Study guide Urinary System

1. **Urinary system functions** – removal of nitrogenous waste, mainly urea, electrolyte balance, acid-base balance and water balance of the body.

2. **Urinary system** of humans is formed of a pair of Kidneys, a pair of ducts called Ureters, a Urinary Bladder to store urine and Urethra the duct that carries urine outside the body.

3. **Each kidney** lies attached to back wall partly covered by 12th rib. It is a flat bean shaped organ. Median side has an indentation, hilum. A transparent membrane, the fibrous capsule, covers each kidney. In addition a fat capsule and a fibrous renal fascia surround the kidney and keep it in position. Take notice, peritoneum only covers anterior surface of kidneys.

4. **Nephron** is the functional unit of kidney. **Cortical Nephrons** lie in outer part of cortex and have a short loop of Henle barely entering medulla. **Juxtamedullary nephrons** (15%) lie near border of cortex and medulla and have long loop of Henle present in most of medulla.

5. Each kidney has about 1 million Nephrons. **Each nephron** is formed of a Glomerular capsule, PCT – proximal convoluted tubule, Nephron Loop or Loop of Henle with descending and ascending limbs, DCT – distal convoluted tubule and a collecting duct. Glomerulus $\rightarrow$ glomerular capsule $\rightarrow$ PCT $\rightarrow$ descending limb $\rightarrow$ ascending limb $\rightarrow$ DCT $\rightarrow$ collecting duct.

6. Each nephron has Renal Corpuscles formed of outer cup shaped Glomerular capsule and inner Glomerulus formed of a bunch of blood capillaries. Afferent arteriole brings blood to glomerulus and Efferent arteriole takes it away from glomerulus. Efferent arteriole then wraps around different parts of nephron as Peritubular capillaries.

7. Outer part, **Cortex** of kidney, appears granular in section. Cortex appears lighter in color and has abundant blood supply. Inner part, **Medulla** of kidney, appears striated. It has loop of henle and collecting ducts passing through it.

8. **Renal columns** are extensions of cortex into medulla and separate medullary pyramids from one another.

9. Collecting ducts $\rightarrow$ papillary duct $\rightarrow$ medullary pyramid $\rightarrow$ minor calyx $\rightarrow$ major calyx $\rightarrow$ pelvis $\rightarrow$ ureters $\rightarrow$ urinary bladder $\rightarrow$ urethra $\rightarrow$ urine released outside = micturition.

10. **Ureters** are a pair of urinary ducts that collect urine from kidneys to urinary balder.

11. **Bladder** stores urine before its elimination from body. Urinary bladder has highly extensible wall due to transitional epithelium. It has 2 sphincters to regulate its opening into urethra.

12. **Trigone** is a small triangular area in urinary bladder having 2 openings of ureters and a 3rd for urethra. Trigone develops from mesoderm and rest of bladder is endodermal in origin. Trigone is smaller in females than in males. Trigone is sensitive to stretching and passes the information to brain for need to empty the bladder.

13. **Urethra** in males is much longer (8”) than in females (1.5”). Urethra in males passes through the penis and is a passage for both urine and semen – fluid carrying sperms. In females urethra opens independent of vagina and carries only urine. Women get frequently urinary infections due to proximity of urethral opening and anus.

14. **Renal Blood Supply**: Renal arteries arise from descending aorta and one enters hilum of its side. Renal artery $\rightarrow$ segmental artery $\rightarrow$ lobar artery $\rightarrow$ interlobar artery arcuate artery $\rightarrow$ interlobular artery or cortical radiate artery $\rightarrow$ afferent arteriole $\rightarrow$ glomerulus $\rightarrow$ efferent arteriole $\rightarrow$ Peritubular capillaries / Vasa recta $\rightarrow$ Venules $\rightarrow$ interlobular vein $\rightarrow$ arcuate vein $\rightarrow$ interlobar vein $\rightarrow$ renal vein. Renal veins leave the hilum and join inferior vena cava.

15. Urine formation takes place by 3 processes – Filtration, Reabsorption and Secretion.

16. **Filtration**: Glomerular capillaries are highly permeable. The inner membrane of glomerular capsules has a many gaps in it. Inner wall of glomerular capsule is lined by Podocytes with many feet like
extensions. Fenestrae are the gaps between these extensions. Diffusible part of blood having water, glucose, amino acids, urea, ions, enter space of glomerular capsule.

17. **Reabsorption**: Useful substances are reabsorbed from the filtrate. Primary site of reabsorption is PCT and all glucose, most amino acids and majority of salts are absorbed in PCT. Water follows passively. Secondary site is DCT. Most of the reabsorption is active.

18. **Secretion**: Some substances like, K⁺ and H⁺ do not filter from blood, but are actively secreted into filtrate. Others filter in small quantity, like creatinine, and are secreted actively into filtrate.

19. **Excretion**: The urine with wastes like urea, uric acid and creatinine (3 nitrogenous wastes) and excessive salts or amino acids, leaves body with variable amount of water.

20. **Juxtaglomerular Apparatus**: Juxtaglomerular Apparatus = JGA

JGA = juxtaglomerualar cells around afferent arteriole + macula densa in DCT facing cleft of afferent and efferent arterioles + Mesangial Cells in the cleft and in glomerular capsule

JGA secretes renin

Renin converts Angiotensinogen → angiotensin
Angiotensin stimulates adrenal medulla to secrete aldosterone

21. **Role of Angiotensin and Renin**
   a. Liver secretes Angiotensin-1.
   c. Renin activates angiotensin-1 to angiotensin-2.
   d. Angiotensin-2 stimulates Adrenal Cortex to secrete Aldosterone.
   e. Aldosterone makes kidney absorb more Na⁺ and release more K⁺ ions in urine. This helps to maintain Na⁺ and K⁺ balance in ECF.

22. **Counter Current System**
   a. When a tube makes a loop, the fluid moving in its 2 limbs move in opposite directions to form a ‘Counter Current System’. Kidney has 2 counter current systems: Loop of Henle and Vasa Recta.
   b. The counter current systems of kidney maintain a concentration multiplier system in medulla. Isotonic concentration is 300 milliosmoses; this concentration multiplies 600 → 900 → 1200 milliosmoses towards the end of loop of Henle; it is 4 times than isotonic concentration.
   c. Kidneys can excrete hypertonic urine (more concentrated than blood) due to presence of concentration multiplier system.

23. **Role of ADH**
   a. When blood becomes denser, hypothalamus releases ADH or Vasopressin hormone through posterior pituitary gland. ADH makes the walls of DCT and Collecting duct permeable. Large amount of water passes out from urine by osmosis due to presence of concentration multiplier system outside. Vasa recta remove the absorbed water from medulla and maintain the concentration. This makes the urine hypertonic.
   b. When blood is dilute hypothalamus does not cause the release of ADH. The walls of DCT and Collecting duct remain impermeable. Hypotonic Urine (with large quantity of water) passes out. Therefore, ADH helps to maintain water balance of blood.