

Histology

Urinary system

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Composed of two kidneys, two ureters, the urinary bladder, and the urethra, the urinary system plays a critical role in:

- 1-** Blood filtration,(filtration of cellular wastes from blood).
- 2-** Maintenance of fluid homeostasis,(selective reabsorption of water and solutes).
- 3-** Regulation of blood pressure,(renin a protease that participates in the regulation of blood pressure). ropoi
- 4-**Erythrocyte formation,(Erythetin a glycoprotein that stimulates the production of erythrocytes.
- 5-** Vitamin D conversion to an active form.

Functionally, the urinary system is subdivided into the:

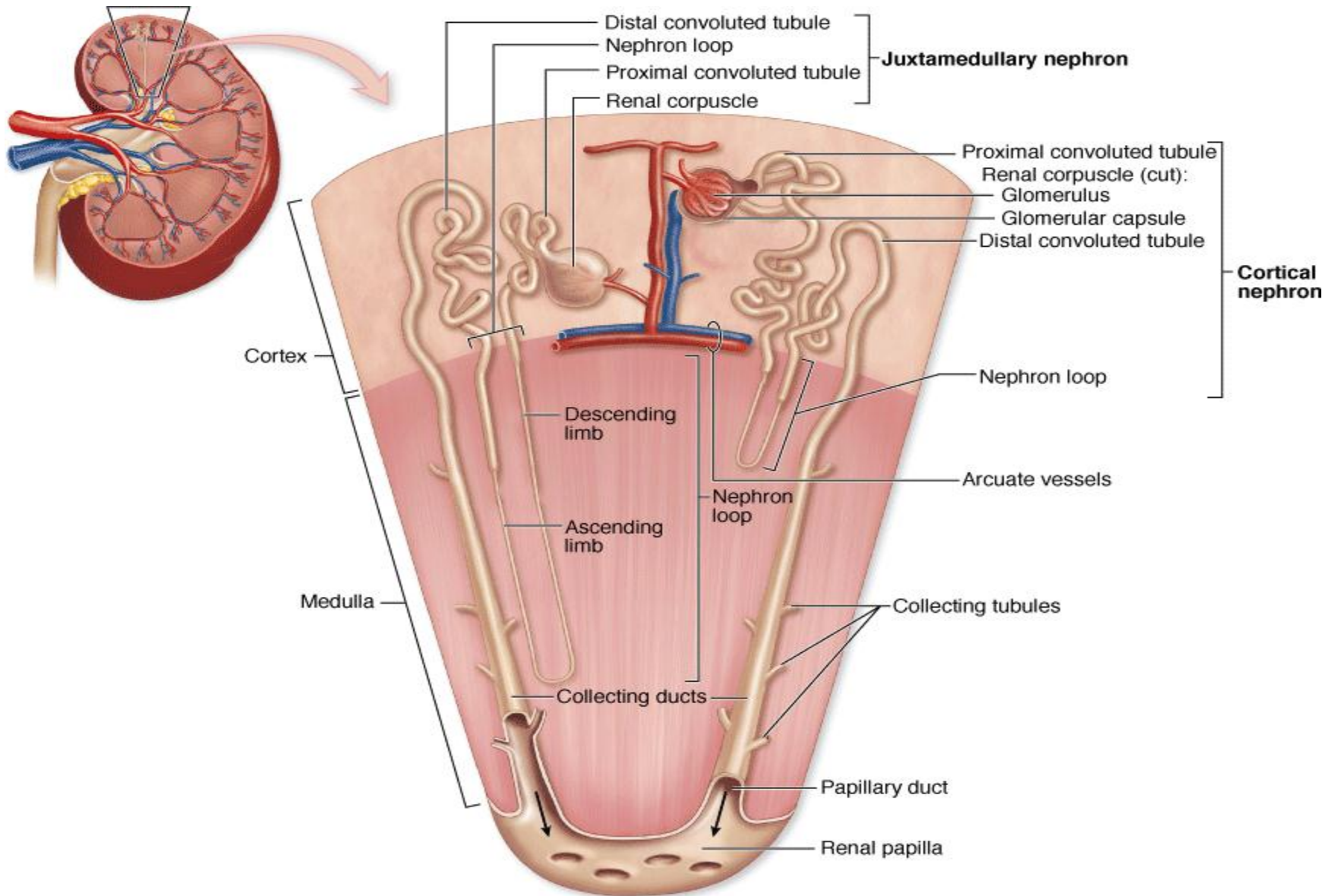
- **Excretory portion** (nephrons), responsible for blood filtration and production of urine.
- **The collecting portion** (collecting ducts, calyces, ureter, bladder, and urethra), which receives, transports, and temporarily stores formed urine until excretion

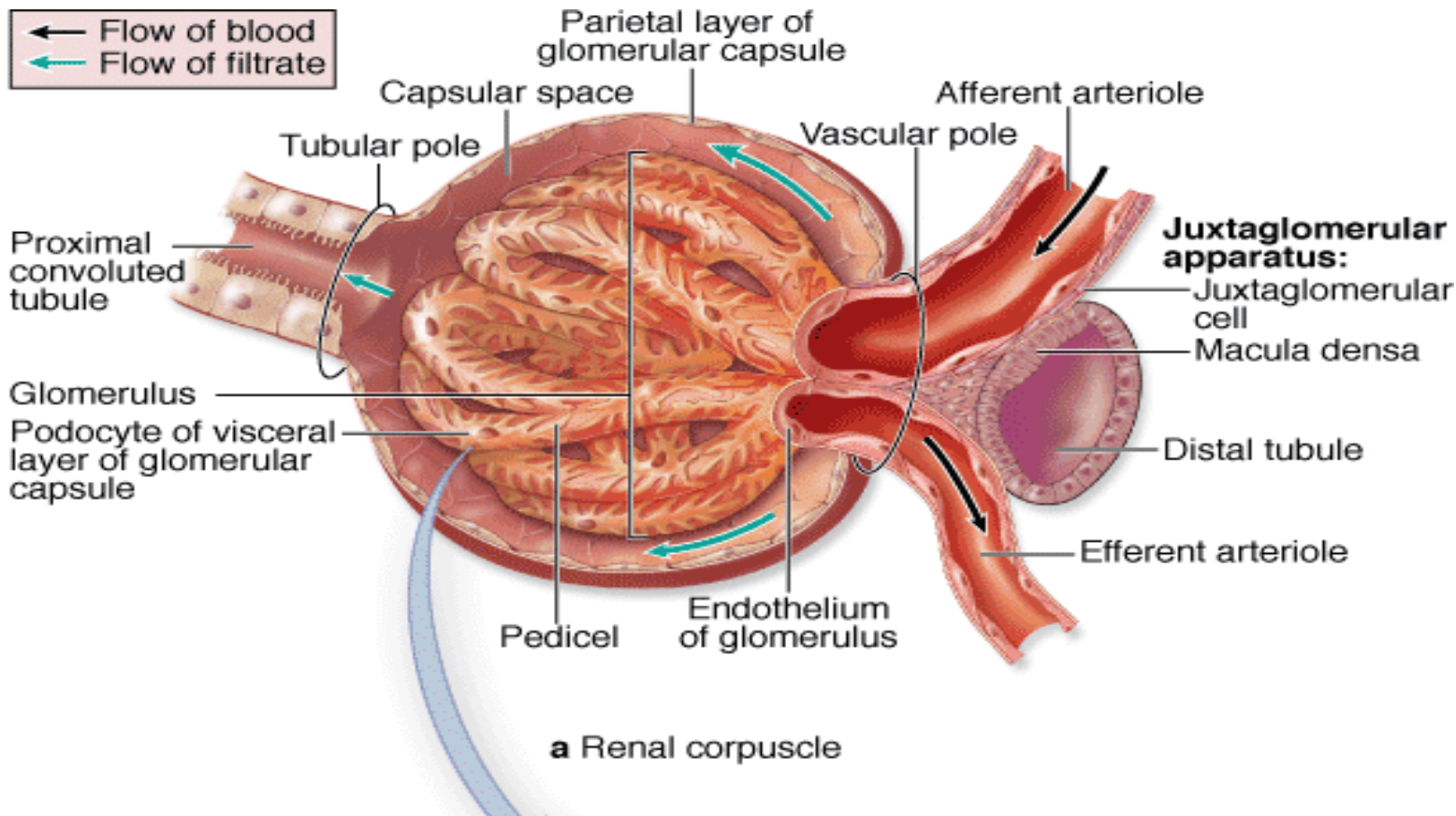
Each kidney contains 1–1.4 million functional units called **nephrons** .

Nephron: Structural and functional unit of the kidney composed of the following segments :

- **Renal corpuscle:** an initial dilated portion in cortex, Spherical structure made of glomerulus surrounded by a double-layered Bowman capsule .
- **Proximal convoluted tubule:** located in the cortex.
- **Loop of Henle:** thin and thick limbs , Where concentration of urine takes place.
- **Distal convoluted tubule:** Where resorption, acid-base balance occurs.
- **Collecting tubules and ducts:** They belong to the collecting portion of the urinary system,

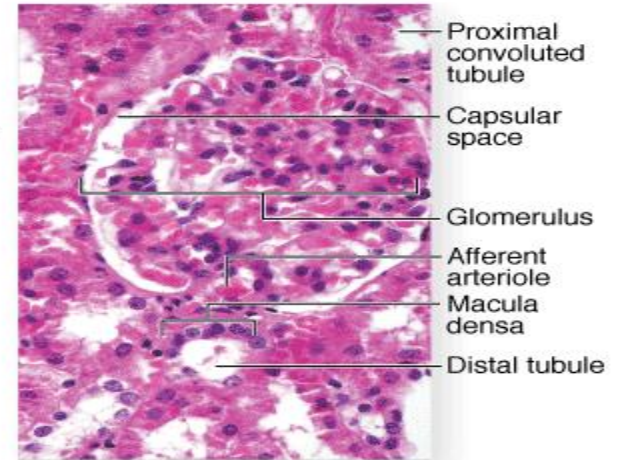
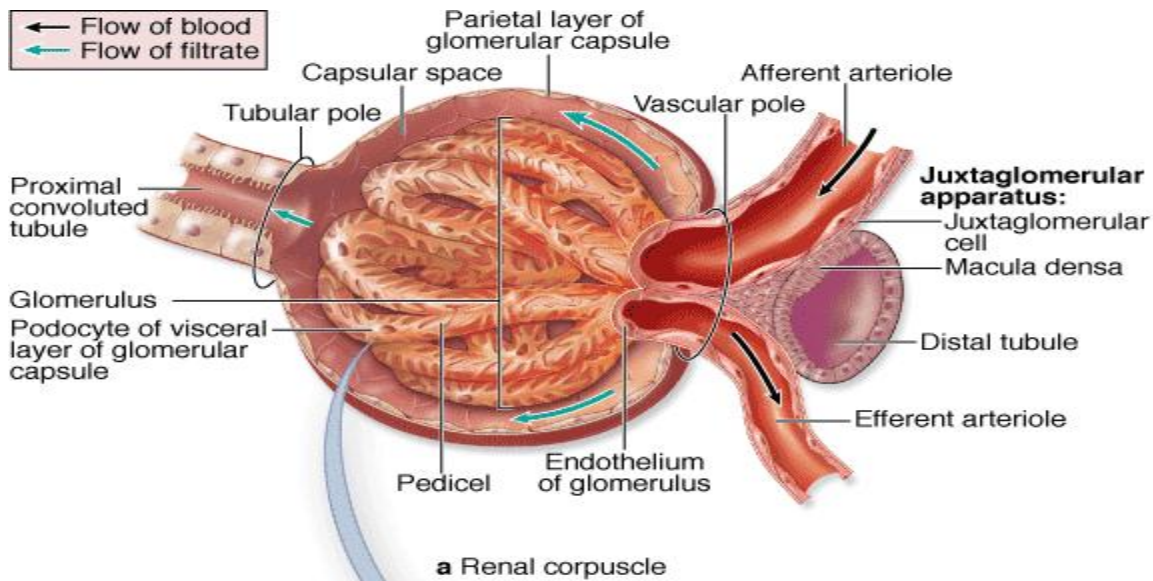
- **Juxtaglomerular apparatus:** Composed of macula densa of the DCT, JG cells of the afferent arteriolar smooth muscle, and lacis cells. Regulates blood volume and pressure via renin-angiotensin-aldosterone system.
- **Glomerular filtration barrier:** Layers through which blood filtrate passes to enter the urinary space. Composed of glomerular endothelium, basement membrane, and podocyte filtration slits of the visceral layer of the Bowman capsule. The basement membrane in particular plays a critical role in restricting the movement of large proteins and charged molecules
- **Cortical nephrons:** Positioned closer to the capsule with the loop of Henle traveling only a short distance into the medulla. Hence, urine produced is not as heavily concentrated.
- **Juxtamedullary nephrons:** Positioned closer to the medulla with the loop of Henle traveling deep into the medulla. Hence, urine produced is more concentrated.



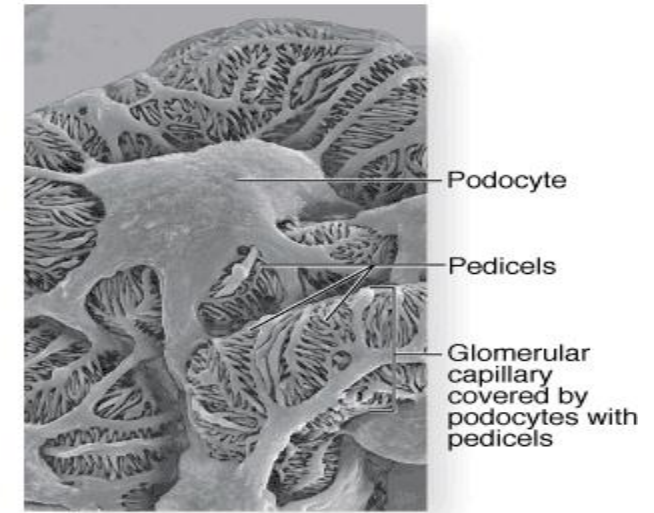
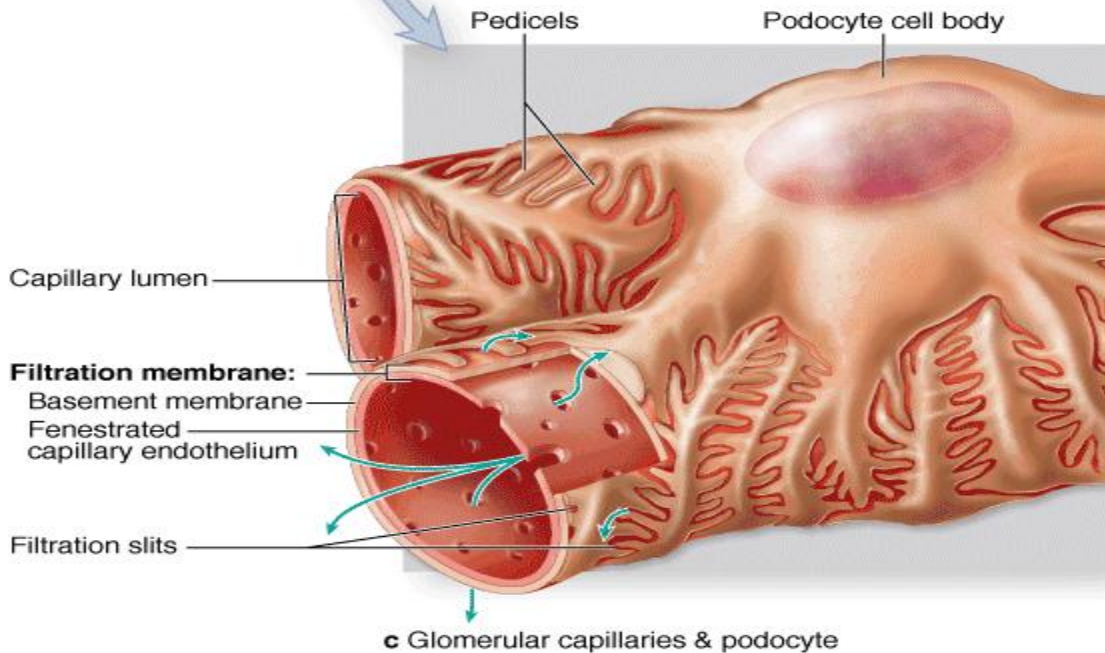


At the beginning of each nephron is a renal corpuscle, containing a loose knot of capillaries, the glomerulus, surrounded by a double-walled epithelial capsule called the glomerular (Bowman's) capsule. The internal layer (visceral layer) of the capsule closely envelops the glomerular capillaries. The external parietal layer forms the outer surface of the capsule.

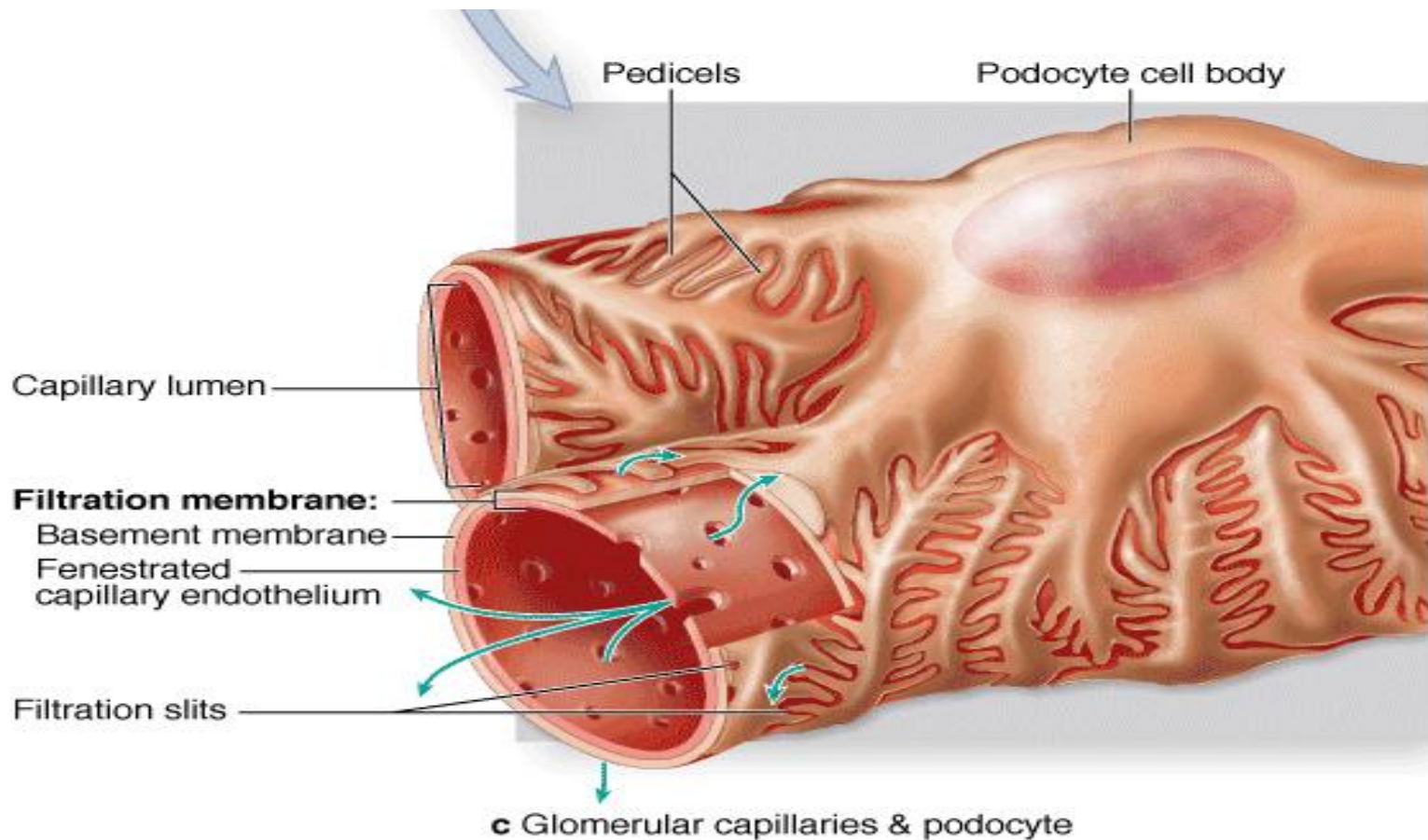
Between the two capsular layers is the urinary or capsular space, which receives the fluid filtered through the capillary wall and the visceral layer



b Histology of renal corpuscle



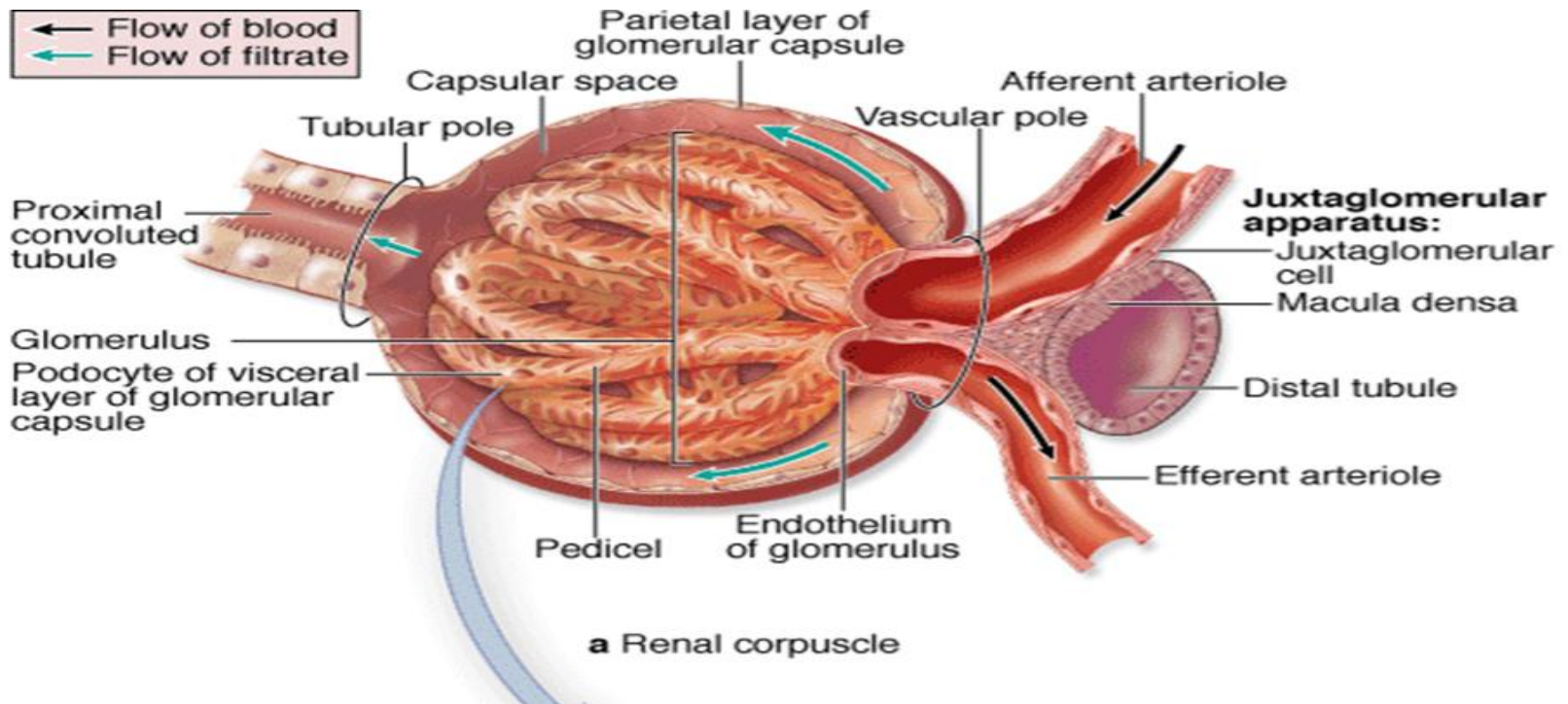
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The cells of this layer, the **podocytes**, have a cell body from which arise several primary processes. Each primary process gives rise to numerous secondary (foot) processes or pedicels that embrace a portion of one glomerular capillary. The cell bodies of podocytes do not contact the basement membrane of the capillary, but each pedicel is in direct contact with this structure.

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

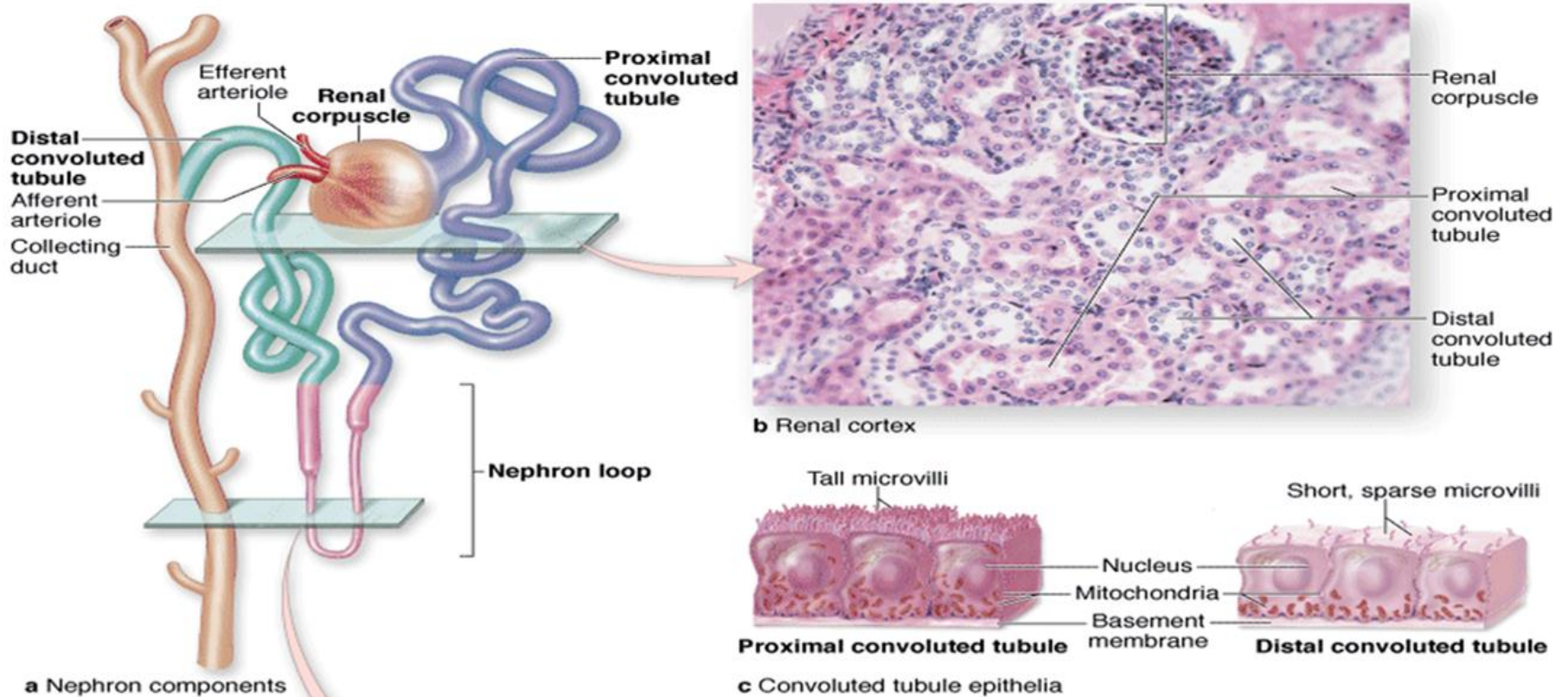
The parietal layer of a glomerular capsule consists of a simple squamous epithelium supported externally by a basal lamina and a thin layer of reticular fibers. At the tubular pole, this epithelium changes to the simple cuboidal epithelium characteristic of the proximal tubule .



Proximal Convoluted Tubule

At the tubular pole of the renal corpuscle, the squamous epithelium of the capsule's parietal layer is continuous with the cuboidal epithelium of the proximal convoluted tubule . This very tortuous tubule is longer than the distal convoluted tubule

The cell apex has abundant long microvilli which form a prominent brush border for reabsorption .

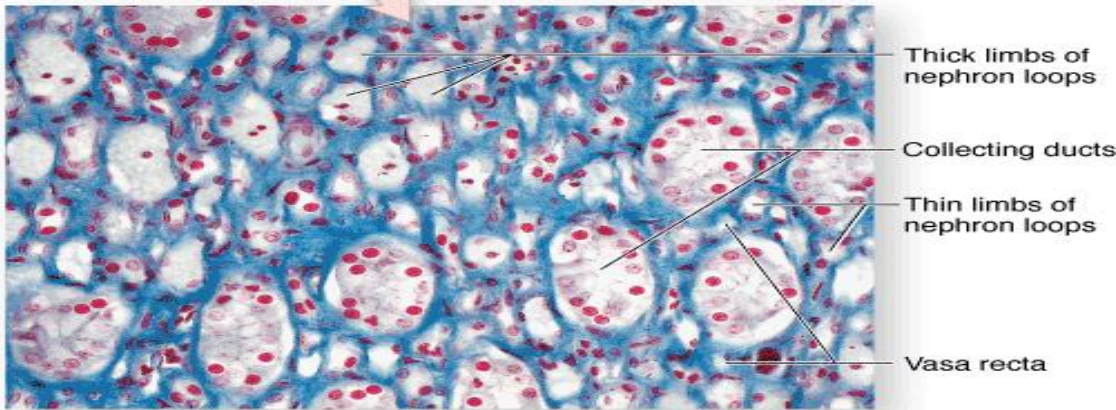
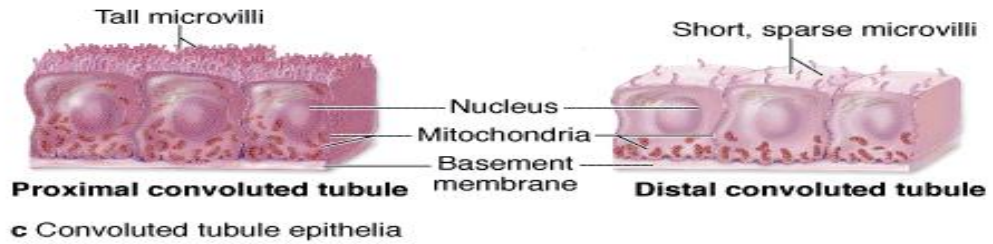
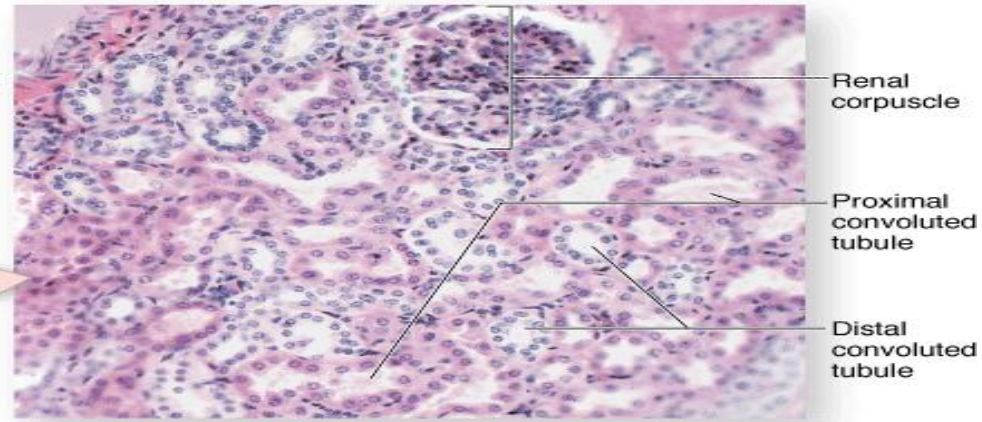
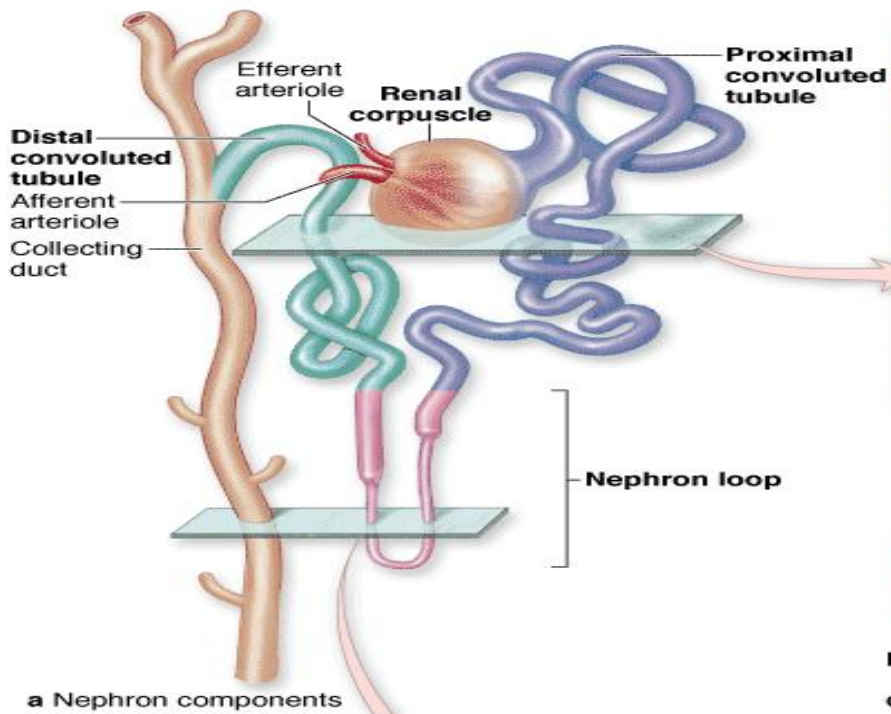


Nephron Loop (of Henle):

- This is a U-shaped structure with a descending limb and an ascending limb, both composed of simple epithelia, cuboidal near the cortex, but squamous deeper in the medulla .
- Thick descending limb : **Simple Cuboidal epithelium**, permeable to water, impermeable to salt .
- Thin descending limb: **Simple squamous epithelium**. permeable to water, increase filtrate impermeable to NaCl.
- Thin ascending limb : **Simple squamous epithelium**. Resorb NaCl ,impermeable to water , maintains the hyperosmotic interstitium.
- Thick ascending limb : **Simple cuboidal epithelium**, permeable to NaCl, impermeable to water.

Distal Convoluted Tubule & Juxtaglomerular Apparatus

The thick ascending limb of the nephron loop is straight as it enters the cortex, and then becomes tortuous as the distal convoluted tubule. The simple cuboidal cells of these tubules differ from those of the proximal convoluted tubules in being smaller and having no brush border. The rate of Na^+ absorption and K^+ secretion by the sodium pumps is regulated by aldosterone from the adrenal glands and is important for the body's water-salt balance.



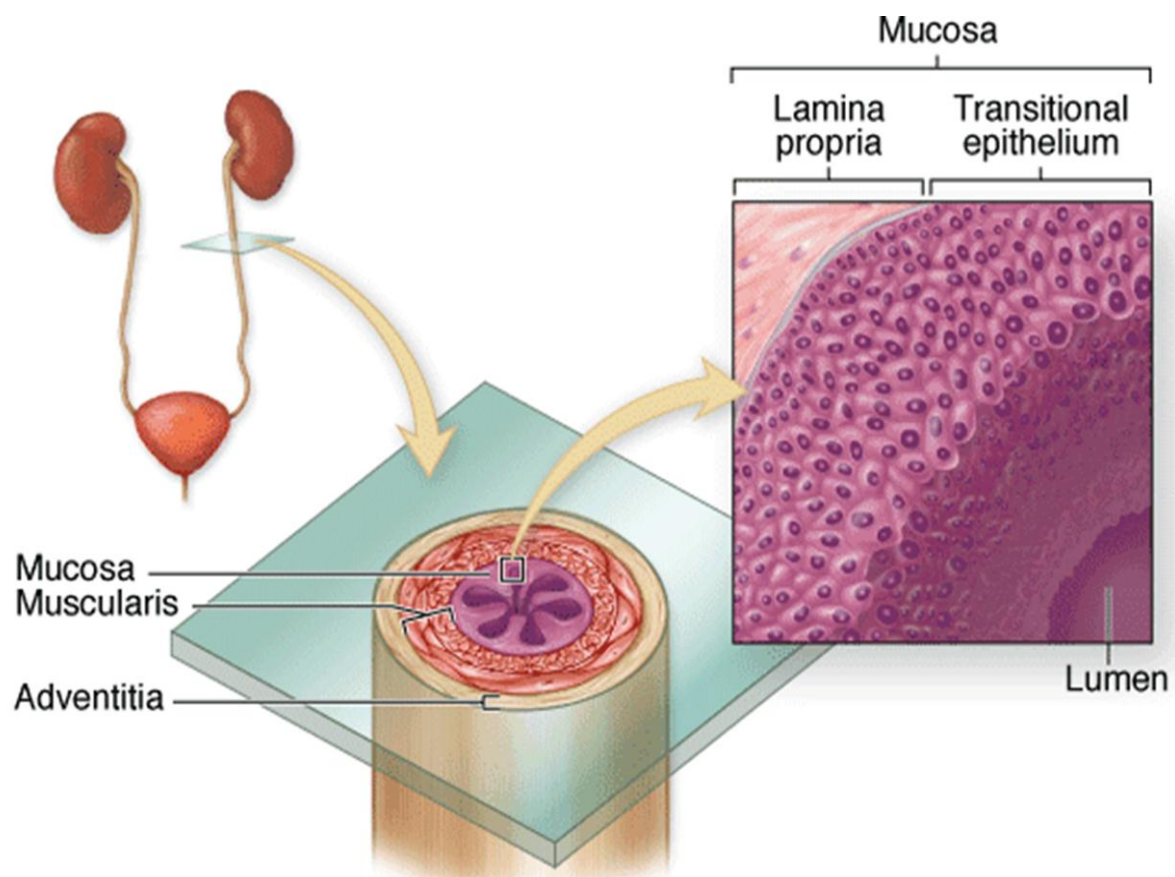
Collecting Tubules & Ducts

Urine passes from the distal convoluted tubules to **collecting tubules**, the last part of each nephron, which join each other to form larger, straight **collecting ducts** that run to the tips of the medullary pyramids and empty into the minor calyces . The collecting tubules are lined with cuboidal epithelium .

Along their entire extent, collecting tubules and ducts are composed mainly of weakly staining **principal cells** with few organelles and scanty microvilli . In the medulla, collecting ducts are a major component of the urine-concentrating mechanism. Cells of collecting ducts are particularly rich in **aquaporins**, integral proteins found in most cell membranes that function as selective pores for passage of water molecules.

Ureters, Bladder, & Urethra

Ureter, and bladder have the same basic histologic structure, with the walls becoming gradually thicker closer to the bladder. The mucosa of these organs is lined by unique stratified **transitional epithelium** or urothelium . This is surrounded by a folded lamina propria and submucosa, followed by a dense sheath of interwoven smooth muscle layers and adventitia . Urine moves from the renal pelvises to the bladder by peristaltic contractions.



The **urothelium** is composed of the following three layers:

1 - a **single layer** of small basal cells resting on a very thin basement membrane,

2 - an **intermediate region** containing from one to several layers of more columnar cells,

3 - a **superficial layer** of very large, polyhedral or bulbous cells called **umbrella cells** which are bi- or multinucleated and are highly differentiated to protect underlying cells against the cytotoxic effects of hypertonic urine.

The **urethra**

The urethral mucosa has large longitudinal folds, giving it a distinctive appearance in cross section. The male urethra consists of three segments:

- The **prostatic urethra**, 3–4 cm long, is lined by urothelium
- The **membranous urethra**, a short segment, is lined by stratified columnar and pseudostratified epithelium
- The **spongy urethra**, 15 cm in length, is lined by stratified columnar and pseudostratified columnar epithelium , with stratified squamous distally.