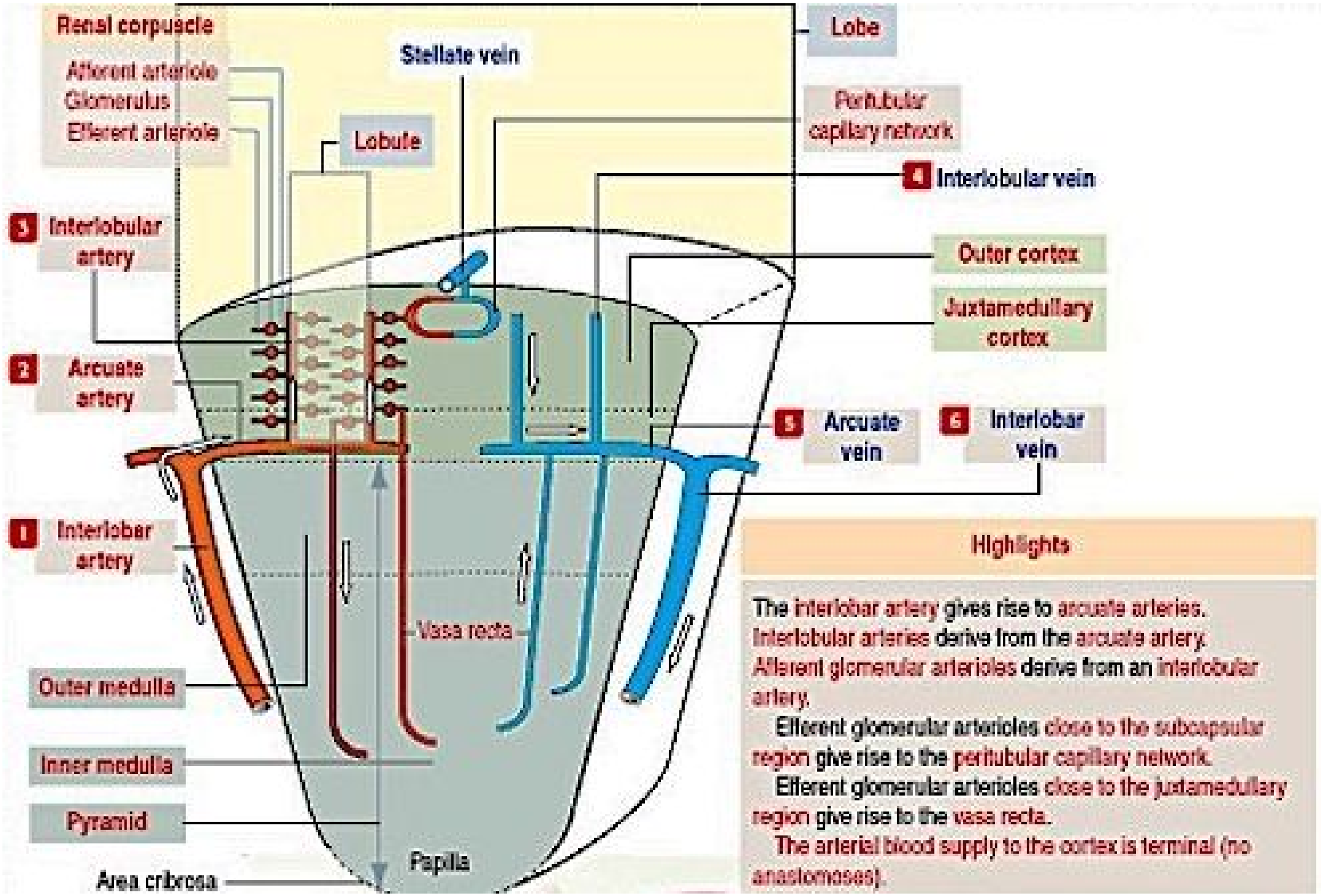
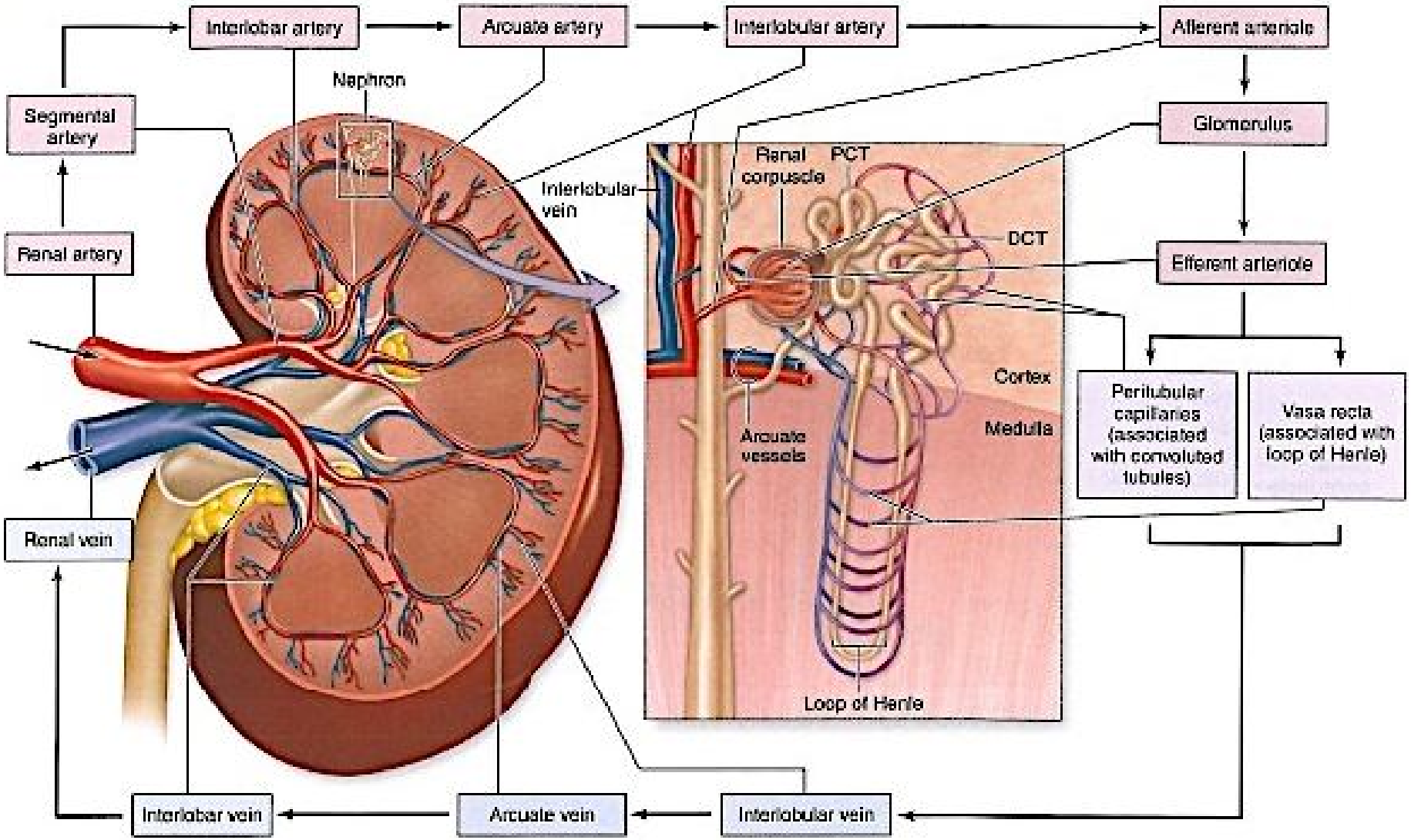
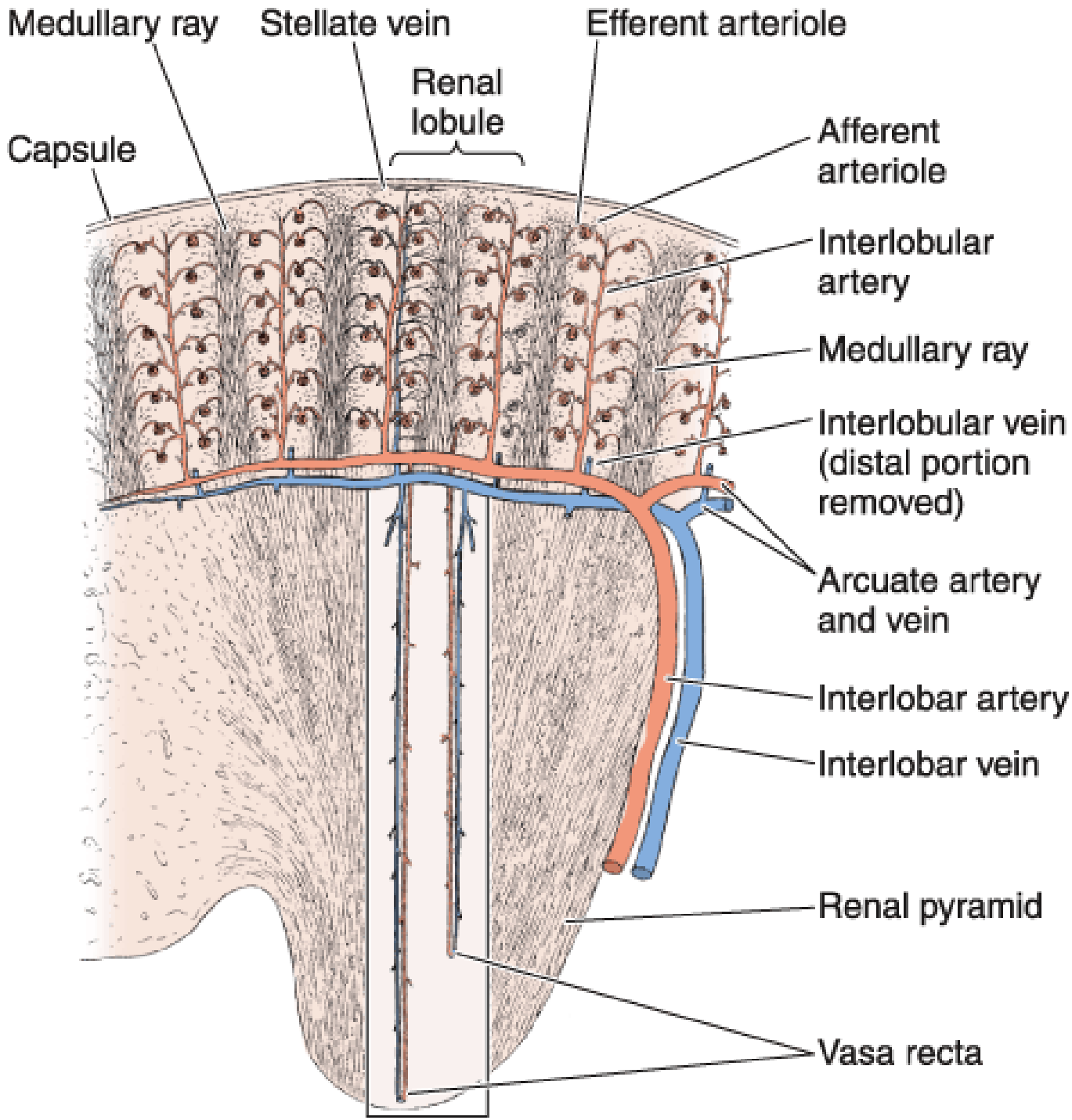


FIGURE 19–3 Blood supply to the kidneys.

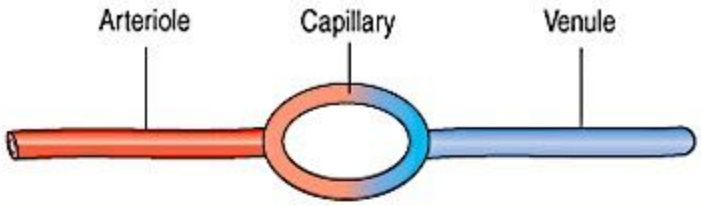


A coronal view (left) shows the major blood vessels diagrammatically, with their names. An expanded diagram (right) includes the microvascular components extending into the cortex, and medulla from the interlobular vessels are shown on the right. Pink boxes indicate vessels with arterial blood and light blue indicate the venous return. The intervening lavender boxes and vessels are intermediate sites where most reabsorbed material reenters the blood.


Medullary ray
Stellate vein
Efferent arteriole
Renal lobule
Capsule
Afferent arteriole
Interlobular artery
Medullary ray
Interlobular vein (distal portion removed)
Arcuate artery and vein
Interlobar artery
Interlobar vein
Renal pyramid
Vasa recta

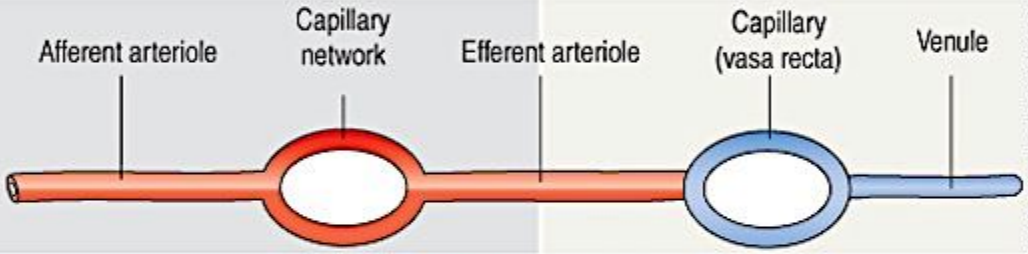
Arterial and venous portal systems

In general, a capillary network is interposed between an arteriole and a venule.



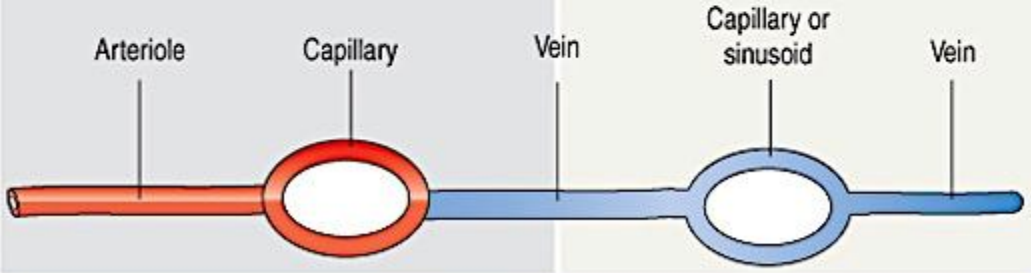
Typical arrangement

In the kidney, an arteriole is interposed between two capillary networks. An afferent arteriole gives rise to a mass of capillaries, the **glomerulus**. These capillaries coalesce to form an efferent arteriole, which gives rise to capillary networks (peritubular capillary network and the vasa recta) surrounding the nephrons.



Arterial portal system

In the liver and hypophysis, veins feed into an extensive capillary or sinusoid network draining into a vein. This distribution is called the **venous portal system**.



Venous portal system

Calyces / pelvis / ureter / urinary bladder epithelium:

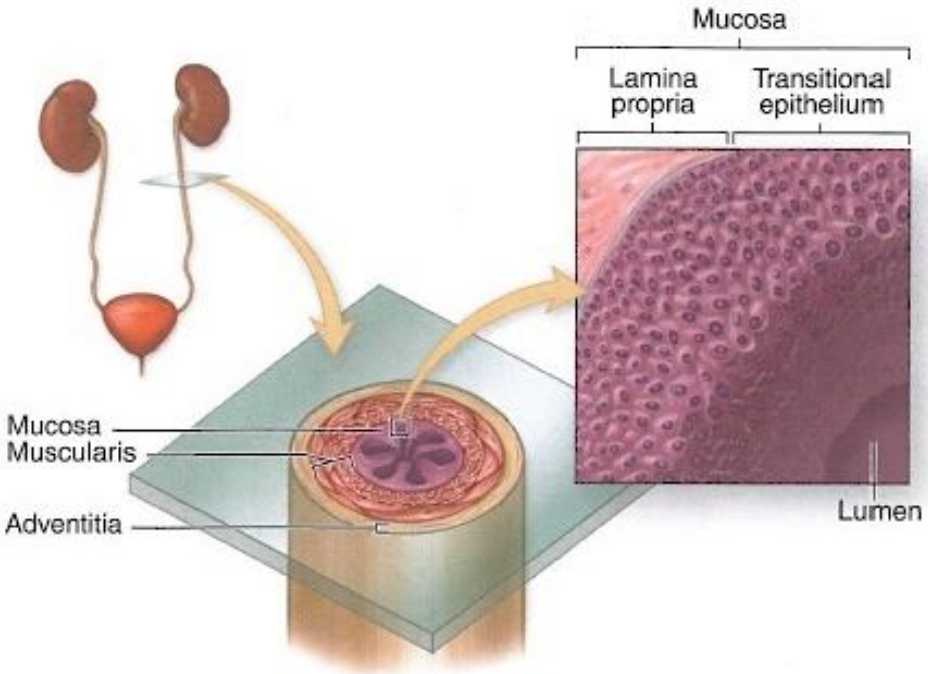
Mucosa:

Calyces & pelvis = 2-3 layers
Ureter = 4-5 layers
Bladder = 6-8 layers

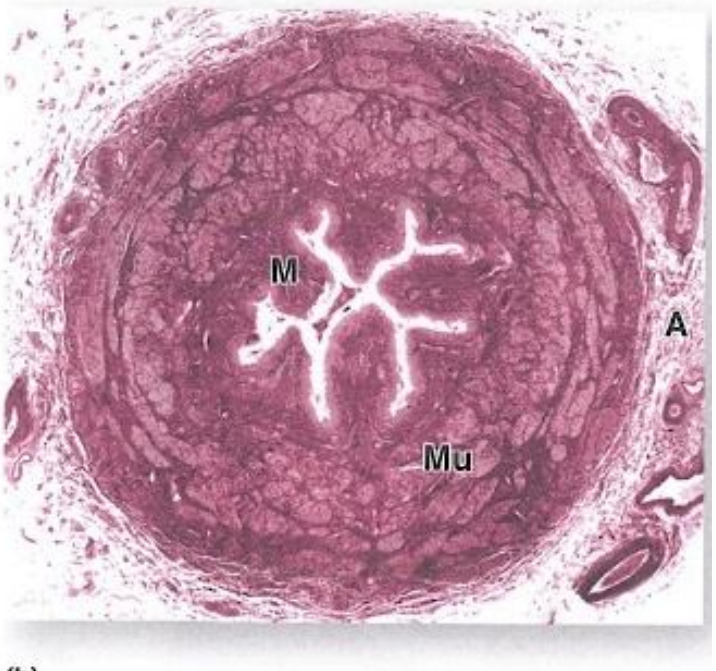
Muscularis :

Sup. 2/3 of ureter = circular / longitudinal
Inf. 1/3 of ureter & bladder = longitudinal / circular / longitudinal

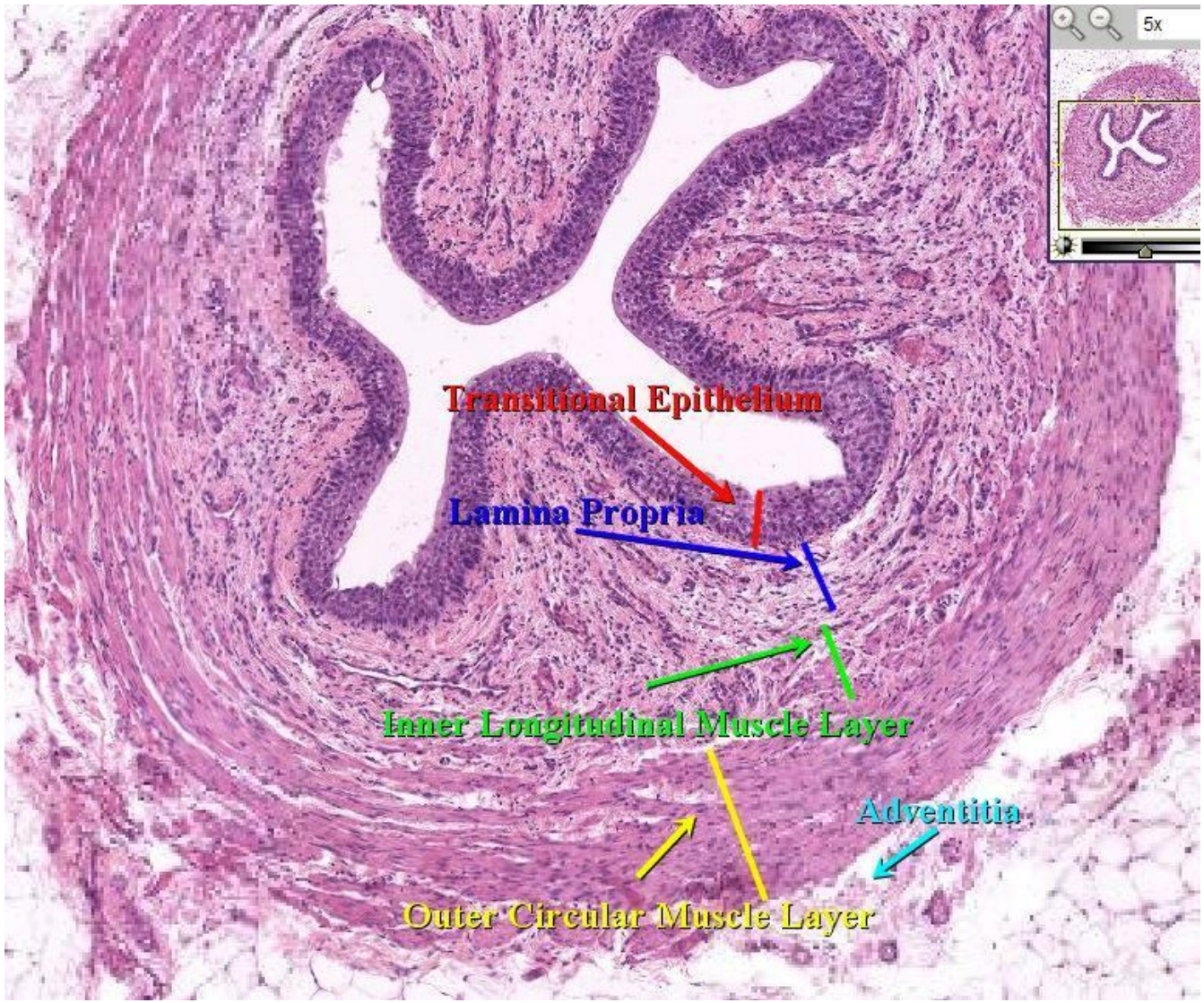
Adventitia : dense connective tissue / renal capsule continued



(a) Ureter cross section



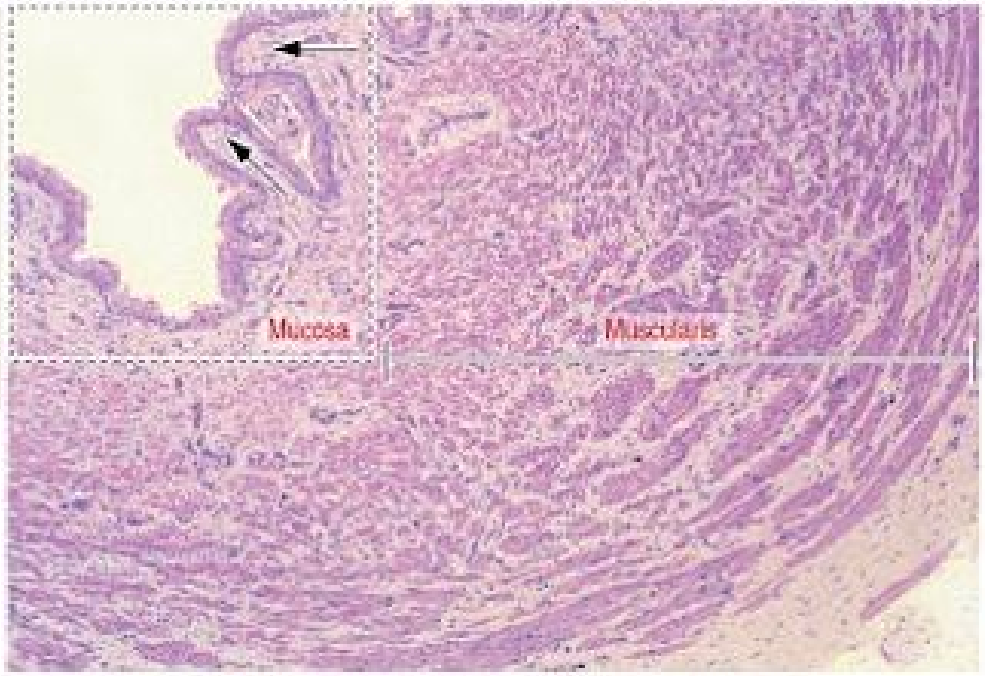
(b)


5x
Transitional Epithelium
Lamina Propria
Inner Longitudinal Muscle Layer
Adventitia
Outer Circular Muscle Layer

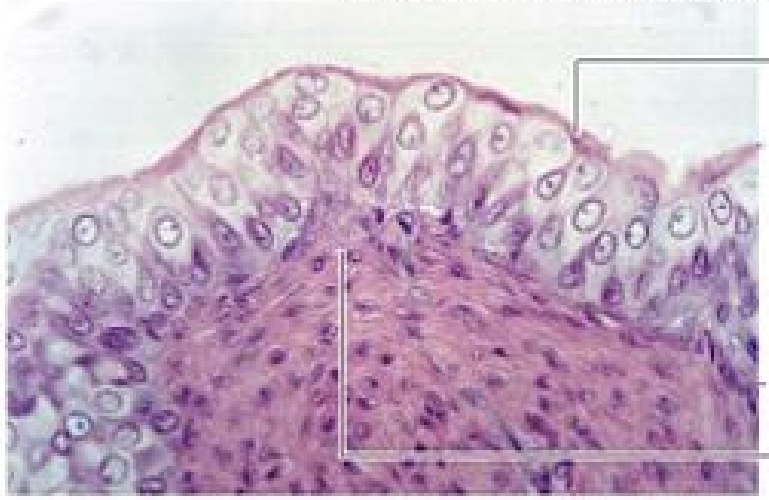
Urinary bladder plaque

Transmembrane protein in superficial cells

The mucosa of the urinary bladder is folded and lined with transitional epithelium (urothelium). Fibroelastic connective tissue extends into the folds (arrows).



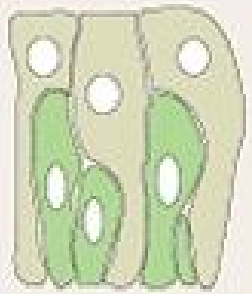
The muscularis contains numerous bundles of smooth muscle cells arranged irregularly as outer and inner longitudinal layers and a middle circular layer.



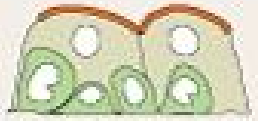
The columnar-like epithelium can stretch and resemble a stratified squamous epithelium when urine is present in the urinary bladder.

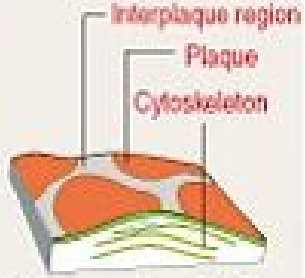
Apical plaques generate a thickened domain able to adjust to large changes in surface area.

Urothelium of an empty urinary bladder



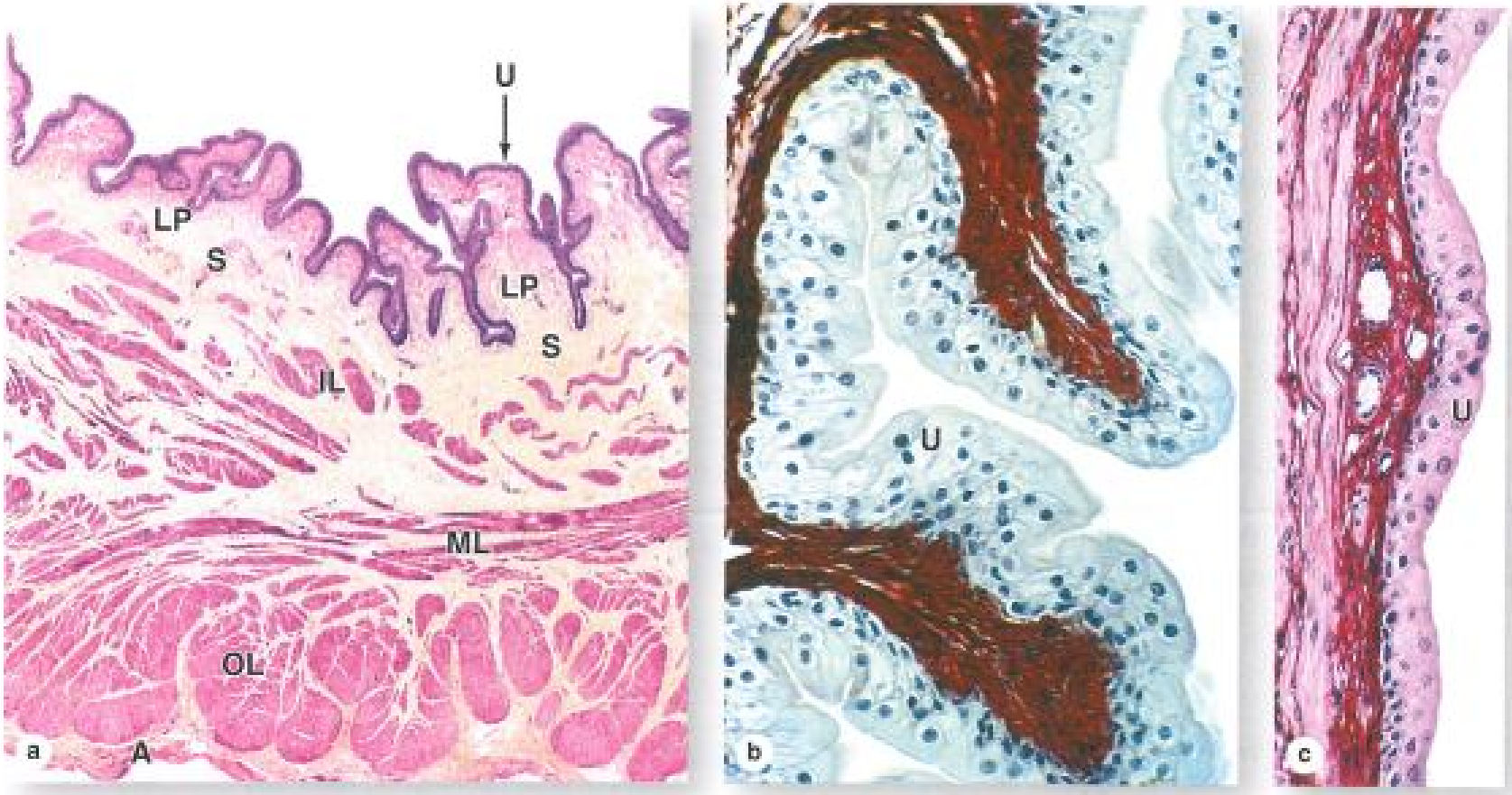
Urothelium of a urinary bladder filled with urine





Plaques are formed by the aggregation of hexagonal intramembranous proteins to which cytoskeletal proteins are anchored on the cytoplasmic side.

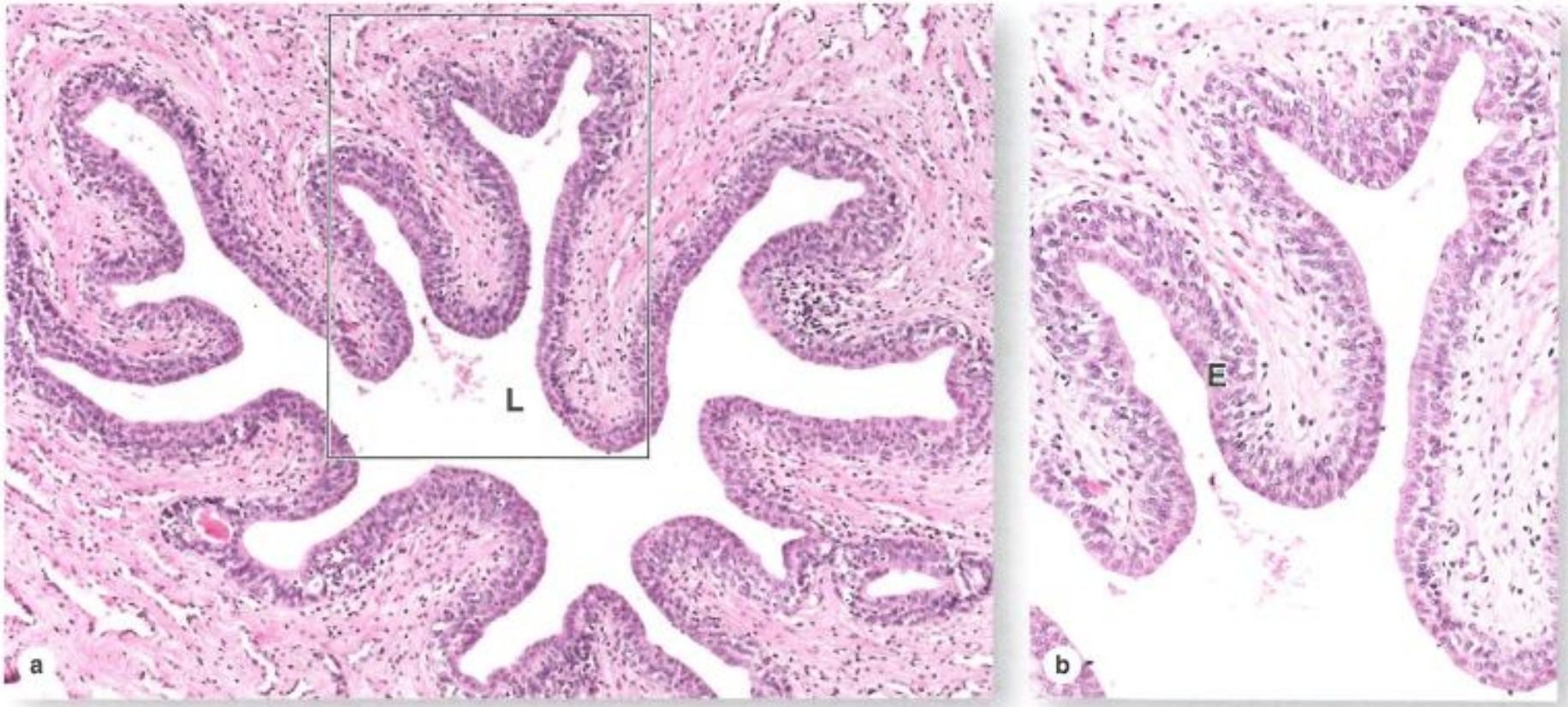
FIGURE **19–17** **Bladder wall and urothelium.**



(a) In the neck of the bladder, near the urethra, the wall shows four layers: the mucosa with urothelium (**U**) and lamina propria (**LP**); the thin submucosa (**S**); inner, middle, and outer layers of smooth muscle (**IL**, **ML**, and **OL**); and the adventitia (**A**). X15. H&E.

(b) When the bladder is empty, the mucosa is highly folded and the urothelium (**U**) has bulbous umbrella cells. X250. PSH. **(c)** When the bladder is full, the mucosa is pulled smooth, the urothelium (**U**) is thinner, and the umbrella cells are flatter. X250. H&E.

FIGURE **19–18** Urethra.



The urethra is a fibromuscular tube that carries urine from the bladder to the exterior of the body.

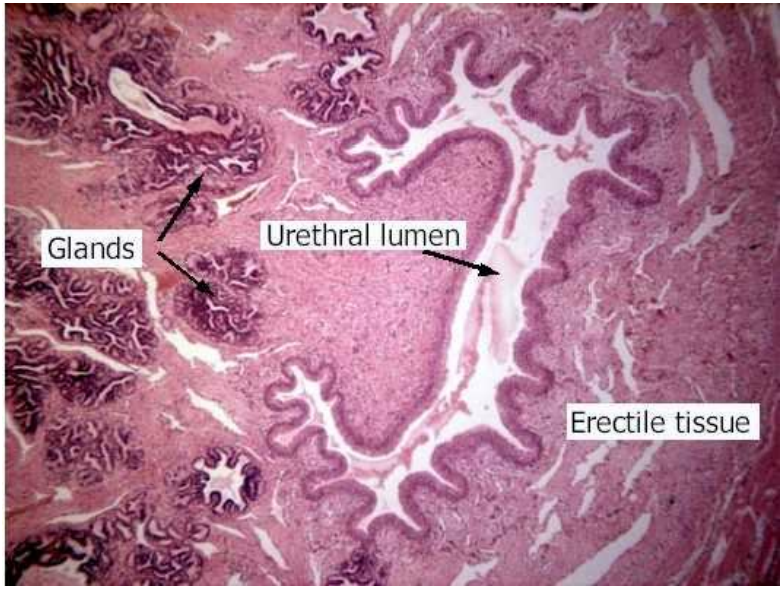
(a) A transverse section shows that the mucosa has large longitudinal folds around the lumen (**L**). X50. H&E.

(b) A higher magnification of the enclosed area shows the unusual stratified columnar nature of the urethral epithelium (**E**). This thick epithelial lining varies between stratified columnar in some areas and pseudostratified columnar elsewhere, but it becomes stratified squamous at the distal end of the urethra. X250. H&E.

Male urethra:

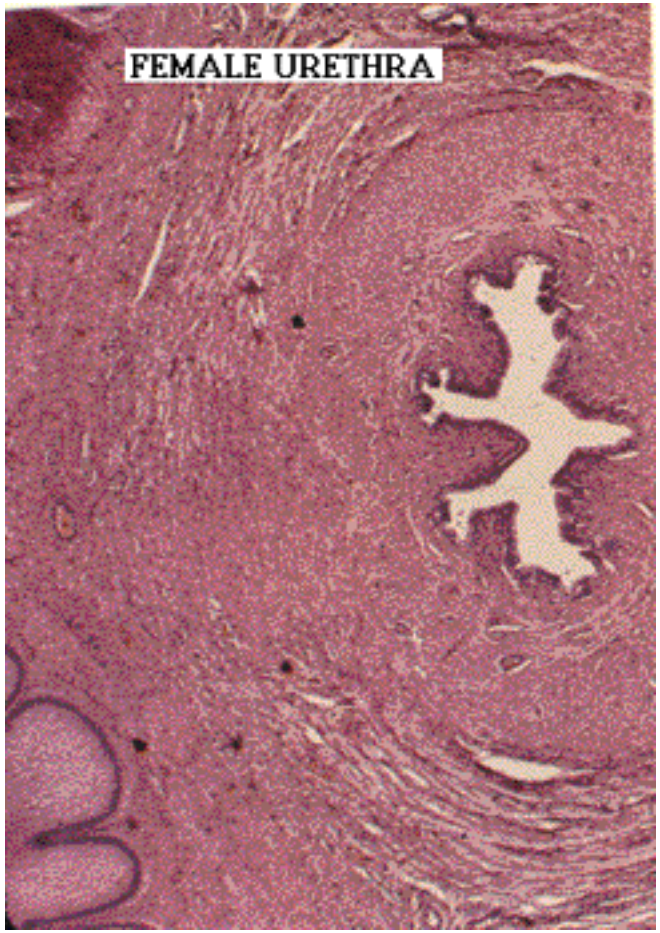
- Prostatic part = 3.5 cm / transitional epithelium
- Membranous part = 1.5 cm / pseudo stratified epithelium
- Spongios part = 15 cm / pseudo stratified & squamous stratified epithelium
- Navicular fossa = squamous stratified epithelium

Lamina propria = fibro elastic connective tissue / mucosal cells (litters glands)



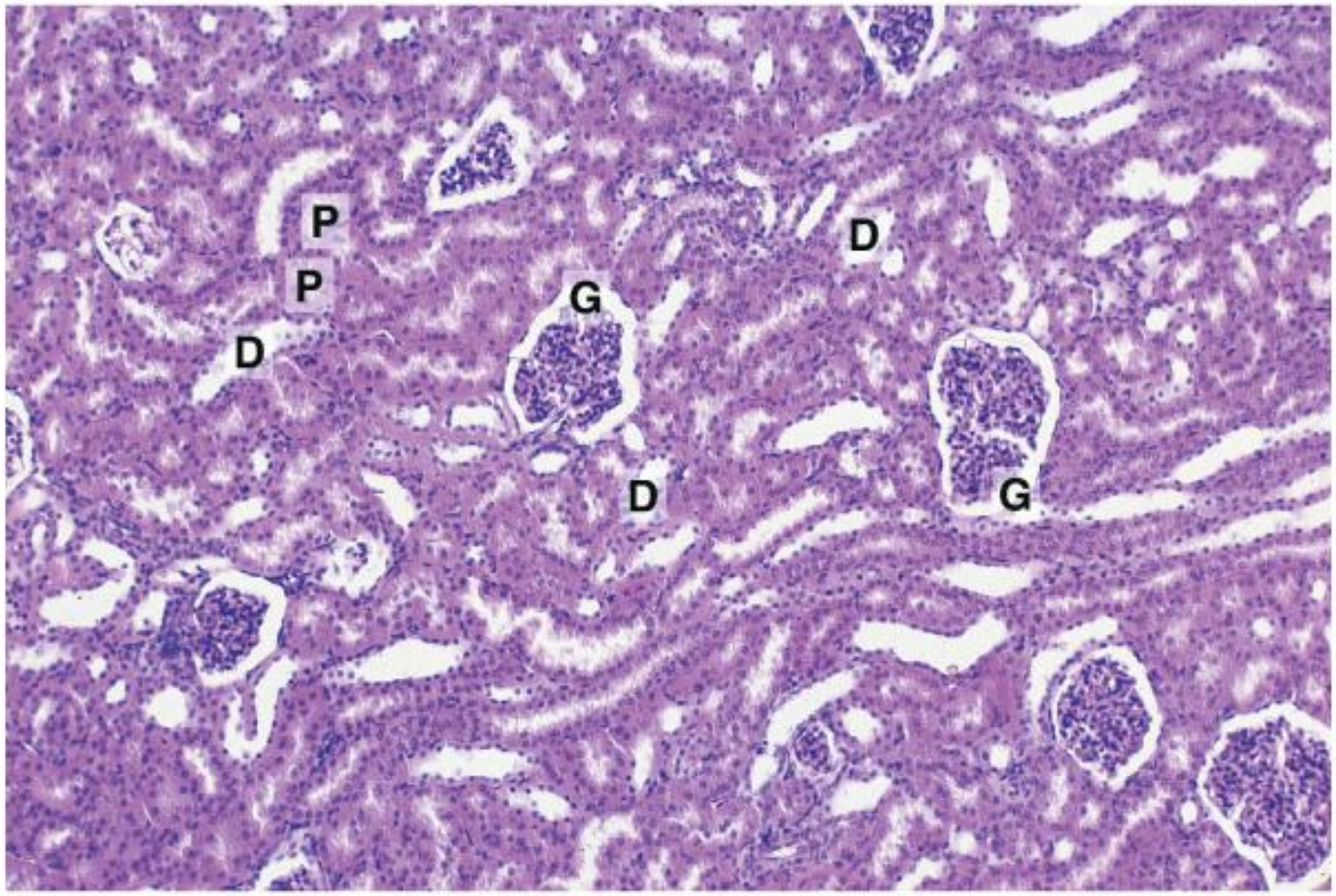
Female urethra: 4 cm

✓Near bladder = transitional epithelium
✓End part = squamous stratified epithelium
✓Lamina propria = mucosal cells (litters glands)

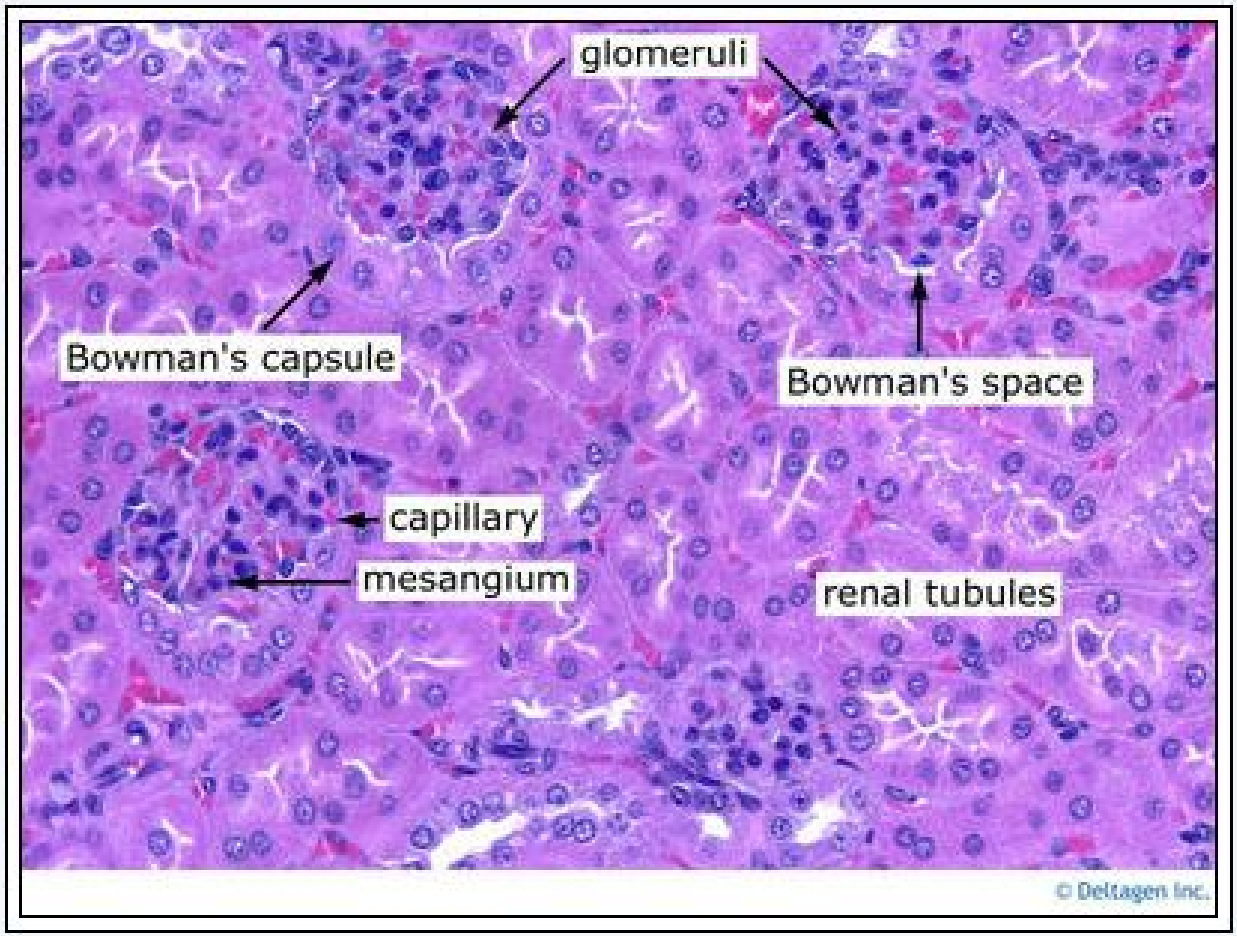


HISTOLOGY SAMPLES

Urinary tract

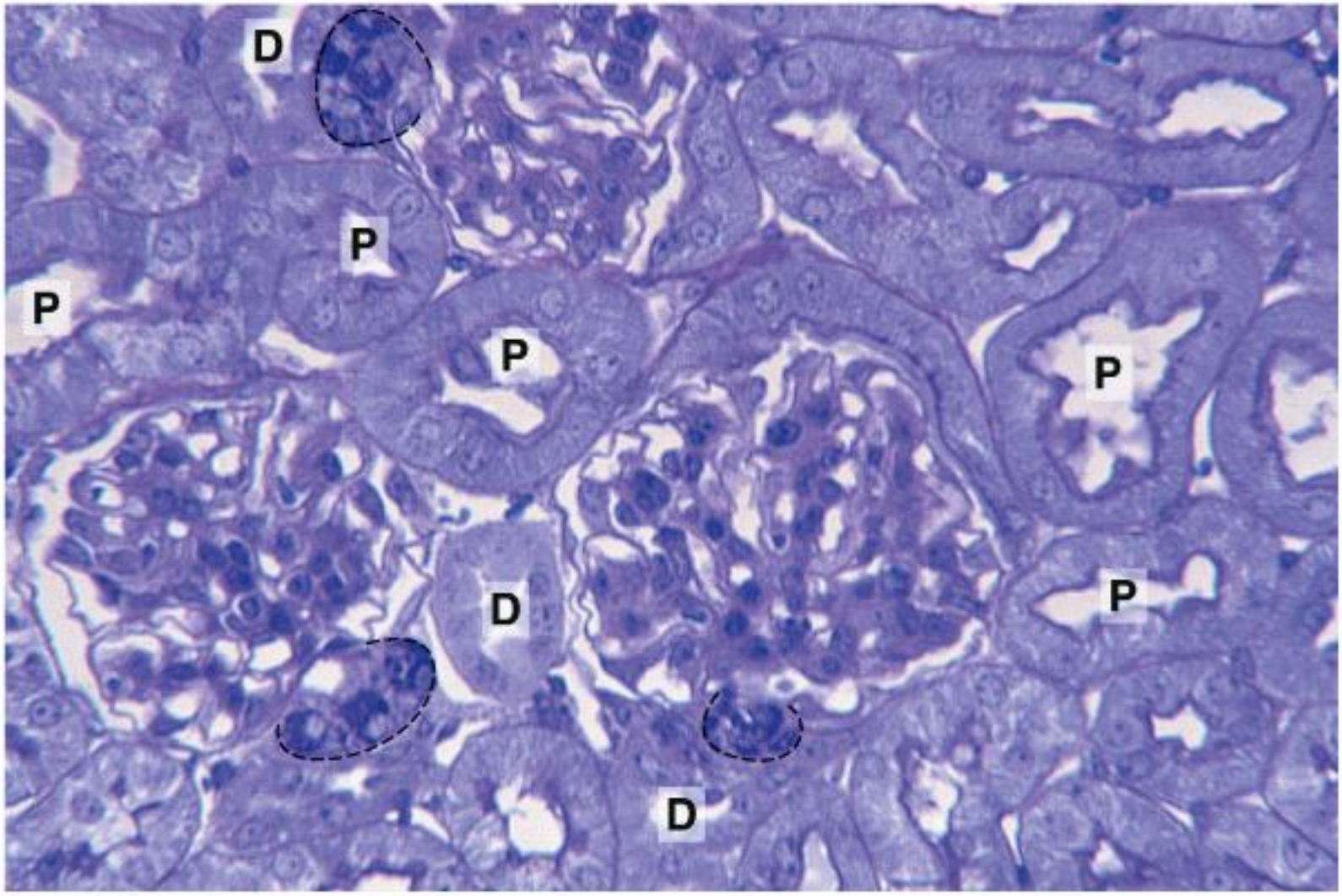


Bird's-eye view of the renal cortex, which is composed mainly of proximal (P) and distal (D) convoluted tubules and renal glomeruli (G). Pararosanilineâ€"toluidine blue (PT) stain. Low magnification.

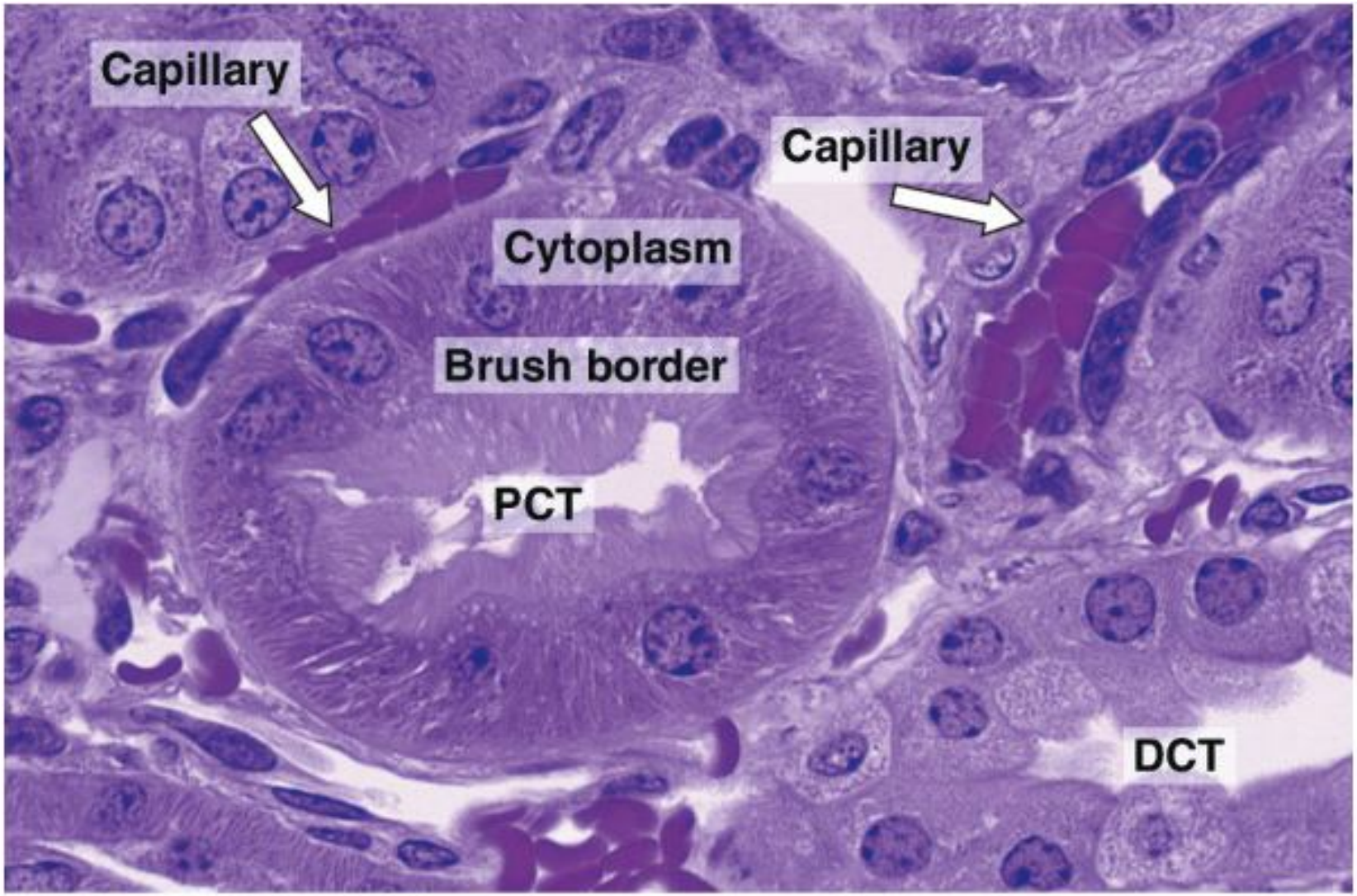


Kidney (labels) - histology slide

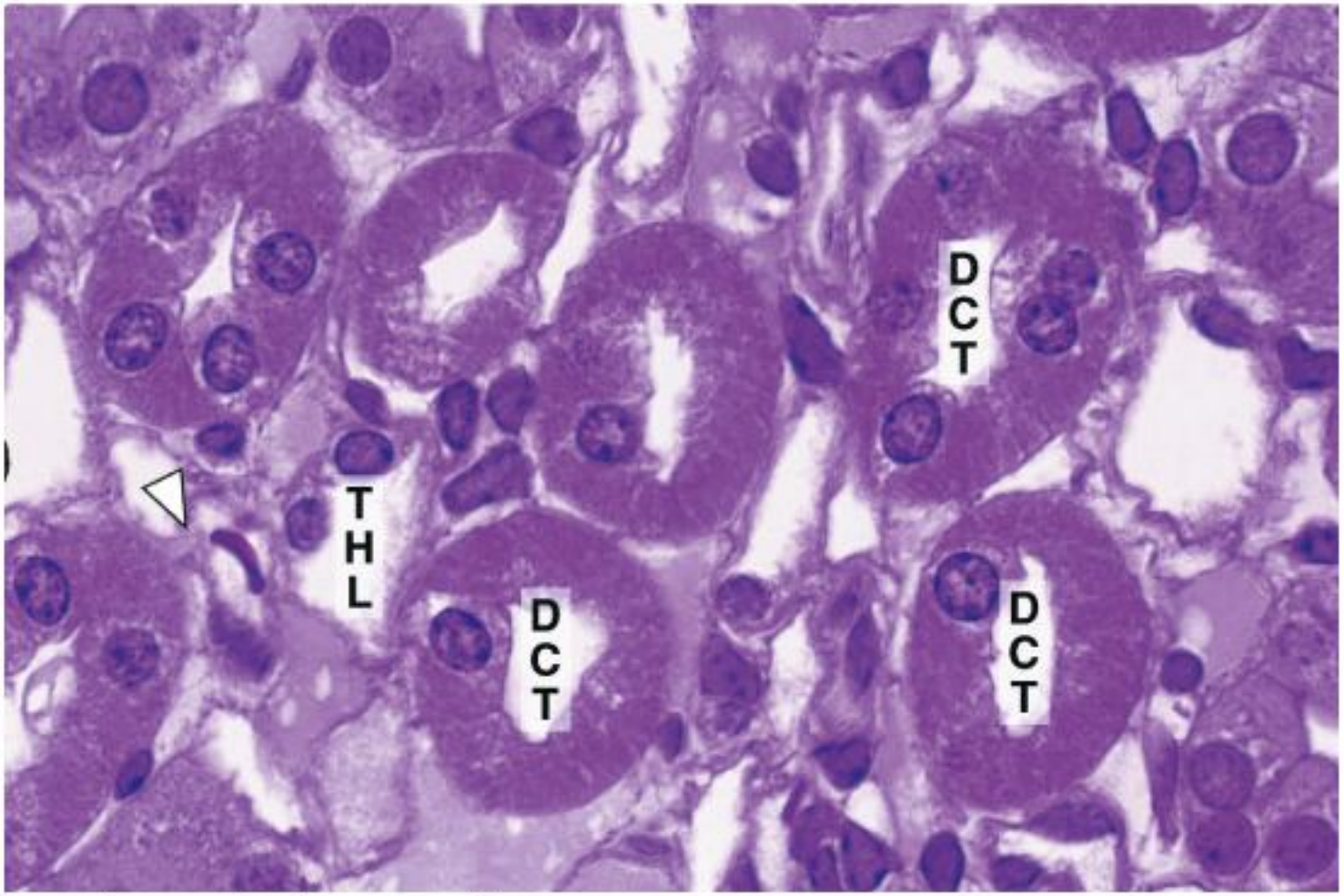
This is a histology slide of the kidney.



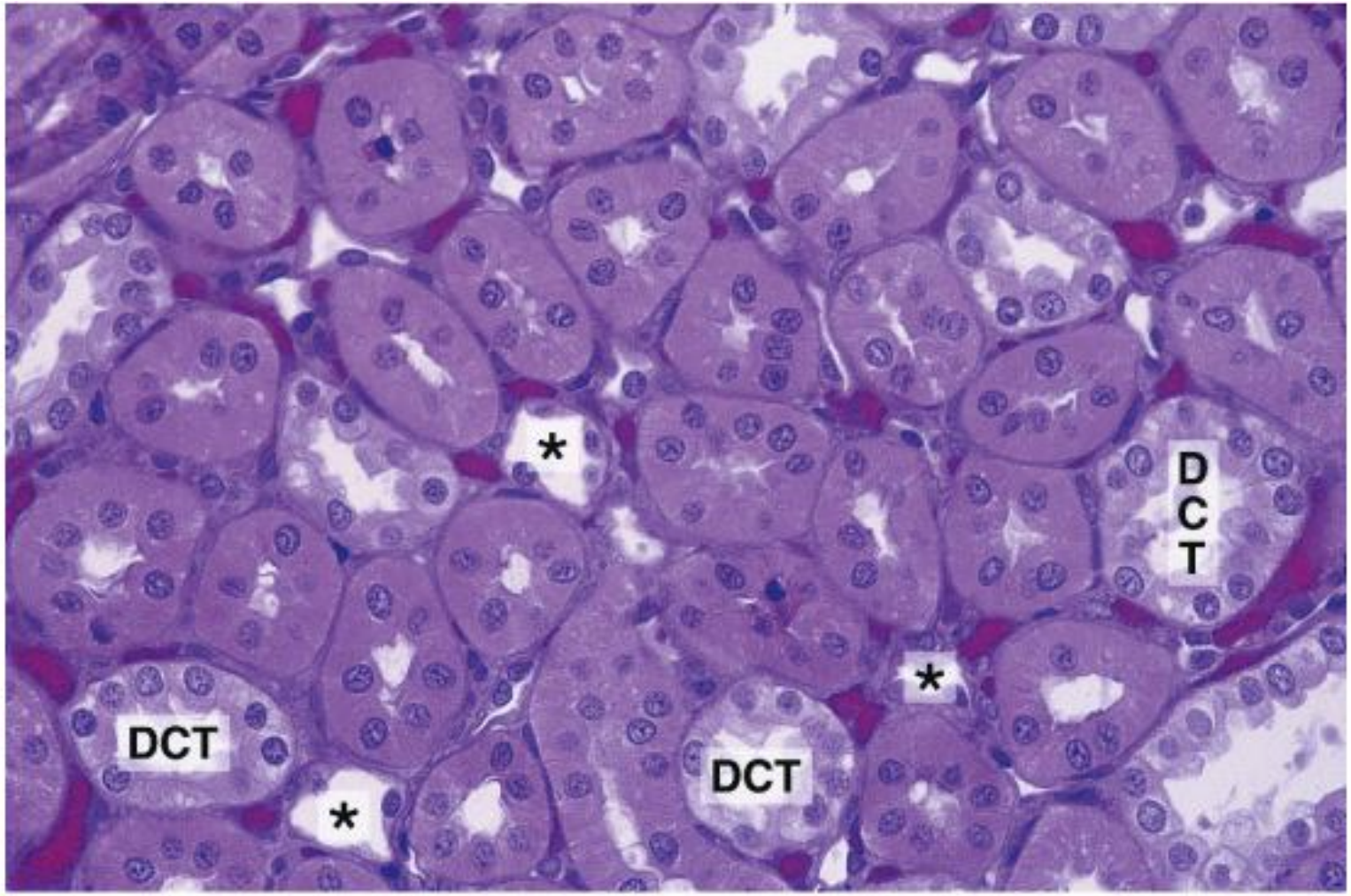
Renal cortex showing proximal (P) and distal (D) convoluted tubules. Sections can be seen through the vascular pole of three renal corpuscles where juxtaglomerular renin-secreting cells appear well stained (broken lines). PT stain. Medium magnification.



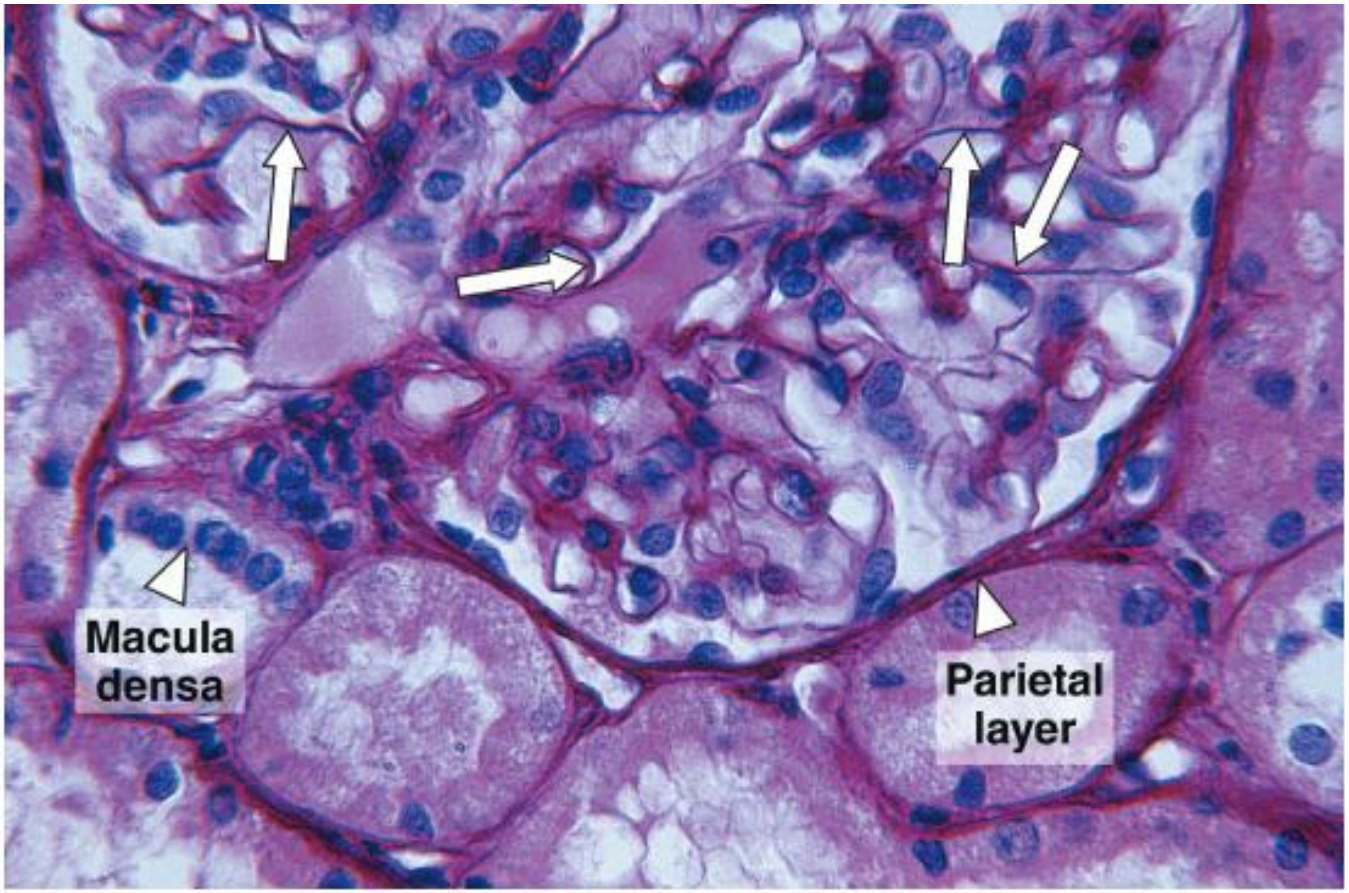
Renal cortex section showing a proximal convoluted tubule (PCT) with its large cuboidal cells presenting a brush border formed by numerous microvilli. Distal convoluted tubules (DCT) are also present. PT stain. Medium magnification.



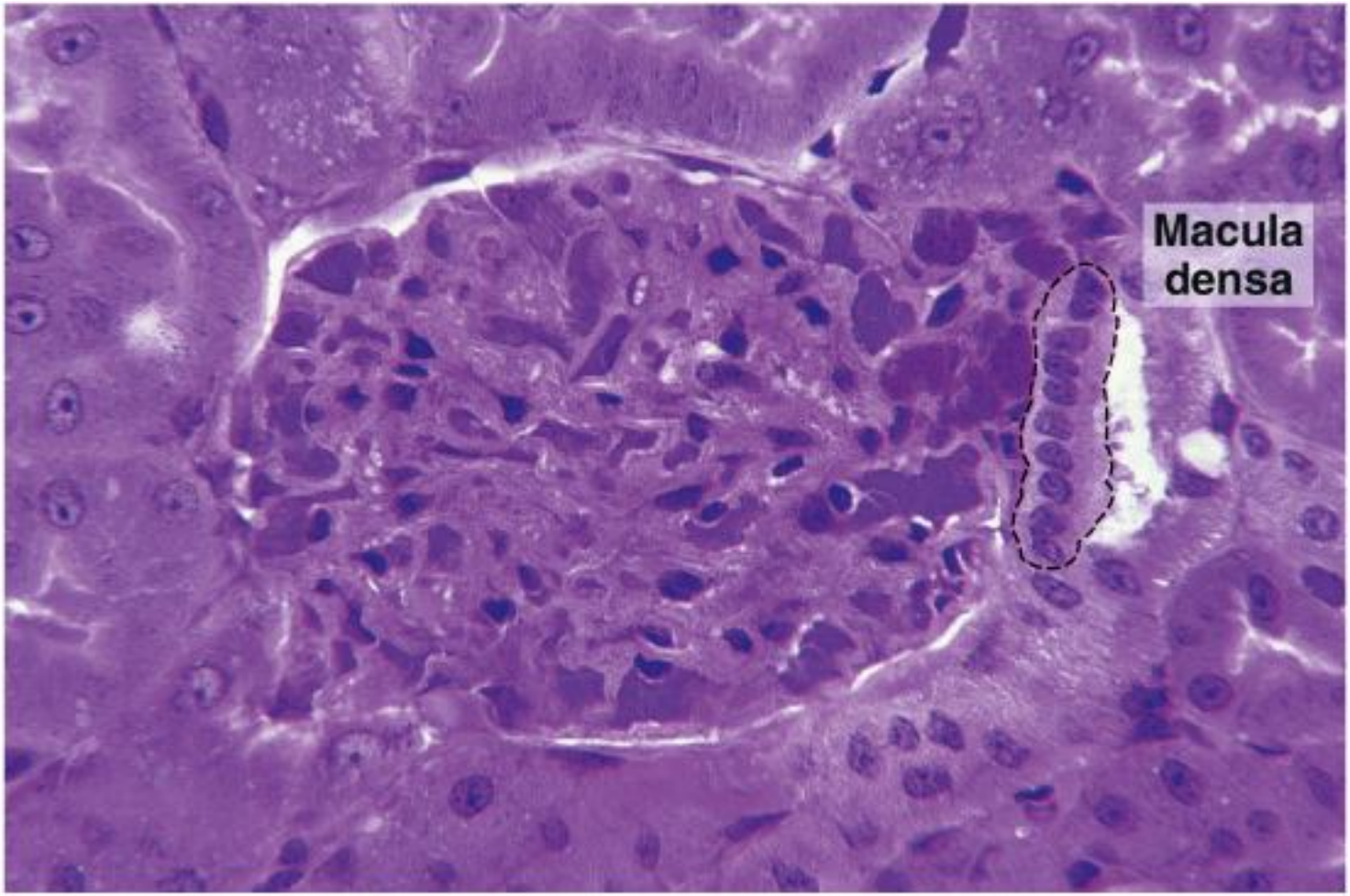
Distal convoluted tubules (DCT) characterized by the absence of brush border. Note also a thin portion of Henle's loop (THL) and a blood capillary (arrowhead). PT stain. Medium magnification.



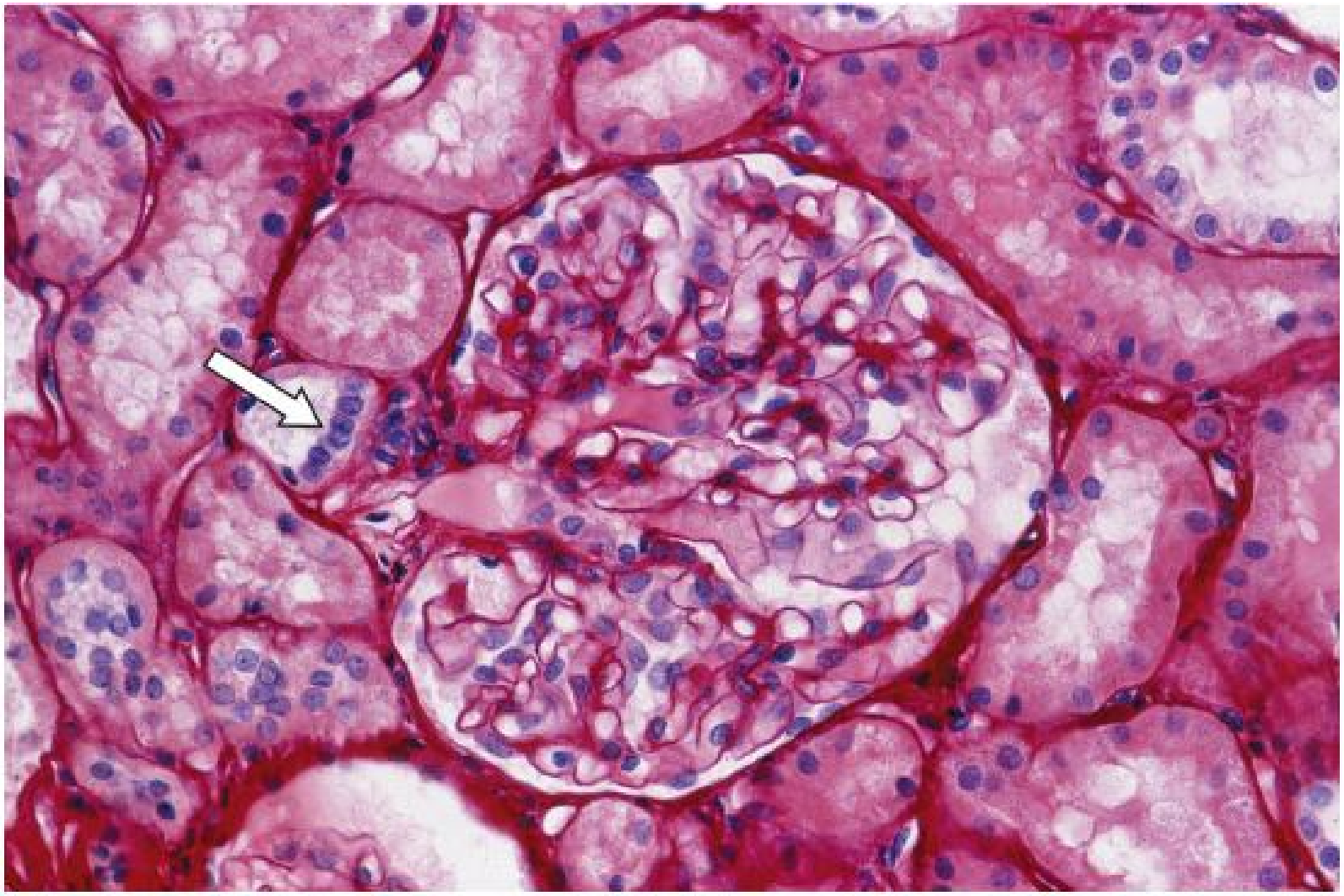
Region of the kidney consisting mainly of distal convoluted tubules (DCT) and thin segments of Henle's loop (asterisks). Capillaries filled with blood appear in red. PT stain. Medium magnification.



Photomicrograph of a renal cortex showing parts of two renal corpuscles, macula densa, and distal and proximal convoluted tubules. The collagen type IV of the basement membrane of the glomerular capillaries is clearly visible (arrows). The collagen of the parietal layer of Bowman's capsule and the basal membrane of a distal tubule are shown by the arrowhead. Picrosirius stain. Medium magnification.

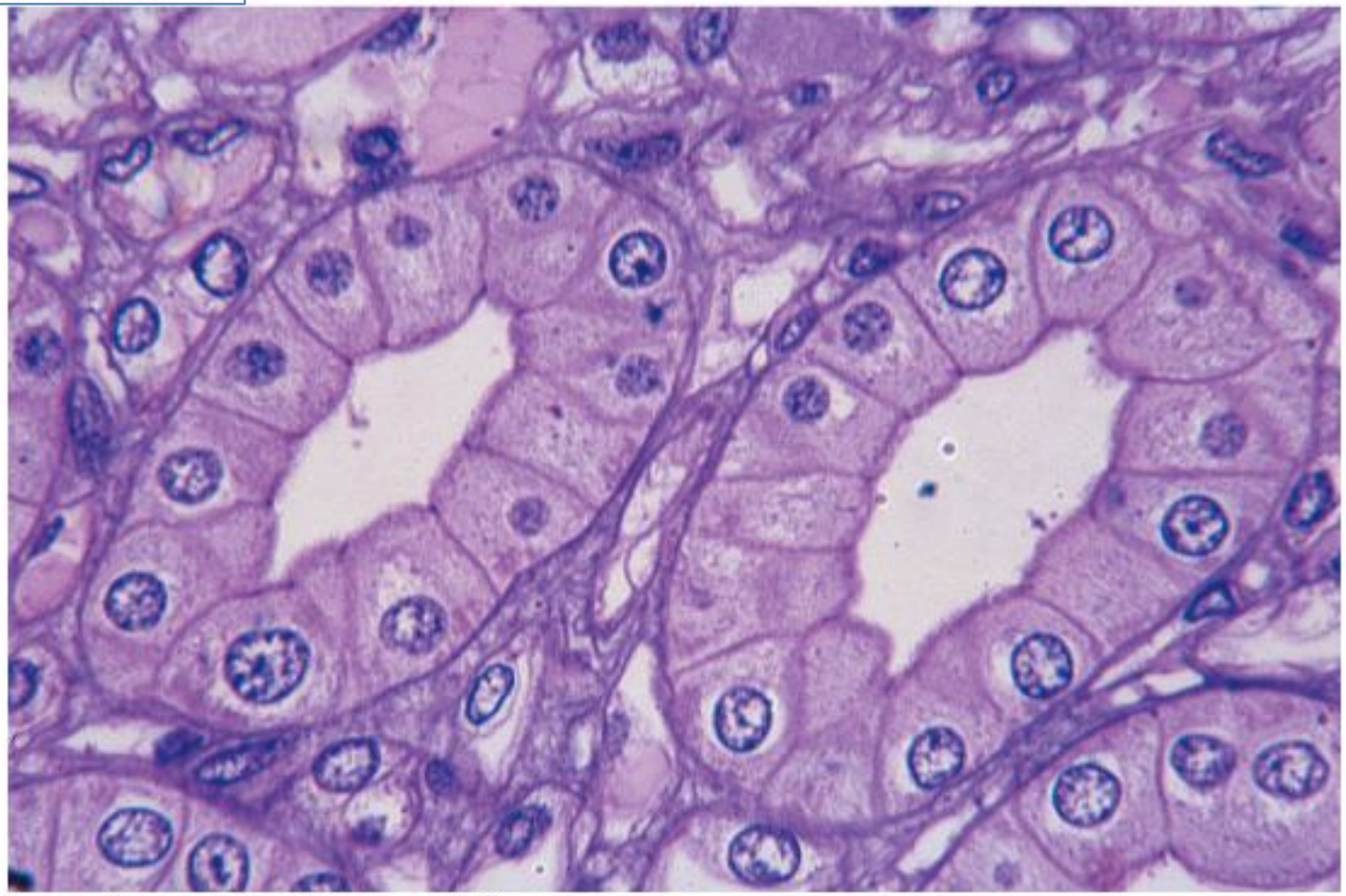


Renal cortex showing a distal convoluted tubule with a macula densa formed by closely packed epithelial cells (broken line). This structure is sensitive to the ionic concentration of the filtrate in the distal tubule and is believed to influence glomerular filtration. PT stain. Medium magnification.



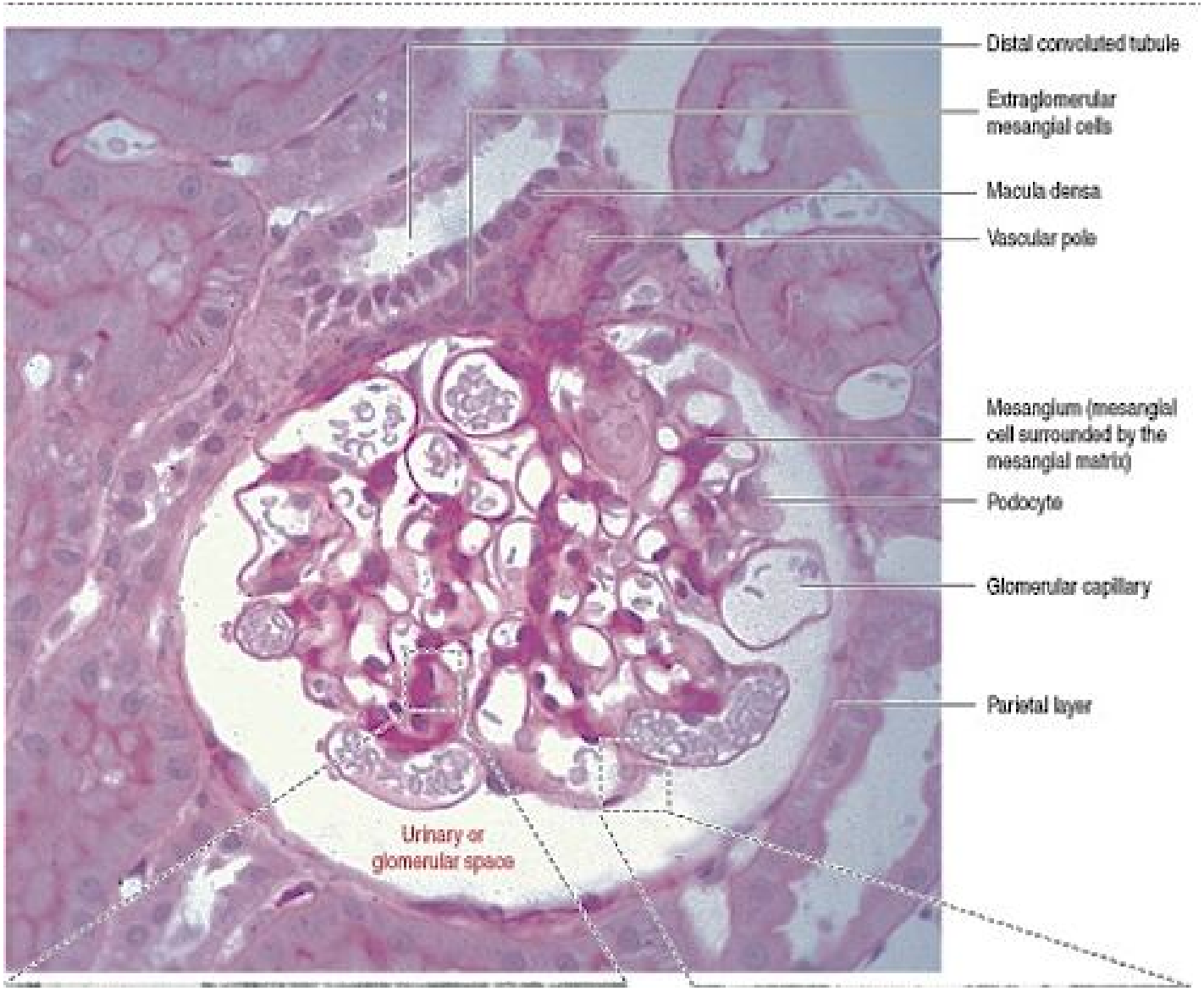
Photomicrograph of renal cortex. A macula densa is clearly seen (arrow) at the vascular pole of a renal corpuscle. Picrosiriusâ€hematoxylin (PSH) stain. Medium magnification.

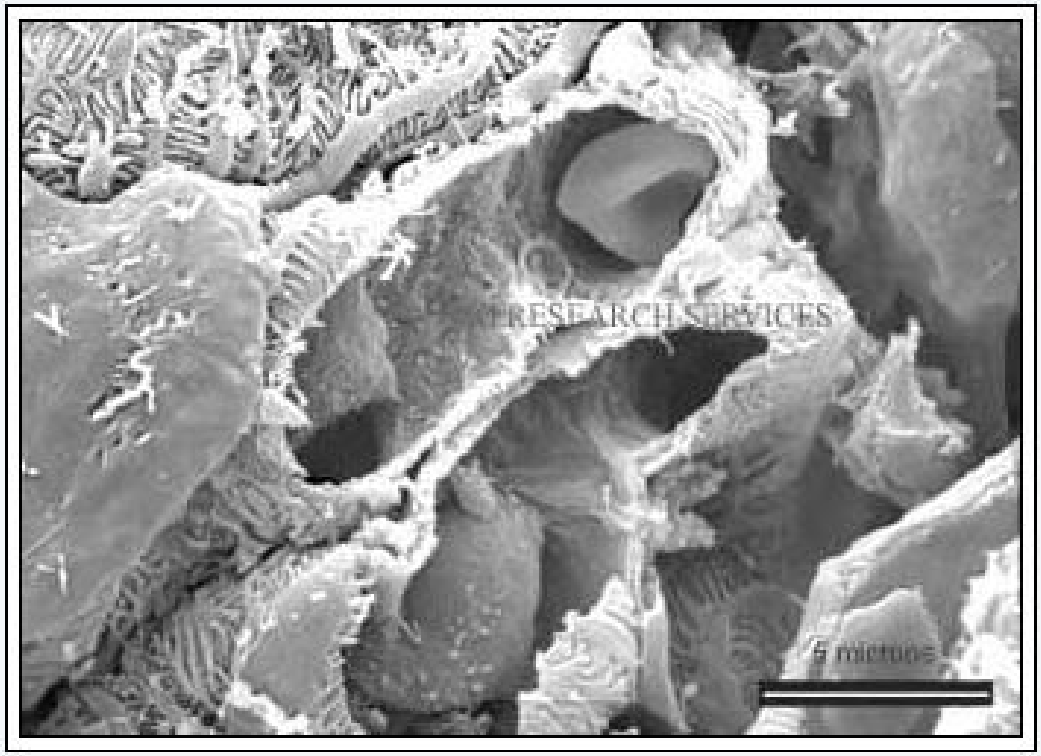
Collecting ducts



Photomicrograph of renal medulla with two collecting ducts consisting of cuboidal cells resting on a basement membrane. In this hypertonic region of the kidney, because of the action of the hypophyseal antidiuretic hormone, water is reabsorbed, controlling the water balance of the body. PT stain. Medium magnification.

Components of the renal corpuscle visualized by light and electron microscopy

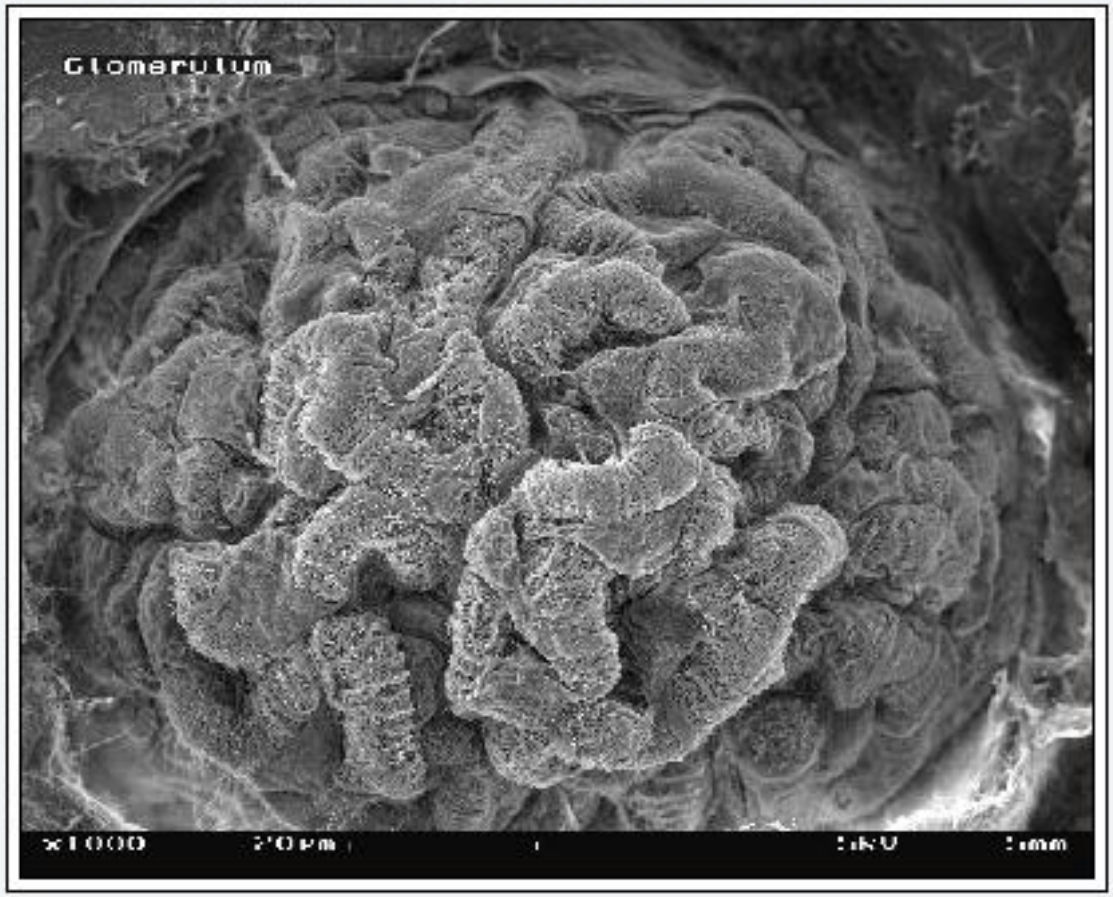




Glomerulus - SEM

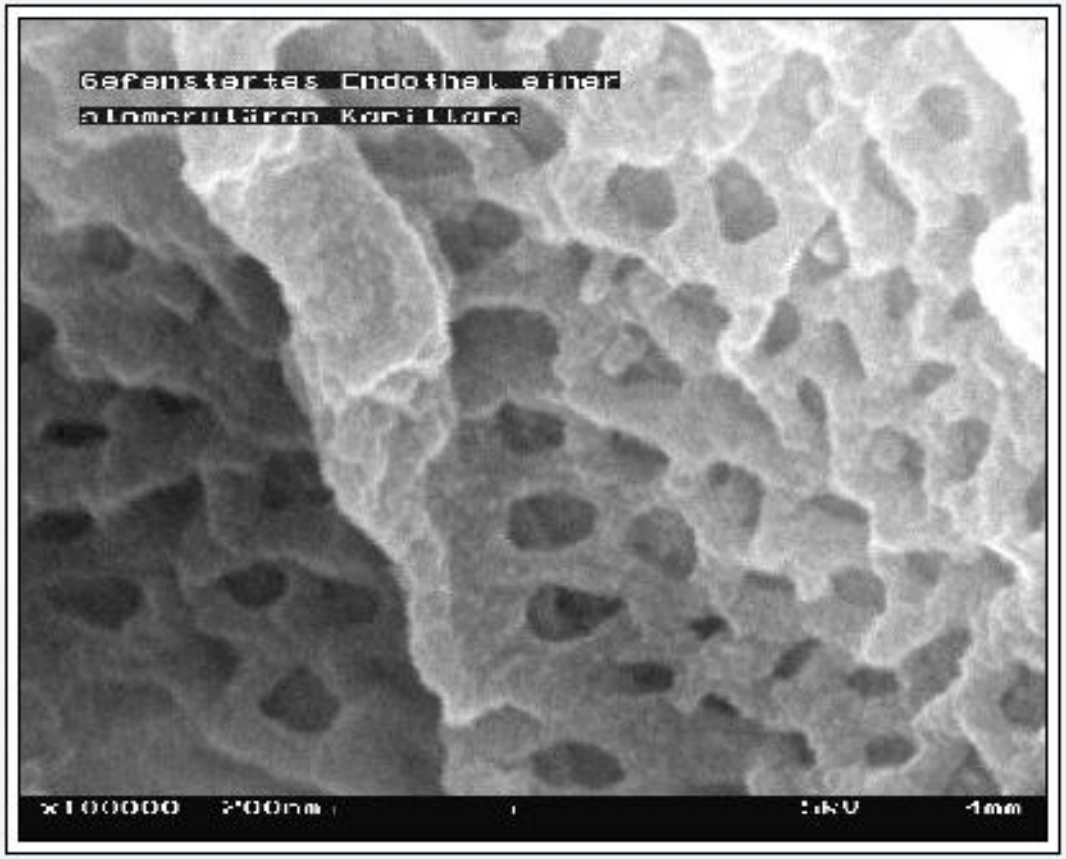
This is a scanning electron micrograph of a glomerulus.

Image courtesy of EM Research Services, Newcastle University.



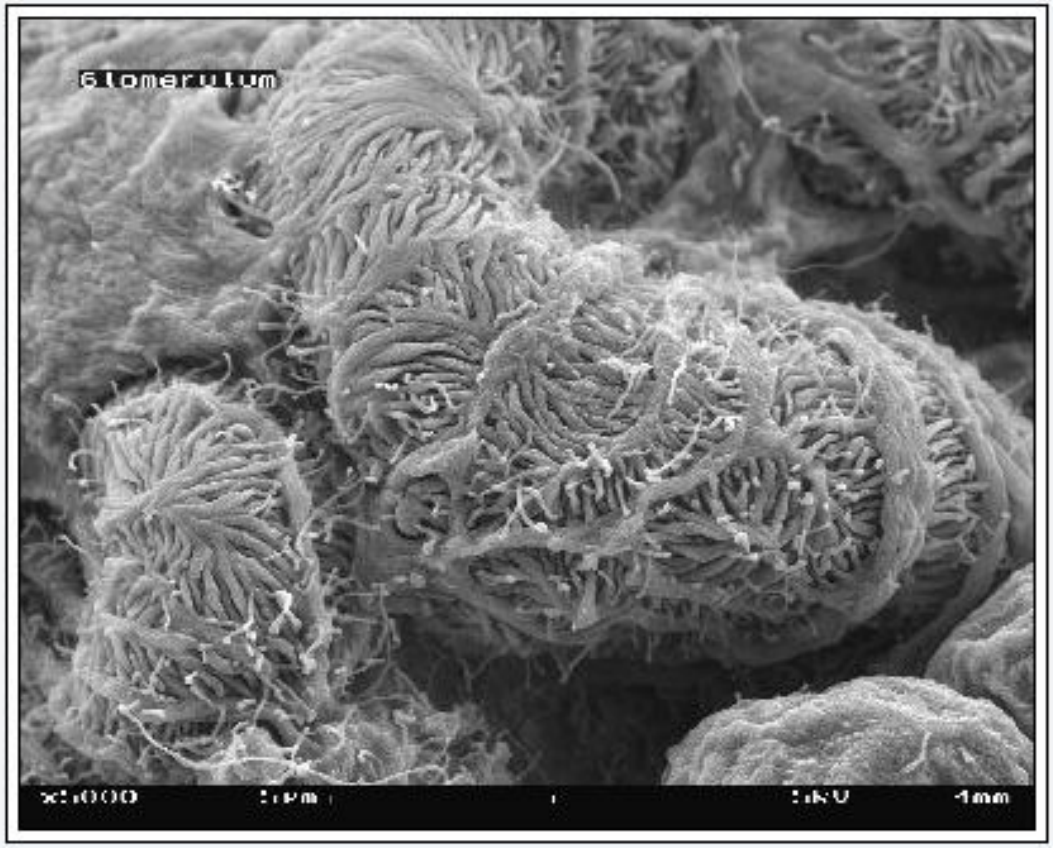
Kidney, mouse - SEM

Glomerulum of mouse kidney in Scanning Electron Microscope. Magnification 1,000x.



Kidney, mouse - SEM

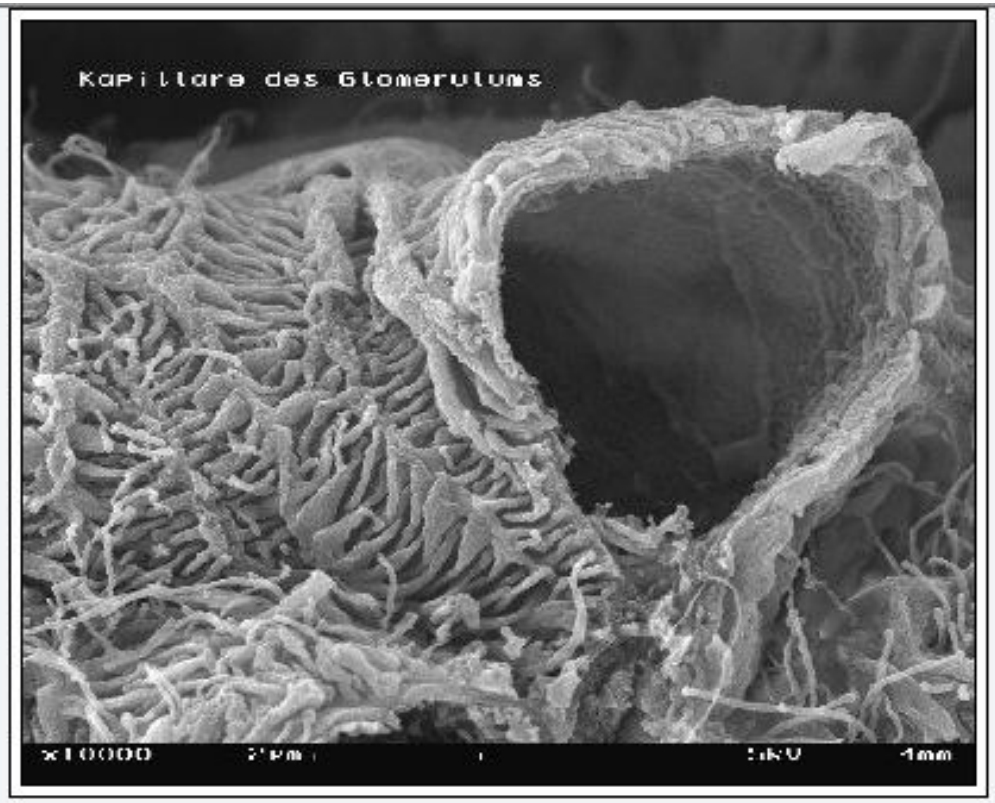
Inner view of fenestrae in capillary of glomerulus in Scanning Electron Microscope. Magnification 100,000x.



Kidney, mouse - SEM

Glomerulum of mouse kidney in Scanning Electron Microscope.
Magnification_5,000x.

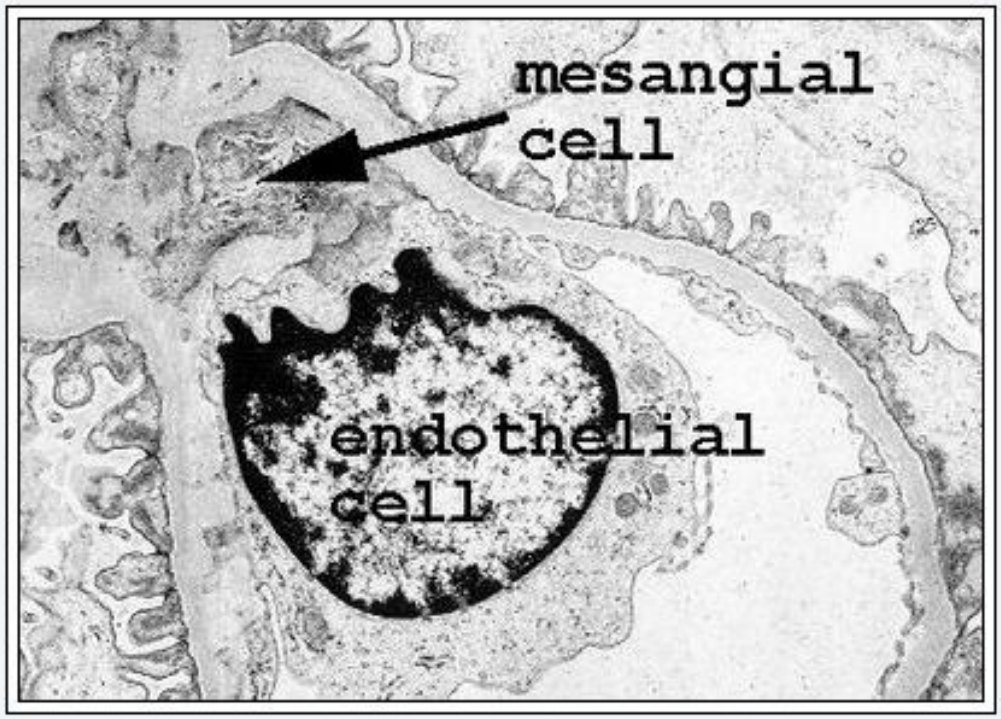
Image courtesy of Wikimedia Commons, user SecretDisc.



Kidney, mouse - SEM

Glomerulum of mouse kidney with broken capillary in Scanning Electron Microscope. Magnification_10,000x.

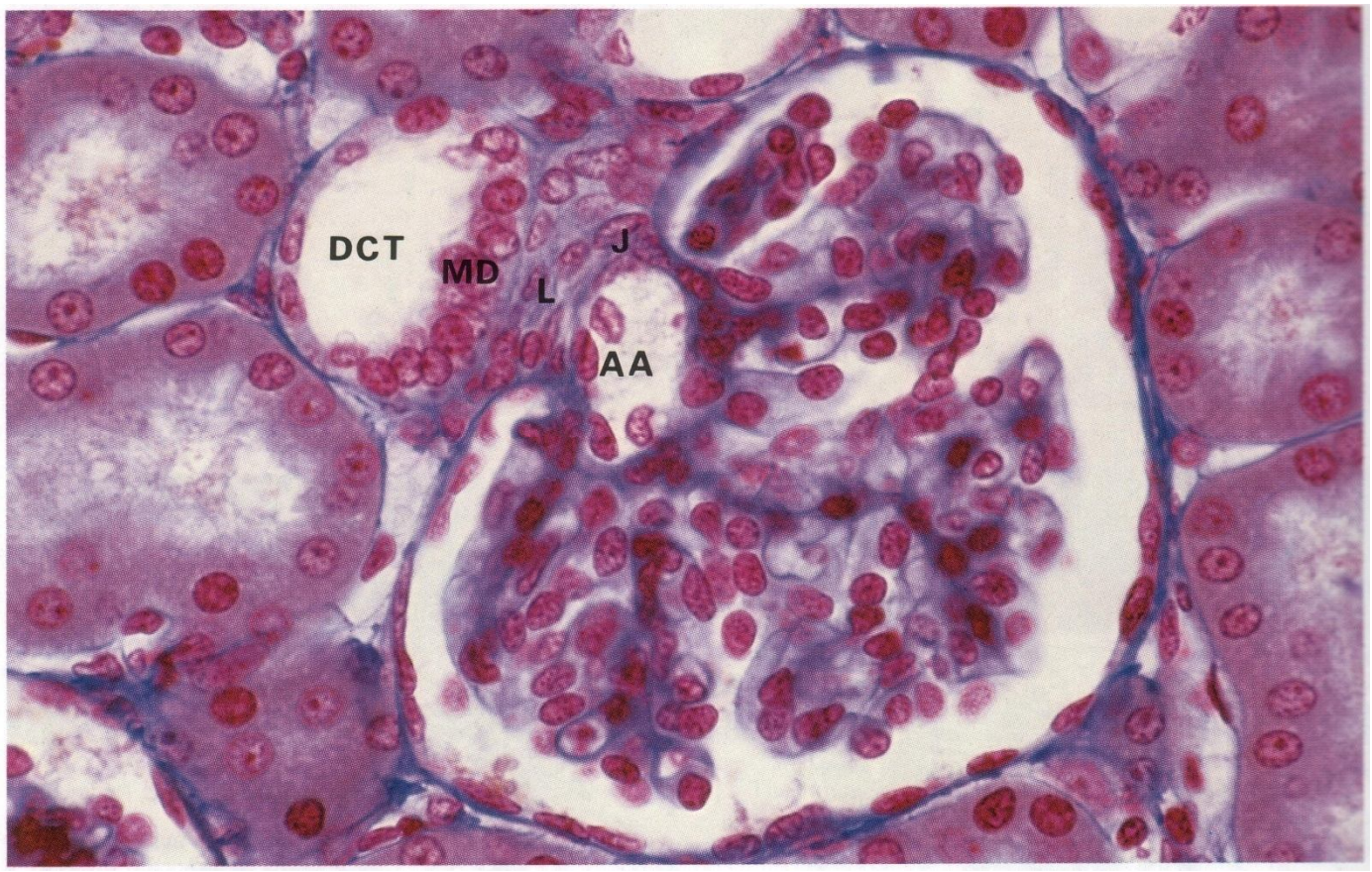
Image courtesy of Wikimedia Commons, user SecretDisc.



Kidney (labels) - EM

This is an electron micrograph that shows a portion of 1 capillary loop with adjacent mesangium. The endothelial cell nucleus sits over the origin of the mesangium, which is where it is usually found. A few pores through the endothelial cytoplasm can be seen. The glomerular basement membrane lamina lucida externa is the thin lucent zone just under the foot processes of the visceral epithelial cell. The bulk of the basement membrane is the lamina densa.

Juxtaglomerular cells and extramesangial cells



URETER

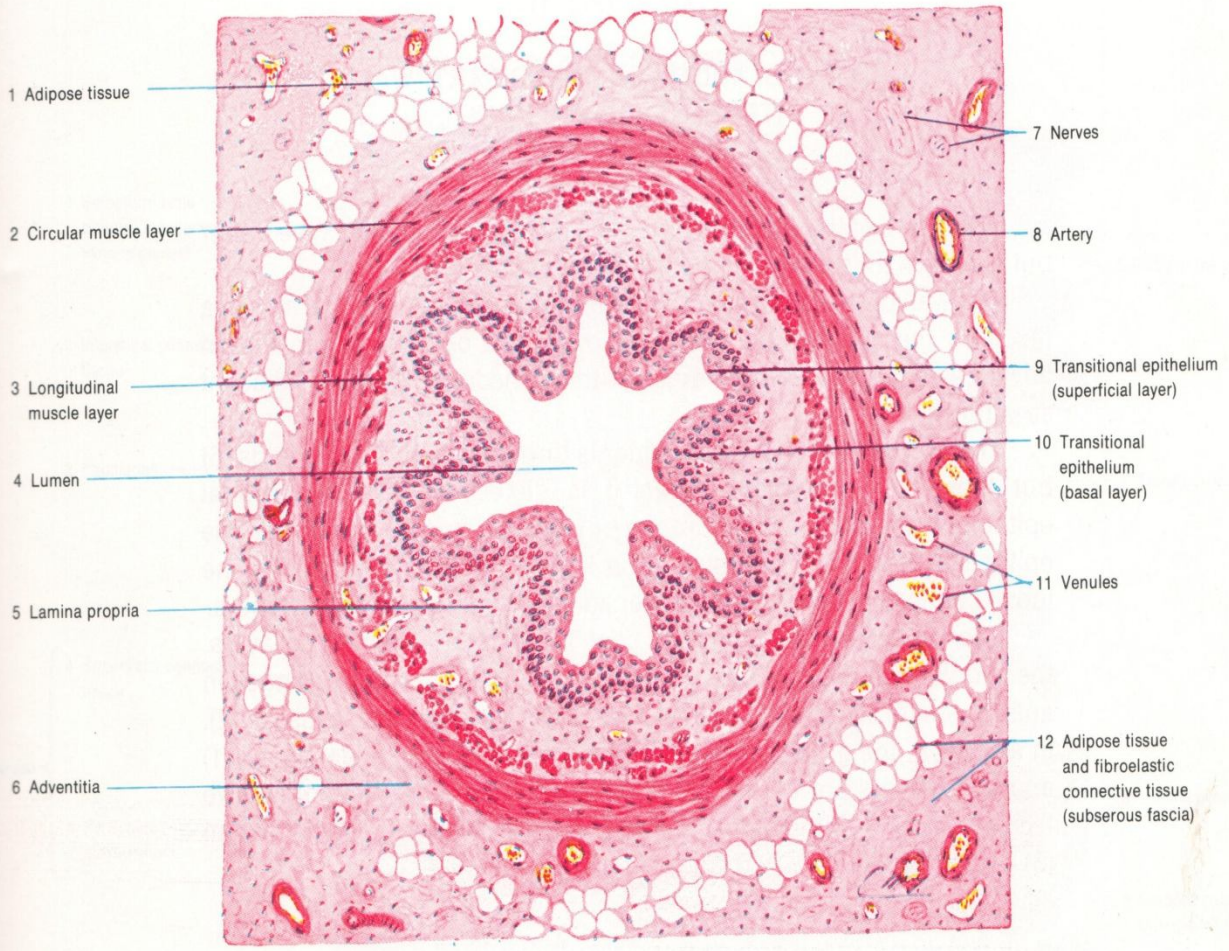
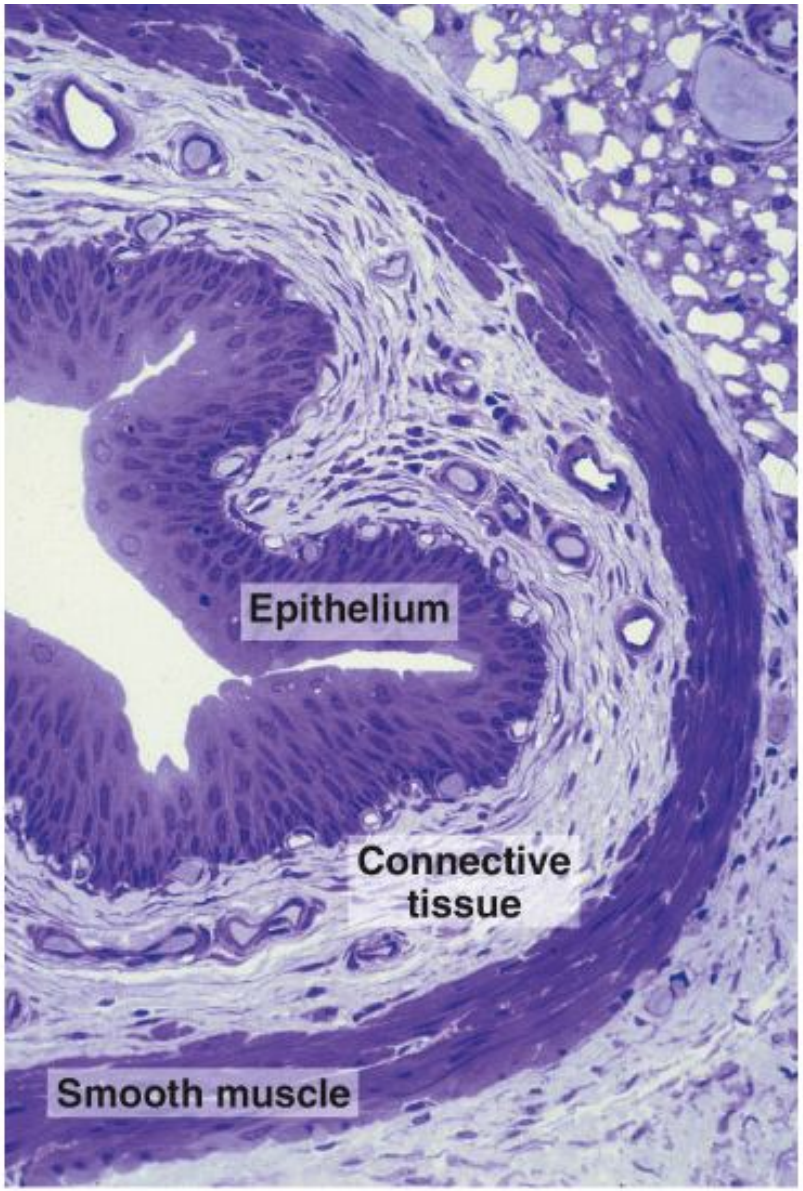
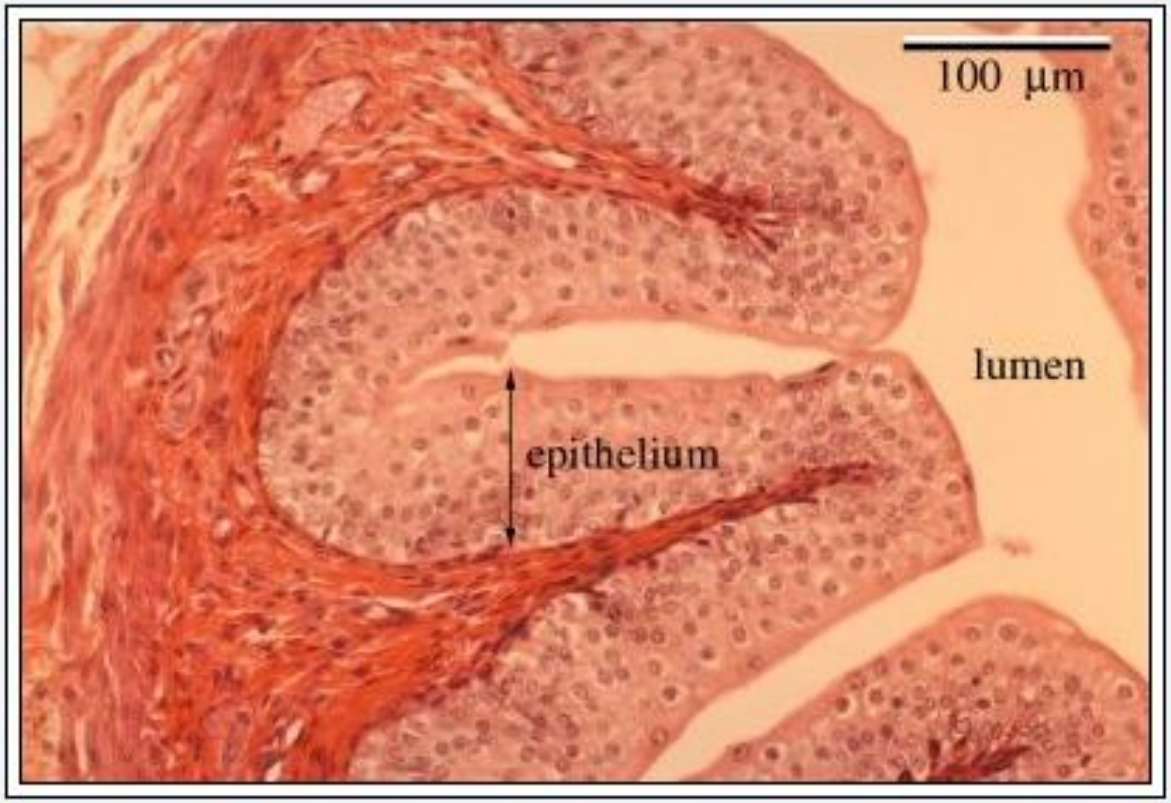


Fig. 1. *Transverse section.*
Stain: hematoxylin-eosin. 50×.

Ureter



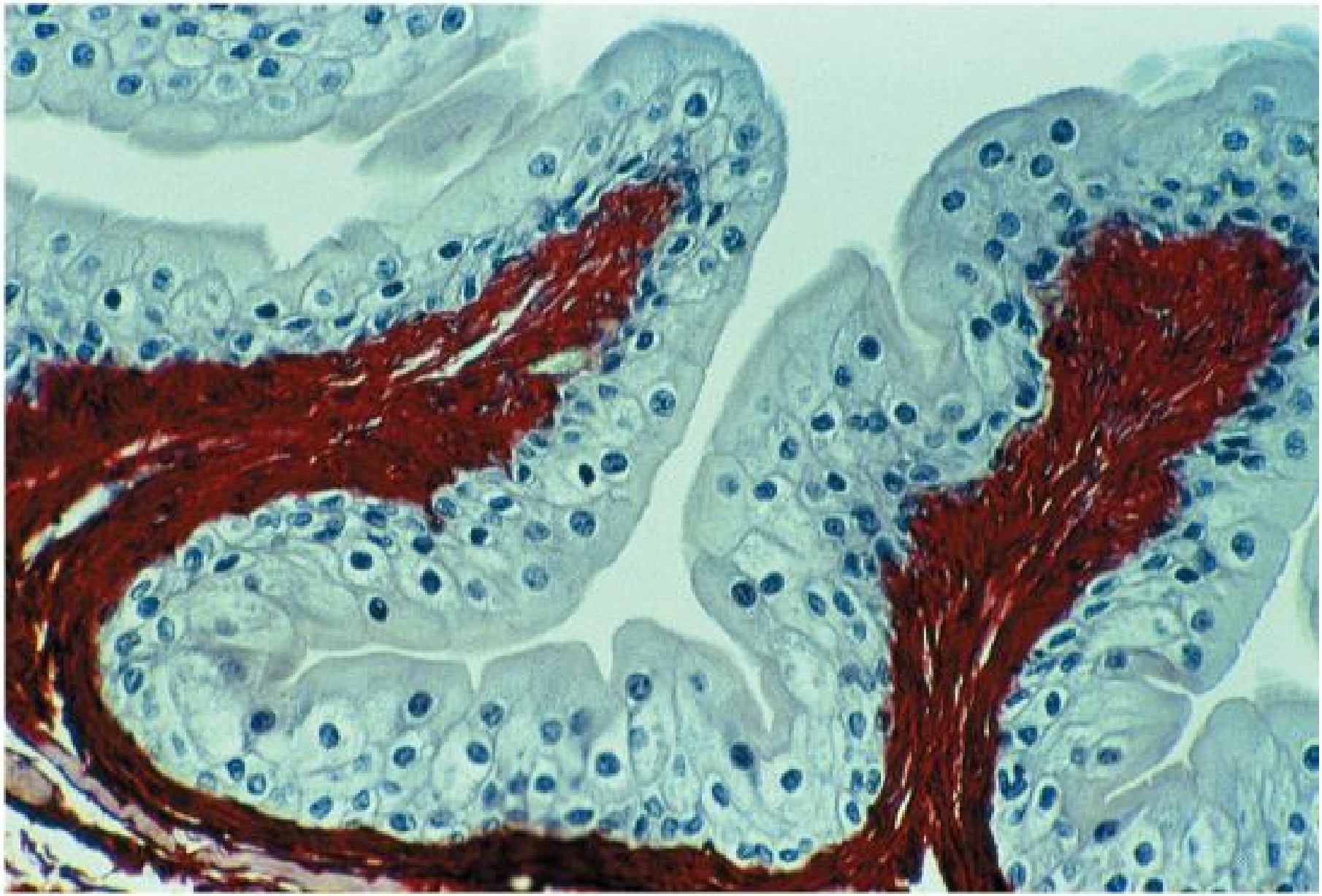
Photomicrograph showing the main components of the ureter, which consists of an inner layer of transitional epithelium, a highly vascularized connective tissue, a smooth muscle layer, and an outer layer of connective tissue. PT stain. Low magnification.



Ureter (labels) - histology slide

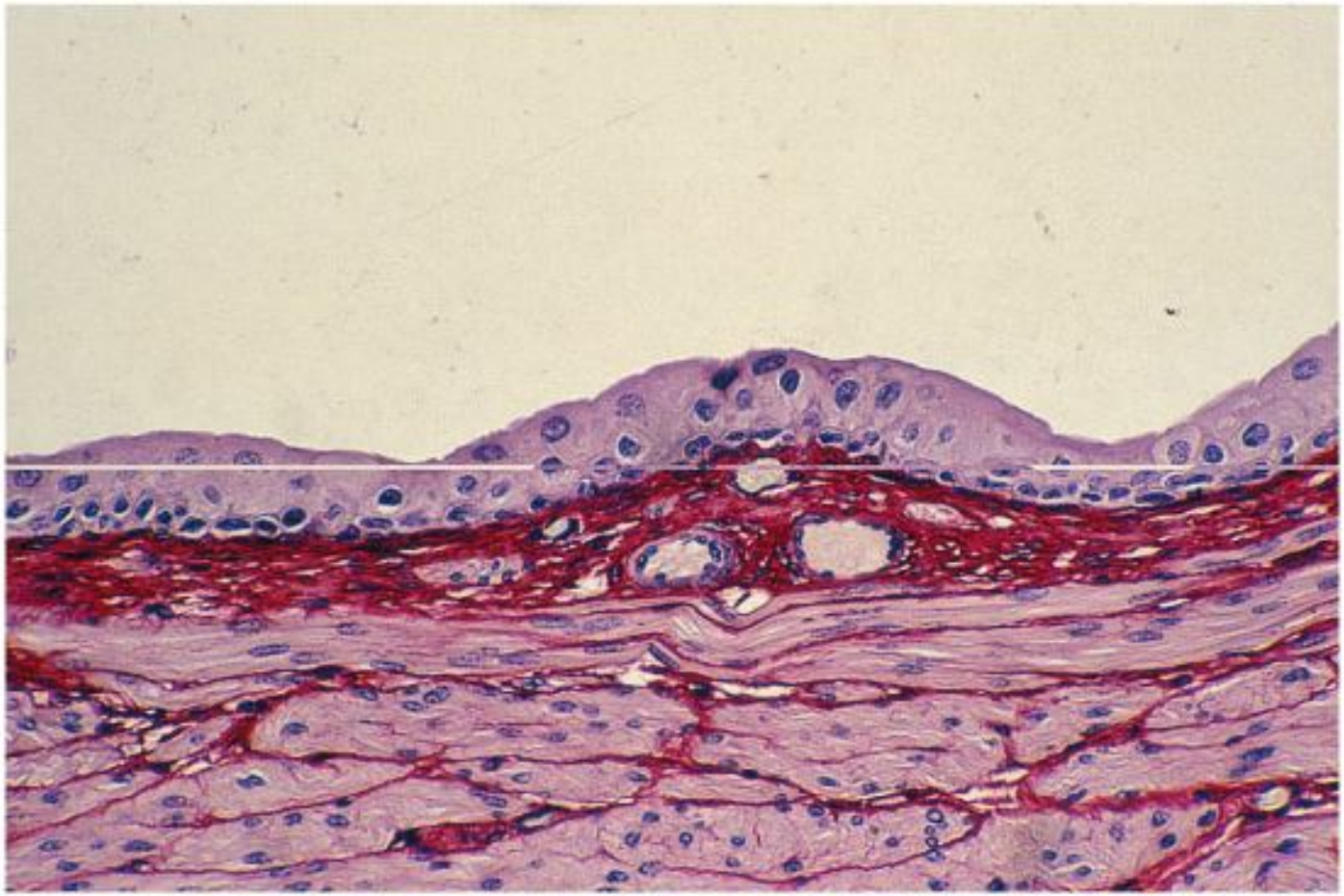
This is a histology slide of the ureter

Bladder (empty)



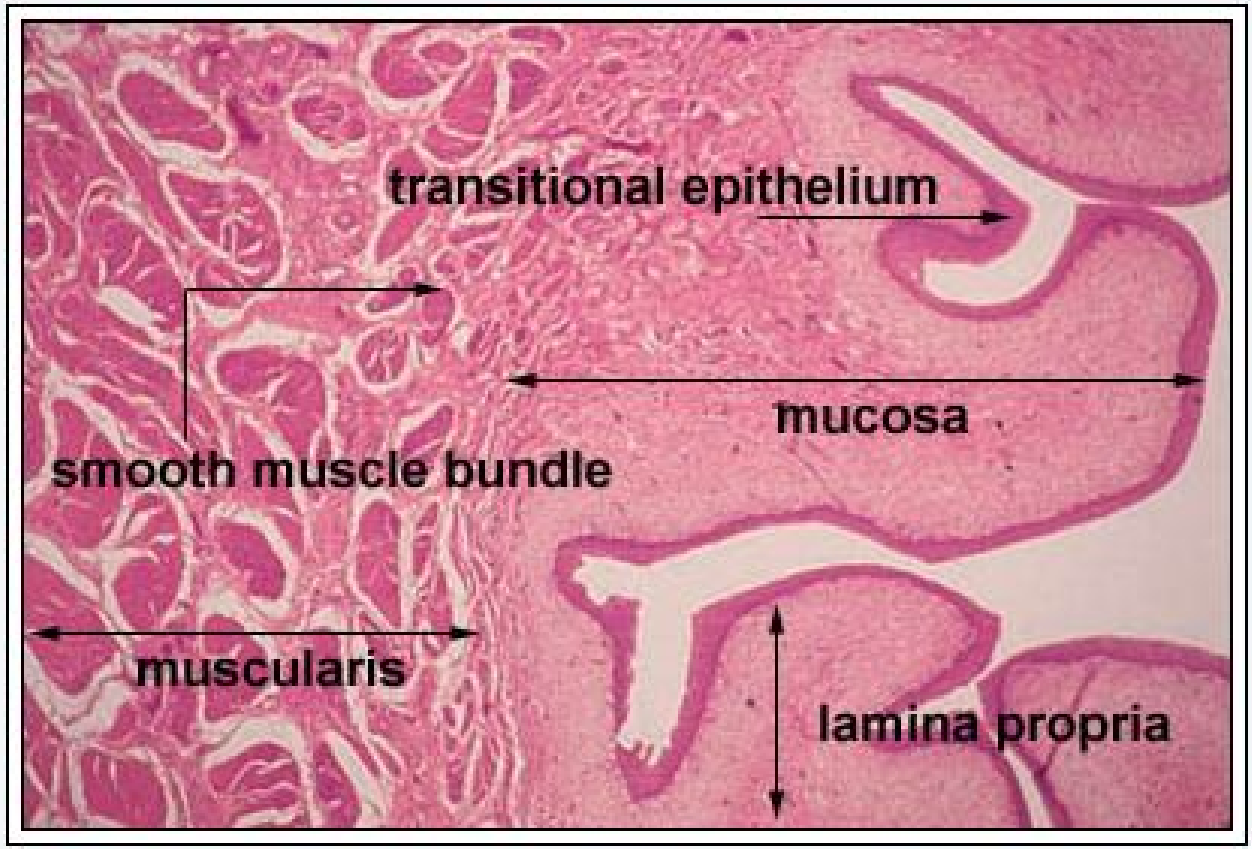
A

Bladder (empty)



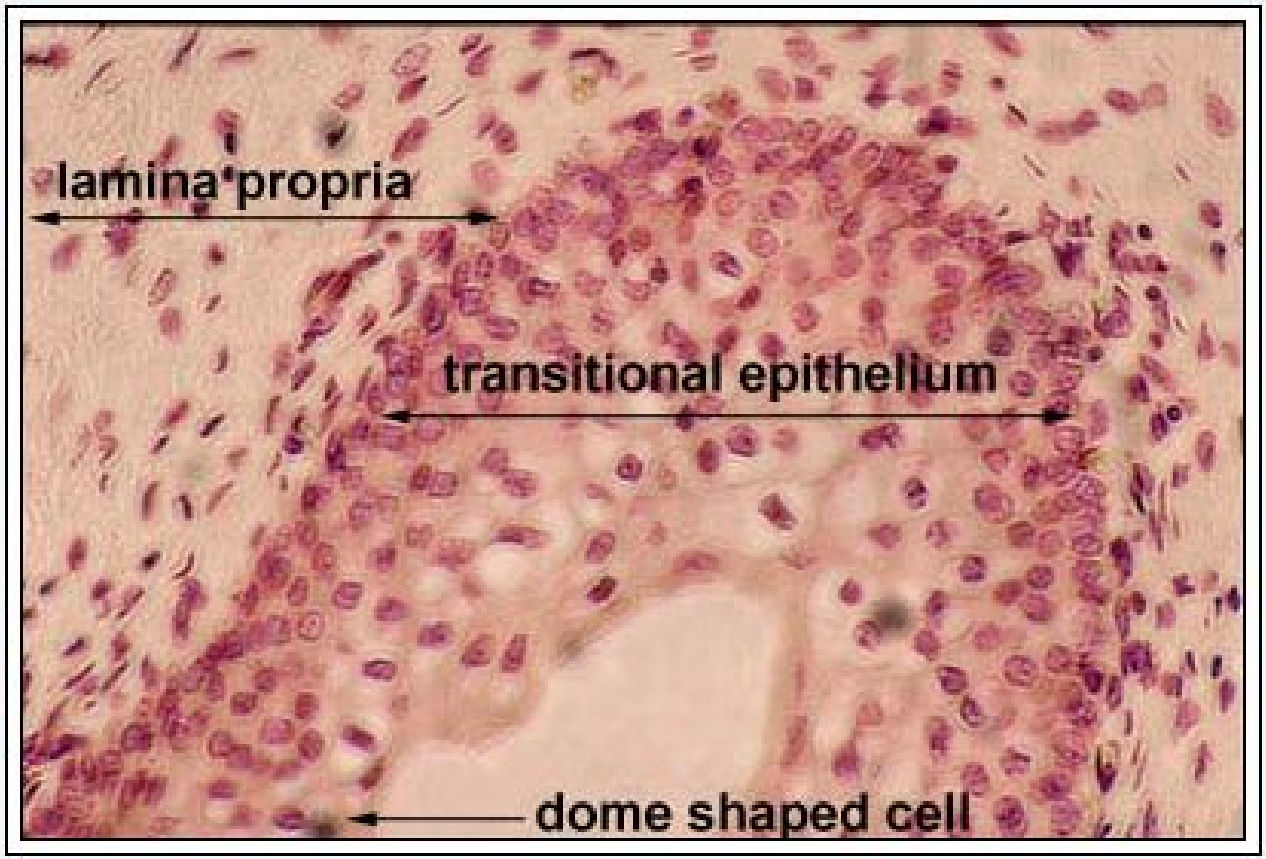
B

Compare the structure of the transitional epithelium when the urinary bladder is empty (**A**) or full (**B**). When the bladder is full, the capacity of epithelial cells to slide upon one another reduces the thickness of the epithelium. As a result, the interior surface of the bladder increases. In **B,** note the thin strands of collagen fibers separating bundles of smooth muscle cells. PSH stain. Medium magnification.



Bladder (labels) - histology slide

This histology slide is from the bladder.

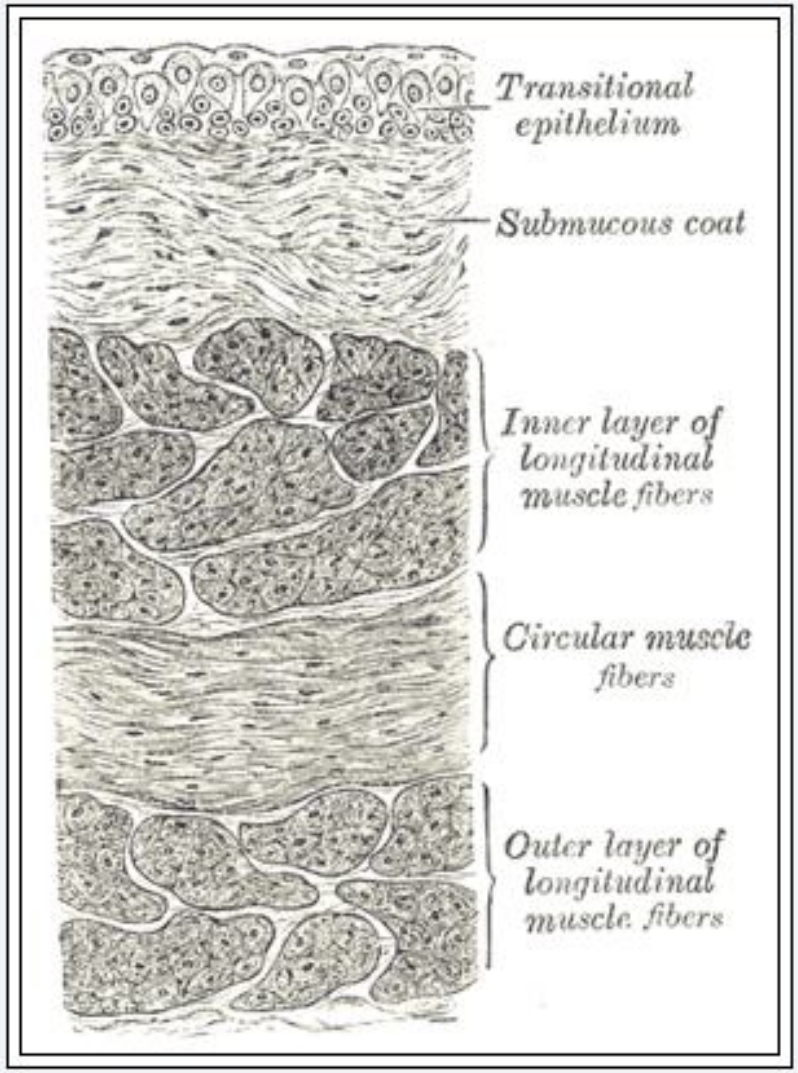


Bladder (labels) - histology slide

This histology slide is from the bladder.

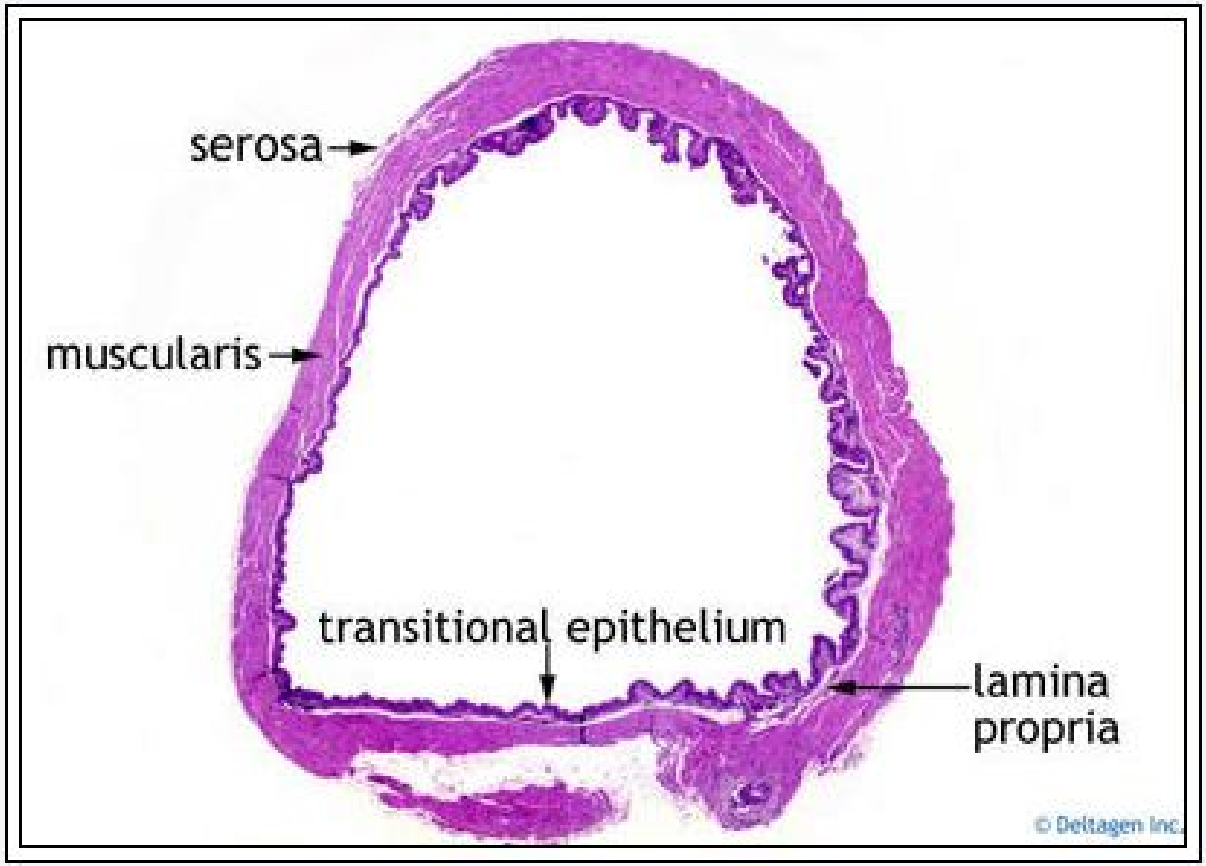
Fig. 1. *Wall (transverse section).* Stain: hematoxylin-eosin. 40×.

Transverse section H&E 160x



Bladder (labels) - histology illustration

Vertical section of bladder wall.



Bladder (labels) - histology

This is a histology slide of the bladder.