**THE URINARY SYSTEM:**

The urinary system consists of the paired kidneys and ureters, the bladder, and the urethra. This system helps maintain homeostasis by a complex combination of

processes that involves the following:

**i)Filtration of cellular wastes from blood.**

**ii)Selective reabsorption of water and solutes.**

**iii)Excretion of the wastes and excess water as urine.**

**KIDNEYS.**

1-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,

2-both covered by a thin fibrous capsule . The expanded upper end of the ureter, called the **renal pelvis,** divides into two or three **major calyces.**

3-The kidney has an outer **cortex** and an inner **medulla**. In humans, the renal medulla consists of 8–15 conical structures called **renal pyramids**, which are separated by cortical extensions called **renal columns**. Each medullary pyramid plus the cortical tissue at its base and along its sides constitutes a **renal lobe.**

**Nephrons.**

1-Within each renal lobe are hundreds of thousands of nephrons, the function unit of the kidney. Each nephron originates in the cortex, at the renal corpuscle associated with glomerular capillaries. 2-Extending from the corpuscle is the proximal convoluted tubule, then the nephron loop (of Henle) into the medulla and back to the cortex, then the distal convoluted tubule and collecting tubule which merges into a collecting duct for urine transport to the calyx. 3-All nephrons are located completely within the cortex except for their medullary loops. **Juxtamedullary nephrons** usually have much longer loops than cortical nephrons.

**The major divisions of each nephron are**:

**I-Renal Corpuscles(** **glomerulus) :**

1-At the beginning of each nephron is a renal corpuscle, and containing a loose knot of capillaries, the glomerulus, surrounded by a double walled epithelial capsule called the **glomerular (Bowman's) capsule** . 2-The internal layer (**visceral layer**) of the capsule closely envelops the glomerular capillaries . The external **parietal layer** forms the outer surface of the capsule. 3-Between the two capsular layers is the urinary or **capsular space,**which receives the fluid filtered through the capillary wall and the visceral layer. 4-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 . 5- After entering the renal corpuscle, the afferent arteriole usually divides and subdivides into the two to five capillaries of the renal glomerulus. 6-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 .

**II-Proximal Convoluted Tubule:**

1-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** . 2-This very tortuous tubule is longer than the distal convoluted tubule and is therefore more frequently seen in sections of renal cortex.

**Function of** **proximal convoluted tubule** : 1-Cells of the proximal tubule reabsorb 60–65% of the water filtered in the renal corpuscle, along with almost all of the nutrients, ions, vitamins, and small

plasma proteins. The water and its solutes are transferred directly across the tubular wall and immediately taken up by the **peritubular capillaries**. 2- The cells of the proximal tubules have acidophilic cytoplasm because of the presence of numerous mitochondria. The cell apex has abundant long microvilli which form a prominent **brush border** for reabsorption . 3- Because the cells are large, each transverse section of a proximal tubule typically contains only three to five rounded nuclei.

**III-Nephron Loop (of Henle):**

1-The proximal convoluted tubule continues as a much shorter proximal straight tubule which enters the medulla and becomes the **nephron loop**. 2- 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 .

3-The lumen of this segment of the nephron is wide and the wall consists of squamous epithelial cells whose nuclei protrude slightly into the lumen . 4-The nephron loop and surrounding tissue are involved in making urine hypertonic and conserving water.

**Cells of nephron loop and function:**

***i)*Cuboidal cells** of the loops' thick ascending limbs actively transport sodium chloride out of the tubule against a concentration gradient into the hyaluronate-rich interstitial connective tissue, making that compartment hyperosmotic. ***ii)*Squamous cells** of the loops' thin descending limbs are freely permeable to water but not salts, while the thin ascending limbs are permeable to NaCl but impermeable to water.

**IV-Distal Convoluted Tubule :**

1-The thick ascending limb of the nephron loop is straight as it enters the cortex, and then becomes tortuous as the **distal convoluted tubule** . 2-The simple cuboidal cells of these tubules differ from those of the proximal convoluted tubules in being smaller and having no brush border . 3-Because distal tubule cells are flatter and smaller than those of the proximal tubule, more nuclei are typically seen in sections of distal tubules than in those of proximal tubules. 4- Cells of the distal convoluted tubule do have basal membrane invaginations and associated mitochondria similar to those of proximal tubules, indicating their

similar ion-transporting function.

**Function of** **distal convoluted tubule** . ***A)***At the point of contact with the arterioles, the cells of the distal tubule become columnar and more closely packed, with apical nuclei, basal Golgi complexes, and a more elaborate and varied system of ion channels and transporters. ***B)***This thickened spot of the distal tubule wall is called the **macula densa** . Adjacent to the macula densa, the tunica media of the afferent arteriole is also modified.

***C)***The distal tubule also secretes H+ and NH4+ into tubular urine, an activity essential for maintenance of the acid-base balance in the blood.

**V-Juxtaglomerular apparatus** (**JGA**):

1-The initial, straight part of the distal tubule makes contact with the vascular pole of the renal corpuscle of its parent nephron and forms part of a specialized structure,the **juxtaglomerular apparatus** (**JGA**) . 2-Cells of this structure establish a feedback mechanism that allows autoregulation of renal blood flow and keeps the rate of glomerular filtration relatively constant.

**VI-Collecting Tubules & Ducts.**

1-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. 2-The collecting tubules are lined with cuboidal epithelium .Cells of the converging collecting ducts are more columnar and the duct near the tips of the medullary pyramids. 3- Along their entire extent, collecting tubules and ducts are composed mainly of weakly staining **principal cells** with few organelles and scanty microvilli.

4-Ultrastructurally the principal cells can be seen to have basal membrane infoldings,consistent with their role in ion transport. Scattered among the principal cells are variably darker **intercalated cells** with more abundant mitochondria which help regulate the acid-base balance by secreting H+ and absorbing HCO3–.

**URETERS, BLADDER, & URETHRA**

1-Urine is transported by the **ureters** to the **bladder** where it is stored until emptied during micturition via the **urethra**. The calyces, renal pelvis, ureter, and bladder have the same basic histologic structure, with the walls becoming gradually thicker closer to the bladder. 2-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.

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

**i)a single layer** of small basal cells resting on a very thin basement membrane,

**ii)an intermediate region** containing from one to several layers of more columnar cells,

**iii)a superficial layer** of very large, polyhedral or bulbous cells called **umbrella cells.**

**Umbrella cells: 1-**which are occasionally bi- or multinucleated and are highly differentiated

to protect underlying cells against the cytotoxic effects of hypertonic urine.

2-Umbrella cells are especially well developed in the bladder, where contact with urine is the greatest. These cells,have extensive intercellular junctional complexes surrounding unique apical membranes.

**The bladder's:**

1-**The bladder's** lamina propria and dense irregular connective tissue of the submucosa are highly vascularized. 2- The muscularis consists of three poorly delineated layers,collectively called the detrusor muscle, which contract to empty the bladder .Three muscular layers are seen most distinctly at the neck of the bladder near the urethra. 3-**The ureters** pass through the wall of the bladder obliquely, forming a valve that prevents the backflow of urine into the ureters. 4- All the urinary passages are covered externally by an adventitial layer, except for the upper part of the bladder which is covered by serous peritoneum.

**Urethra:**

1-The **urethra** is a tube that carries the urine from the bladder to the exterior. The urethral mucosa has large longitudinal folds, giving it a distinctive appearance in cross section. **2-In men**, the two ducts for sperm transport join the urethra at the prostate gland. The male urethra is longer and consists of three segments:

**A)**The **prostatic urethra**, 3–4 cm long, extends through the prostate gland and is lined by urothelium.

**B)**The **membranous urethra**, a short segment, passes through an **external sphincter** of striated muscle and is lined by stratified columnar and

pseudostratified epithelium.

**C)**The **spongy urethra**, 15 cm in length and is lined by stratified columnar and pseudostratified columnar epithelium , with stratified squamous distally.

**3-In women,** the urethra is exclusively a urinary organ. The female urethra is a tube 4 to 5 cm long, lined initially with transitional epithelium, then by stratified

squamous epithelium and some areas of pseudostratified columnar epithelium. The middle part of the female urethra is surrounded by the external striated muscle

sphincter.