HISTOLOGY Of the Kidney :II

Lecture (36)

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Learning objectives (ILOs) and contents

.

After this lecture, students should be able to: -

1- Compare between the histological structure of the proximal convoluted tubules ,loop of Henle , distal convoluted tubules & collecting ducts and discriminate the type of their lining epithelium and identify their functions.

2- Describe the histological structure of the Juxtaglomerular apparatus and identify its functions.

3- Renal interstitial tissue.

4- Describe the blood supply of the kidney .

Components of the tubular system of each nephron:

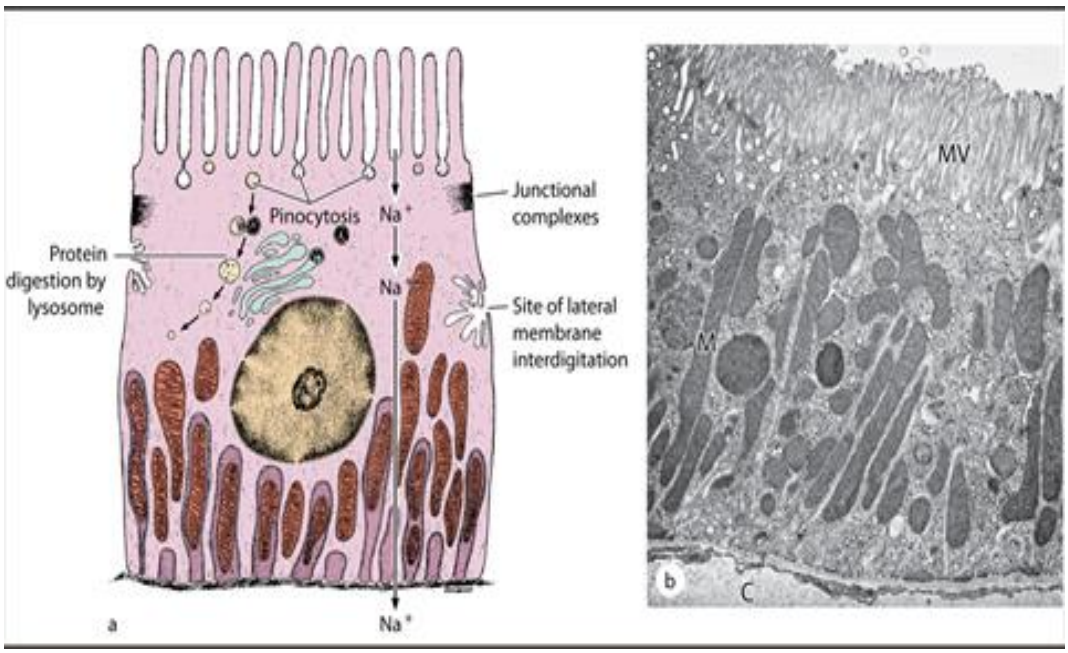
1- Proximal tubule, a long convoluted part, located entirely in the cortex, with a shorter straight part that enters the medulla;
2- Loop of Henle (or nephron loop), in the medulla, with a thin descending and a thin ascending limb;
3- Distal tubule, consisting of a thick straight part ascending from the loop of Henle back into the cortex and a convoluted part completely in the cortex; and
4- Connecting tubule, a short minor part linking the nephron to collecting duct .

-Connecting tubules from several nephrons merge to form collecting tubules that then merge as larger collecting ducts. These converge in the renal papilla, where they deliver urine to *a minor calyx*.

Microscopic structure of Proximal convoluted tubules (PCTs)

- **L.M. At the tubular pole of the renal corpuscle, the simple squamous epithelium of the capsule's parietal layer is continuous with the simple cuboidal epithelium of the proximal convoluted tubule (PCT) . These long, tortuous tubules fill most of the cortex. The PCT continues with the much shorter proximal straight tubule that enters the medulla and continues as the *Henle's loop.* The PCT is**

- **lined with simple cuboidal epithelium. Only 3-5 nuclei appear in a cross section.**
- **They have brush borders that may be disorganized and give the lumens a fuzz-filled appearance.**
- **The cytoplasm is granular and deeply acidophilic.**
- **The basal part of the cytoplasm show vertical acidophilic striations.**
- **The cell borders are ill- defined.**



A diagram and TEM of cells of proximal convoluted tubule of the kidney. Typically, long invaginations of the basal cell membrane outline regions with mitochondria (**M**). Interdigitations from neighboring cells are also present laterally. Immediately below the microvilli (**MV**) are many pinocytotic vesicles. Immediately below the basal lamina is a capillary (**C**) that removes water absorbed across the epithelium.

E.M. of P.C.Ts. **The luminal border consists of countless microvilli Immediately below the microvilli are many pinocytotic vesicles, indicating active endocytosis and pinocytosis .**

- **Interdigitations with neighboring cells are also present laterally.**
- **Typically, long invaginations of the basal cell membrane outline regions with mitochondria supply ATP locally for the membrane proteins involved in active transport.**
- **Immediately below the basal lamina, blood capillaries remove water absorbed across the epithelium.**

Functions : The cells of the proximal tubules have major roles in reabsorption and secretion owing to a large variety of transmembrane ion pumps, ion channels, transporters, enzymes, and carrier proteins .
Cells of the proximal tubule also perform hydroxylation of vitamin D and release to the capillaries.

The Henle's loop **: This is a U-shaped structure with a thin descending limb and a thin ascending limb, both composed of simple squamous epithelia. -The straight part of the proximal tubule has an outer diameter of about 60 µm, but it narrows abruptly to about 30 µm in the thin limbs of the loop.**
- The wall of the thin segments consists only of squamous cells with few organelles (indicating a primarily passive role in transport) and the lumen is prominent.

The distal convoluted tubules (DCTs) **The simple cuboidal cells of the distal tubules differ from those of the proximal tubules in being smaller and having no brush border and more empty lumens.**

Connecting tubules **are composed mainly of pale staining principal cells with few organelles, sparse microvilli, and unusually distinct cell boundaries. Ultrastructurally the principal cells can be seen to have basal membrane infoldings, consistent with their role in ion transport. Principal cells are particularly rich in aquaporins, the integral membrane pore proteins that function as specific channels for water molecules.**

Proximal convoluted tubules P.C.T.	Distal convoluted tubules D.C.T.
L.M: - The P.C.T. is lined with simple cuboidal epithelium. - They have brush borders. In routine histologic preparations, the long brush border may be disorganized and give the lumens a fuzz-filled appearance. - The cytoplasm is granular and deeply acidophilic. - The basal part of the cytoplasm show vertical acidophilic striation. - The nuclei are large and spheroidal. - Only 3-5 nuclei appear in a cross section. - The cell borders are ill- defined. - The lumen of the tubule varies according to the activity of the cells.	**L.M:** - The D.C.T. is lined by cuboidal cells which are smaller, more flat than those of PCT. - No brush border. - Less granular cytoplasm. - Less acidophilic cytoplasm and less basal striations. - The number of the cells is (5-8). - The cell borders are well- defined - The lumen is wider.
E.M. - The luminal border consists of countless microvilli,the apical cytoplasm of these cells has numerous pits and vesicles near the bases of the microvilli, indicating active endocytosis and pinocytosis . -Have many long basal membrane invaginations and lateral interdigitations with neighboring cells . -Both the brush border and the basolateral folds contain the many types of transmembrane proteins that mediate tubular reabsorption and secretion. - A large number of gaint elongated mitochondria arranged parallel to the long axis of the cells and between the basal infoldings supply ATP locally for the membrane proteins involved in active transport. - Golgi apparatus is located in the supranuclear part of the cytoplasm.	**E.M.** - Short microvilli. - Less interdigitations. - Less extensive basal infoldings. - Much less tubular reabsorption occurs here than in the proximal tubule. The distal tubule is the primary site of urine concentration.

-A connecting tubule extends from each nephron and several join together in the cortical medullary rays to form collecting ducts of simple cuboidal epithelium and an average diameter of 40 µm.
-In the medulla these merge further, forming larger and straighter collecting ducts with increasingly columnar cells and overall diameters reaching 200 µm. The medullary collecting ducts are the final site of water reabsorption from the filtrate.
-The last part of each nephron, the connecting tubule, carries the filtrate into a collecting system that transports it to a minor calyx and in which more water is reabsorbed if needed by the body .

Juxtaglomerular apparatus

Where the initial, straight part of the distal tubule contacts the arterioles at the vascular pole of the renal corpuscle of its parent nephron, its cells become more columnar and closely packed, forming the macula densa (L. thicker spot). This is a part of ***a specialized sensory structure***, the juxtaglomerular apparatus (JGA) that utilizes feedback mechanisms to regulate glomerular blood flow and keep the rate of glomerular filtration relatively constant.

It is formed of ;

A- Modification in the afferent arteriole:

The smooth muscle cells are modified as ***juxtaglomerular granular (JG) cells,*** with a secretory phenotype including more rounded nuclei, rough ER, Golgi complexes, and granules with the protease renin.

B- Modification in the distal convoluted tubule:

This modification occurs in the portion of the distal convoluted tubule which lies in contact with renal corpuscle.

-The basement membrane is lost.

-The cells become taller columnar and crowded.

-The nuclei become deeply stained and close together. These cells are called ***macula densa cells***.

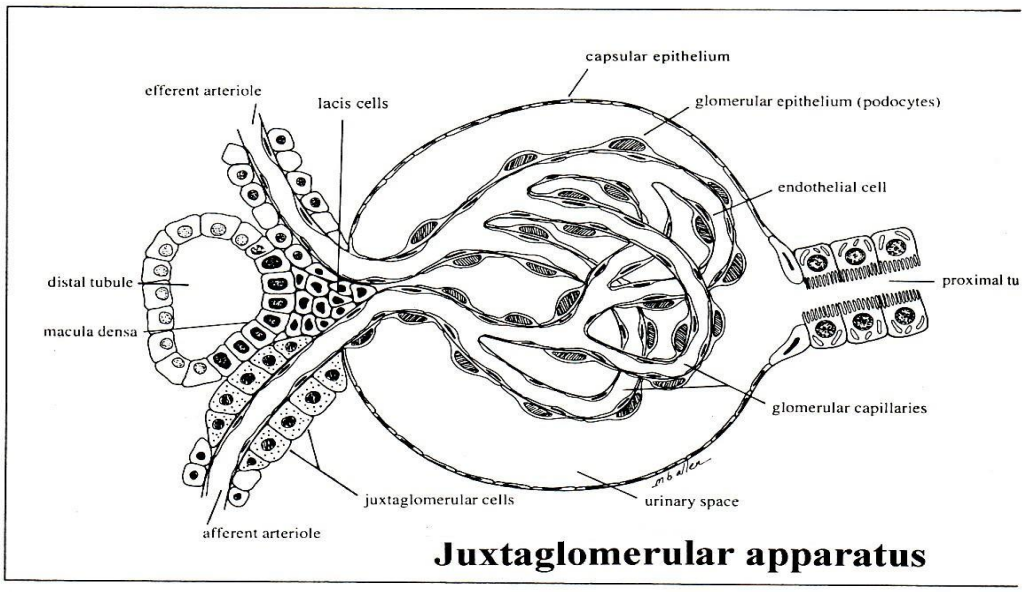
C- Extra glomerular mesangial cells.

Occupy the area between the macula densa, the glomerulus and the afferent arteriole .

Basic functions of the JGA is the autoregulation of the GFR and controlling blood pressure via several activities including;

1-Local baroreceptors in the afferent arteriole, possibly the JG cells themselves and release of renin.

.2-Monitoring of luminal concentrations of Na+ and Cl– in of the nephron by cells of the macula densa.



Renal interstitial tissue

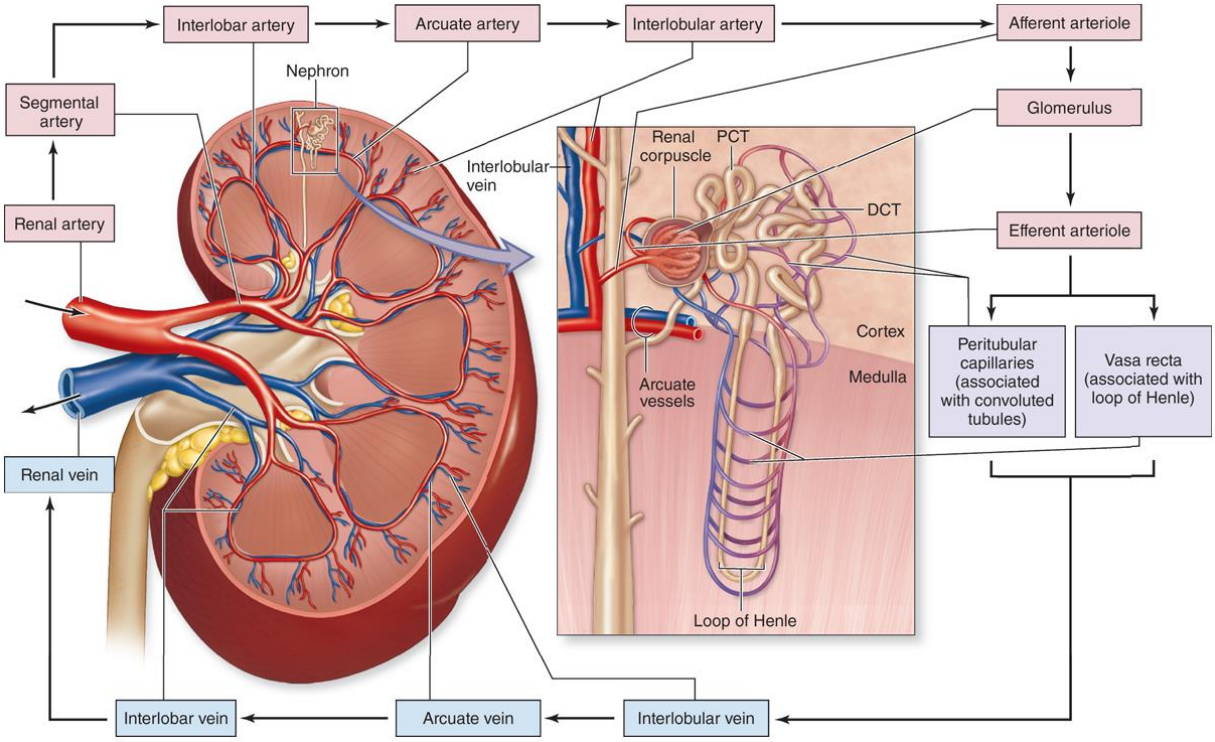
-Both the cortex and the medulla contain specialized cells in the spaces between uriniferous tubules and the blood and lymph vessels. These cells are called "interstitial cells".

-The interstitial cells are more frequent in the medulla where cells containing cytoplasmic lipid droplets are involved in the synthesis of a hypotensor

hormone (medullipin I) a substance that is converted in the liver to medullipin II, a potent vasodilator that lowers blood pressure.
-Peritubular capillaries are abundant in the sparse surrounding connective tissue interstitium, which fills only about 10% of the cortex .
-Moreover, fibroblastic Region of interstitial cells in cortical areas near the proximal tubules produce erythropoietin, the growth factor secreted in response to a prolonged decrease in local oxygen concentration.

Blood supply of the kidney:

As expected for an organ specialized to process the blood, the kidney vasculature is large, well-organized, and closely associated with all components of the nephron. Blood vessels of the kidneys are named *according to their locations or shapes .*



Arterial supply:

1- Each kidney's renal artery divides into two or more segmental arteries at the hilum. Around the renal pelvis, these arteries branch further as

the interlobar arteries, which extend between the renal pyramids toward the corticomedullary junction .

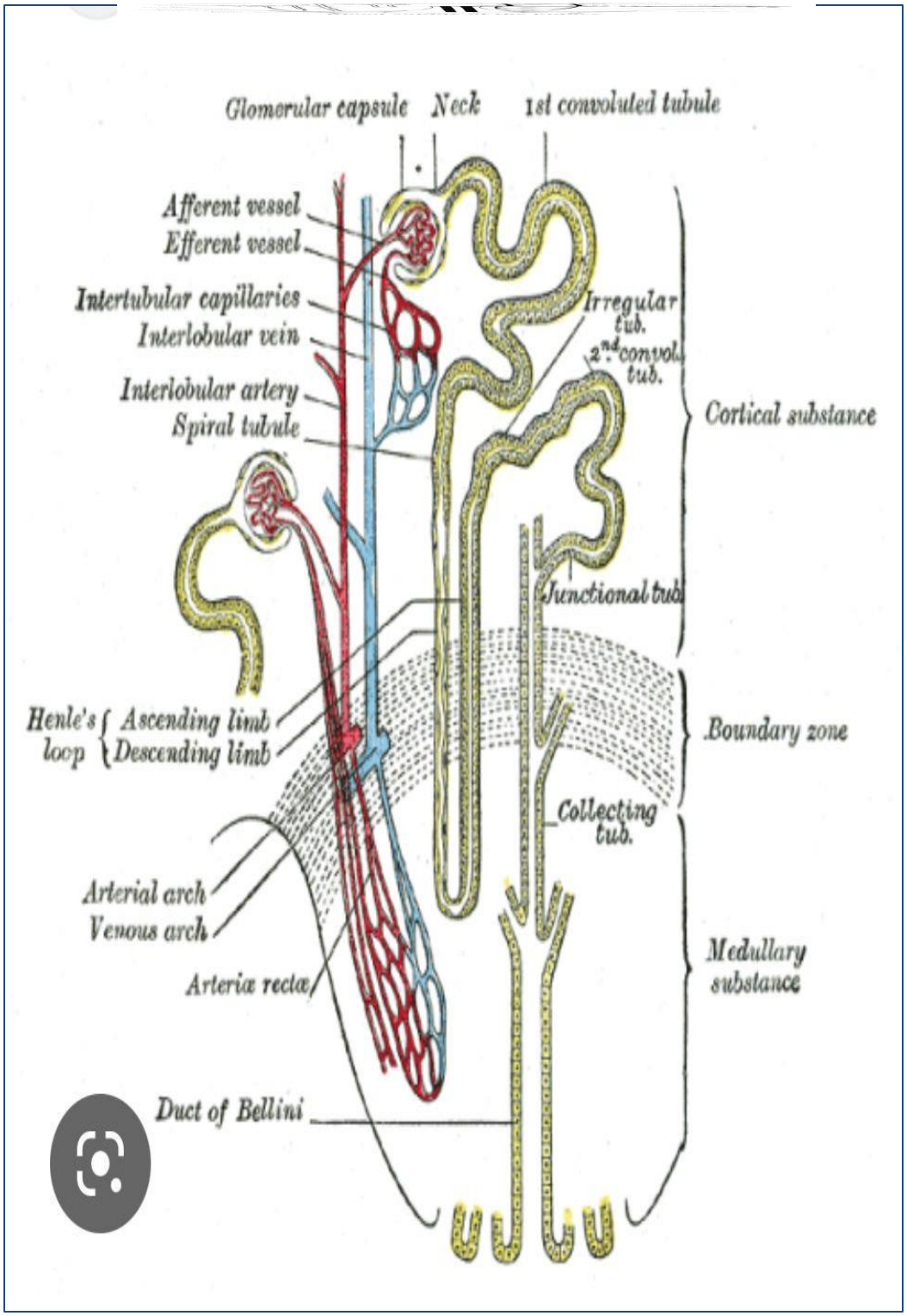
2- At the junction between the pyramid and cortex, the interlobar arteries give arcuate arteries, which give interlobular arteries.

3- The interlobular arteries give off afferent arterioles which form capillary network (glomerulus).

4-Blood leaves the glomerular capillaries, not via venules, but via efferent arterioles, which at once branch again to form another capillary network, usually the peritubular capillaries profusely distributed throughout the cortex.

5- **The efferent arterioles from the juxtamedullary nephrons** near the medulla **form vasae rectae**, they branch repeatedly to form parallel tassel-like bundles of capillary loops called the vasa recta (L. recta, straight) that penetrate deep into the medulla in association with the loops of Henle and collecting ducts..

Collectively, the cortex receives over 10 times more blood than the medulla. Blood leaves the kidney in veins that follow the same courses as arteries and have the same names.



Reference Books

-[Tao_Le_et_al.]_First_Aid_for_the_Basic_Sciences

- First Aid For Studying Basic Medical Science