The Objectives:

In the end of this lecture you should understand:

-Study the histological section, structures of kidneys.

-Revision the general function of urinary system.

-Recognize the major divisions of each nephron.

–Follow the blood circulation in kidneys.

-Revision Renal Corpuscles & Blood Filtration.

The urinary system consists of the paired kidneys and ureters, the bladder, and the urethra. This system's primary role is to ensure optimal properties of the blood, which the kidneys continuously monitor. This general role of the kidneys involves a complex combination of renal functions:

1.Regulation of the balance between water and electrolytes (inorganic ions) and the acid–base balance;

2.Excretion of metabolic wastes along with excess water and electrolytes in urine, the kidneys' excretory product which passes through the ureters for temporary storage in the bladder before its release to the exterior by the urethra;

3.Excretion of many bioactive substances, including many drugs;

4.Secretion of renin, a protease important for regulation of blood pressure by cleaving circulating angiotensinogen to angiotensin I;

The kidney:

Approximately 12–cm long, 6–cm wide, and 2.5–cm thick in adults, each kidney has a concave medial border, the **hilum**—where nerves enter, the ureter exits, and blood and lymph vessels enter and exit—and a convex lateral surface, both covered by a thin fibrous capsule .

Within the hilum the upper end of the ureter expands as the **renal pelvis** and divides into two or three **major calyces**. Smaller branches, the minor calyces, arise from each major calyx. The area surrounding the renal pelvis and calyces contains adipose tissue.

The parenchyma of each kidney has an outer **renal cortex**, a darker stained region with many round corpuscles and tubule cross sections, and an inner **renal medulla** consisting mostly of aligned linear tubules and ducts .

The renal medulla in humans consists of $8-15$ narrowed structures called **renal pyramids**, all with their bases meeting the cortex (at the corticomedullary junction) and separated from each other by extensions of the cortex called renal columns. Each pyramid plus the cortical tissue at its base and extending along its sides constitutes a **renal lobe**.

Parallel ducts and tubules extending from the medulla into the cortex include the medullary rays; these plus their associated cortical tissue are considered renal lobules. The tip of each pyramid, called the **renal papilla**, projects into a minor calyx that collects urine formed by tubules in one renal lobe.

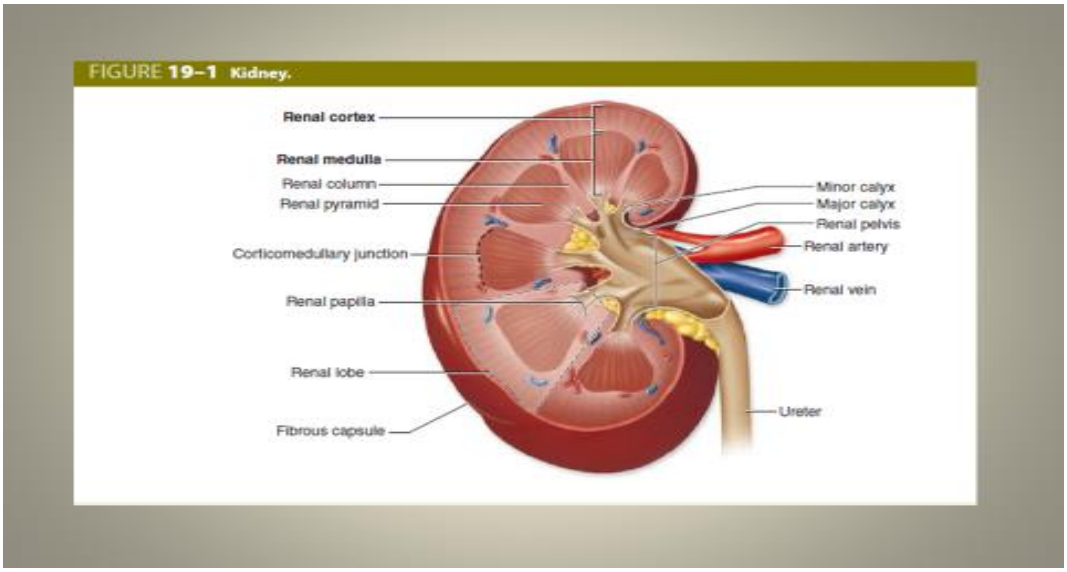
Each kidney contains $1-4$ million functional units called **nephrons** ,each consisting of a corpuscle and a long, simple epithelial renal tubule with three main parts along its length. The following are the major divisions of each nephron:

- **Renal corpuscle**, an initial dilated part enclosing a tuft of capillary loops and the site of blood filtration, always located in the cortex.
- **Proximal tubule**, a long convoluted part, located entirely in the cortex, with a shorter straight part that enters the medulla.
- **Loop of Henle** (or nephron loop), in the medulla, with a **thin descending** and a **thin ascending** limb.
- **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.

- **Connecting tubule**, a short minor part linking the nephron to collecting ducts.

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. **Cortical nephrons** are located almost completely in the cortex while **juxtamedullary nephrons** (about one-seventh of the total) lie close to the medulla and have long loops of Henle.



BLOOD CIRCULATION

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.

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. Here the interlobar arteries divide again to form the **arcuate arteries**, which run in an arc along this junction at the base of each renal pyramid. Smaller **interlobular arteries**

(or cortical radial arteries) radiate from the arcuate arteries, extending deeply into the cortex.

From the interlobular arteries arise the microvascular **afferent arterioles**, which divide to form a plexus of capillary loops called the **glomerulus**, each of which is located within a renal corpuscle where the blood is filtered.

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. From the juxtaglomerular corpuscles near the medulla, efferent arterioles do not form peritubular capillaries, but instead branch repeatedly to form parallel tassel-like bundles of capillary loops called the **vasa recta** (L. *recta*, straight), which 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.

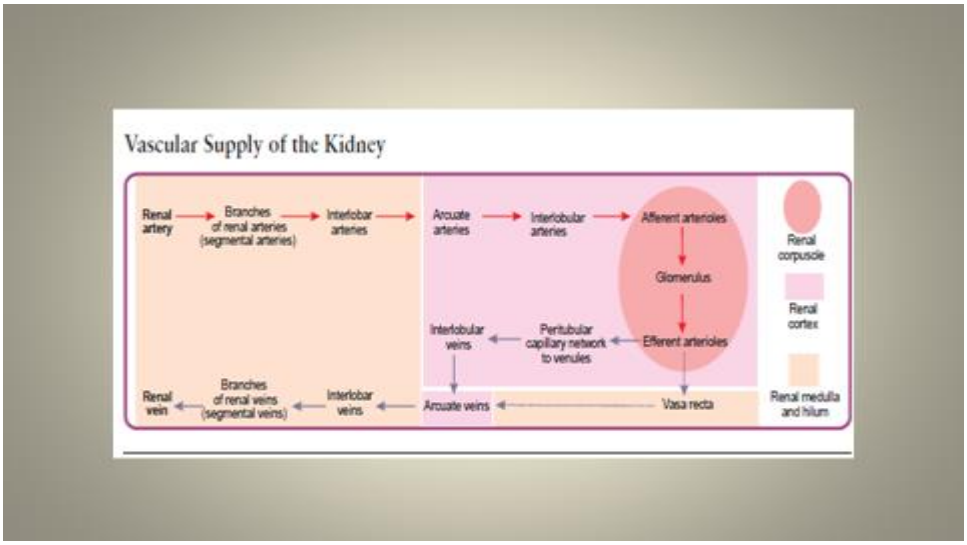
Blood leaves the kidney in veins that follow the same courses as arteries and have the same names.

The outermost peritubular capillaries and capillaries in the kidney capsule converge into small stellate veins that empty into the interlobular veins.

MEDICAL APPLICATION

Polycystic kidney disease: is an inherited disorder in which normal cortical organization of both kidneys is lost due to the formation of multiple, large, fluid-filled cysts.

The cysts may arise from any epithelial cells of the nephron and can lead to gross kidney enlargement and loss of renal function



Renal Corpuscles & Blood Filtration

At the beginning of each nephron is a renal corpuscle, about 200 μm in diameter and containing a tuft of glomerular capillaries, surrounded by a double-walled epithelial capsule called the **glomerular (Bowman)** .

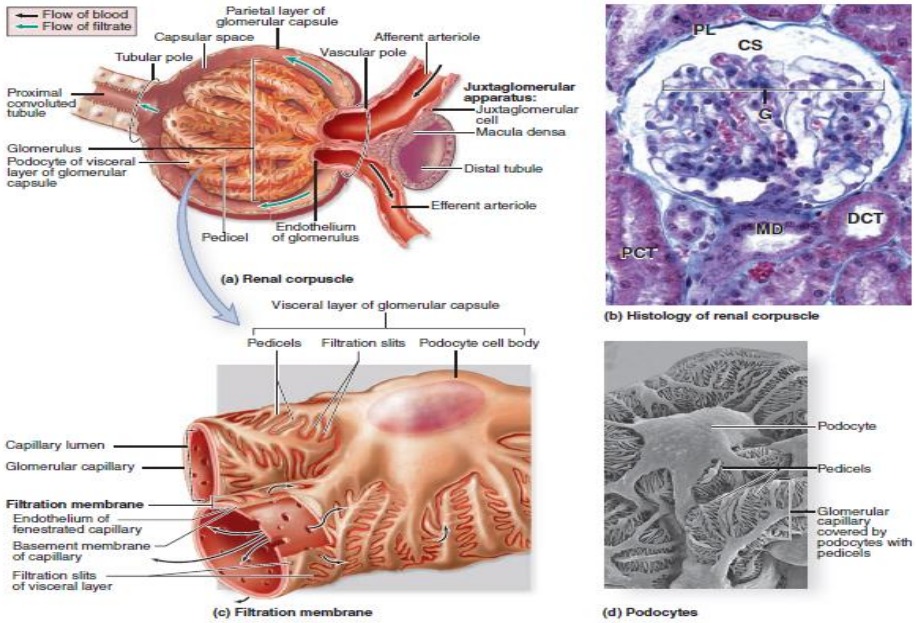
The internal or **visceral layer** of this capsule closely envelops the glomerular capillaries, which are finely fenestrated. The outer **parietal layer** forms the surface of the capsule. Between the two capsular layers is the **capsular (or urinary) space**, which receives the fluid filtered through the capillary wall and the visceral layer.

Each renal corpuscle has a **vascular pole**, where the afferent arteriole enters and the efferent arteriole leaves, and a **tubular pole**, where the proximal convoluted tubule (PCT) begins.

The outer parietal layer of a glomerular capsule consists of a simple squamous epithelium supported externally by a basal lamina. At the tubular pole, this epithelium changes to the simple cuboidal epithelium that continues and forms the proximal tubule

The visceral layer of a renal corpuscle consists of unusual stellate epithelial cells called **podocytes** , which together with the capillary endothelial cells compose the apparatus for renal filtration. From the cell body of each podocyte several **primary processes** extend and curve around a length of glomerular capillary. Each primary process gives rise to many parallel, interdigitating secondary processes or **pedicels**

(L. *pedicellus*, little foot). The pedicels cover much of the capillary surface, in direct contact with the basal lamina .



SUMMARY

Kidney

Each kidney has a thick outer **cortex**, surrounding a **medulla** that is divided into 8–12 renal pyramids; each pyramid and its associated cortical tissue comprises a **renal lobe**.

The apical papilla of each renal pyramid inserts into a **minor calyx**, a subdivision of two or three **major calyces** extending from the **renal pelvis**.

The **ureter** carries urine from the renal pelvis and exits the **renal hilum**, where the **renal artery and vein** are also located.

Renal Vasculature

Renal arteries branch to form smaller arteries between the renal lobes, with **interlobular arteries** entering the cortex to form the microvasculature; venous branches parallel the arterial supply.

In the cortex **afferent arterioles** enter capillary clusters called **glomeruli**, which are drained by **efferent arterioles**, instead of venules, an arrangement that allows higher hydrostatic pressure in the capillaries.

The **efferent arterioles** from cortical glomeruli branch diffusely as **peritubular capillaries**, while those from juxtamedullary glomeruli branch as long microvascular loops called **vasa recta** in the medulla.

Q: Directions: one or more of the given statements or completions is/are correct. Choose the answer: A – if only 1,2, and 3 are correct; B – if only 1 and 3 are correct; C – if only 2 and 4 are correct; D – if only 4 is correct; E – if all are correct.

The following statements regarding the renal podocytes are true:

(1) are the cells of the capsular parietal layer (2) have processes subdivided into pedicels (3) lack their own basement membrane (4) the processes of neighboring podocytes interdigitate to form filtration slits

Selected references:

1. **Histology Textbooks 'Basic Histology', Junqueira,13 th Edition**

2. **'Colour Atlas of Histology' Gartner and Hiatt, 5 th Edition**