Chapter-13 Urinary system

Urinary system

Excretion is the process through which unwanted/toxic substances and metabolic wastes are eliminated from the body and maintains our body in homeostasis stage. Elimination process carry out through the— digestive system, lungs, skin, liver and urinary system.

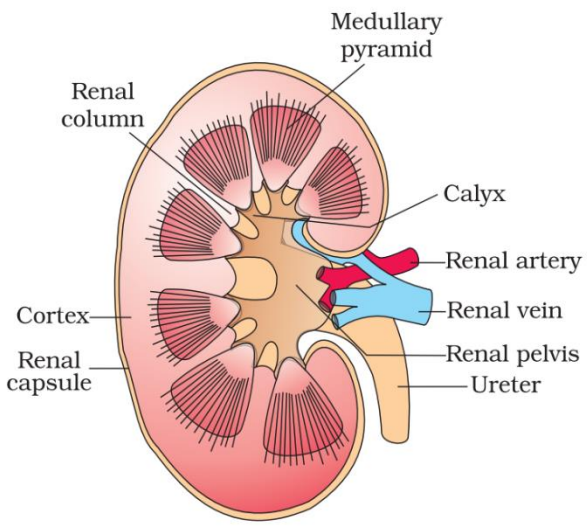
Anatomy and physiology of urinary system.

Introduction— Urinary/Renal system plays a major role in the urine formation and urine elimination, normally urine output in person is about 1 to 1.5 L/day. Urinary system consists of-

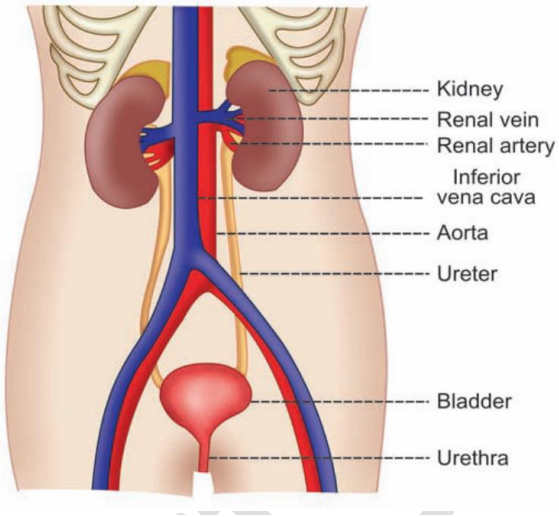
- **A pair of kidneys.**
- **A pair of ureters.**
- **Urinary bladder.**
- **Urethra.**

KIDNEYS— Kidneys are reddish brown, bean shaped structures, covered by connective tissue capsule situated between the levels of last thoracic and third lumbar vertebra close to the dorsal inner wall of the abdominal cavity. Each kidney of an adult human measures 10-12 cm in length, 5-7 cm in width, 2-3 cm in thickness with an average weight of 120- 170 g. There is a depression on the medial border of kidney called hilum, through which renal artery, renal veins, nerves, and ureter pass. Components of kidney are arranged in two layers-

1. Outer cortex— It is dark and granular appearance and extends in between the medullary pyramids as renal columns called columns of Bertini.
2. Inner medulla— Medulla consists about 8 to 18 medullary or Malpighian pyramids. Further it continuous in renal pelvis (expanded part of ureter) by forming of 2 to 3 minor calyces and about 8 major calyces.



LONGITUDINAL SECTION OF KIDNEY



URINARY SYSTEM

NEPHRON.

Nephron is structural and functional unit of kidneys. Each kidney consists of 1 to 1.3 million nephrons. Nephron is divided into two parts—

- Renal corpuscle/Malpighian corpuscles— It is situated near the cortex region of the kidneys and helps in the filtration of the blood. It is formed by two portions-
    1. Glomerulus— Glomerulus is a tuft of capillaries enclosed by Bowman's capsule. It consists of glomerular capillaries interposed between afferent arteriole on one end and efferent arteriole on the other end.
    2. Bowman's capsule— It cover the glomerular capillaries and continue with the tubular part.
- Renal tubule— It is the continuation part of the bowman's capsule. On the basis of structural and functional basis it again divided into the three parts.
    1. Proximal convoluted tubule.
    2. Loop of Henle (descending limb and ascending limb).
    3. Distal convoluted tubule.
    4. Collecting duct.

Types of Nephrons—

1. Cortical/superficial nephron— Renal corpuscle situated near the outer cortex with short length of loop of Henle and helps in the urine formation. Peritubular capillaries present all around the cortical nephron.
2. Juxtamedullary nephrons— Renal corpuscle situated in inner cortex near medulla with long length of loop of Henle and helps in the urine formation and mainly in the urine concentration. Vasa recta capillaries present all around the juxtamedullary nephron.

Physiology of urine formation.

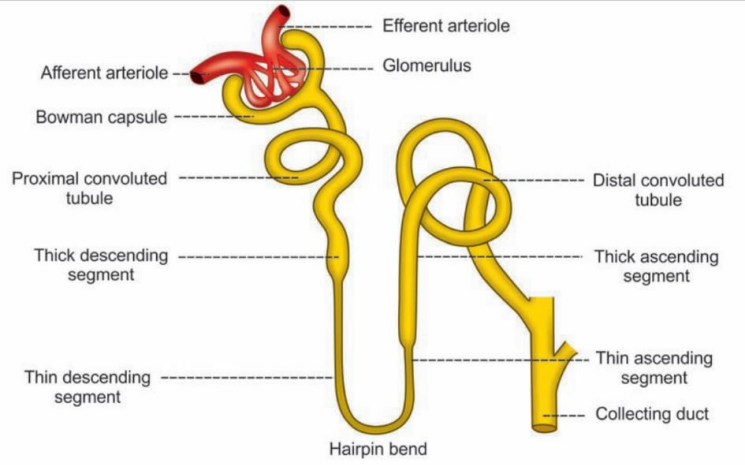
When blood passes through glomerular capillaries the plasma is filter by the filtering membrane into bowman's capsule. Urine formation includes three processes.

- Glomerular filtration—
- Tubular reabsorption.
- Tubular secretion.

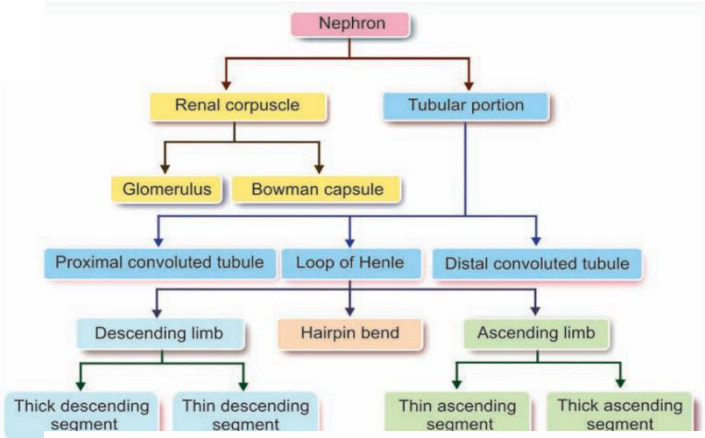
1. **Glomerular filtration—** Glomerular filtration is the process through which capillaries blood going to filter through filtering membrane. It's also called as ultrafiltration because minutes particle also filtered through it except plasma protein and blood cells. The filtered fluid is called glomerular filtrate.
    - Glomerular filtration rate (GFR)— GFR is defined as the total amount of filtrate form in all the nephrons of both the kidneys in the given unit of time. Normal GFR is 125 ml/min or about 180 ml/min.
2. **Tubular reabsorption—** It is the process through which the needed/wanted substances are absorb by the renal tubules and transported into back to the blood. When the filtrate passes through the tubular part the large amount of water, electrolyte, and others substances reabsorbed and resulting qualitative and quantitative changes occurs. Sites of reabsorption—
    - Proximal convoluted tubule— About 85% of the substances reabsorbed by the PCT. Glucose, amino acids, sodium, potassium, calcium, bicarbonates, chlorides, phosphates, urea, uric acid and water are the major substances reabsorbed by the PCT.
    - Loop of Henle— Sodium and chloride are main substances reabsorbed from loop of Henle.

- Distal convoluted tubule— Sodium, calcium, bicarbonate, and water are reabsorbed from DCT.
- Collecting duct— Condition reabsorption happens in the collecting duct because, water reabsorbed in the presence of Antidiuretic hormone (ADH), and sodium reabsorbed in the presence of Aldosterone.

3. **Tubular secretion—** Tubular excretion is the process by which the substances are transported from blood into renal tubules. It is also called renal excretion. Site of secretion-
    - Potassium is secrete actively by sodium-potassium pump in proximal and distal convoluted tubules, and collecting ducts.
    - Ammonia is secreted in the proximal convoluted tubule.
    - Hydrogen ions are secreted in the proximal and distal convoluted tubules. Maximum hydrogen ion secretion occurs in proximal tubule.
    - Urea is secreted in the loop of Henle.



STRUCTURE OF NEPHRON



PARTS OF NEPHRON

Renin - angiotensin system.

Juxtaglomerular Apparatus— it is specialised modification situated near the glomerulus of each nephron. It is formed by the three different structures.

- Macula densa.
- Extraglomerular Mesangial cells
- Juxtaglomerular cells (Secrete renin).

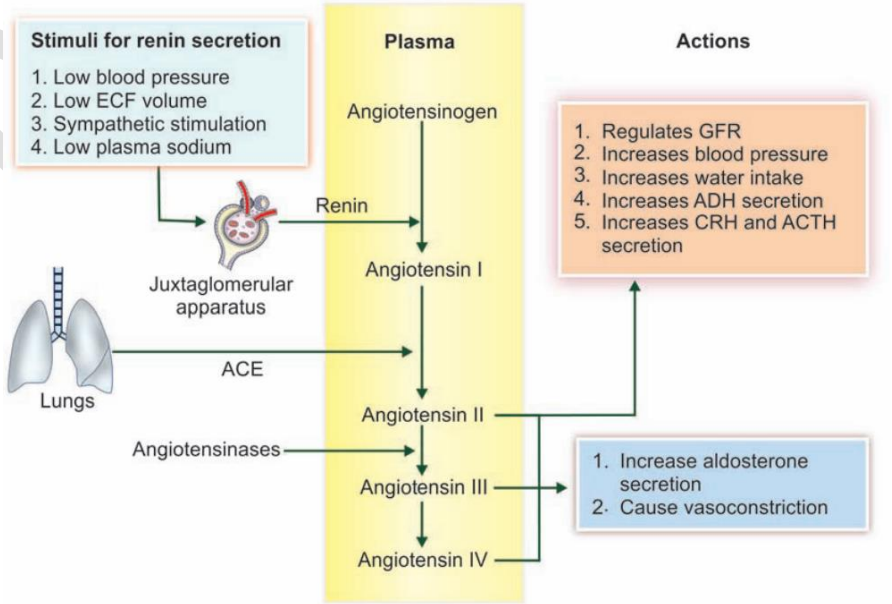
Renin-angiotensin system—

Clearance tests and micturition.

Micturition

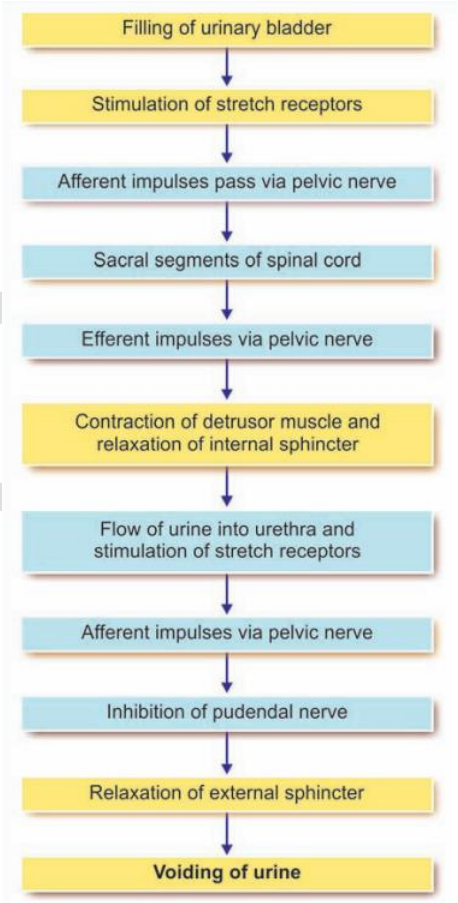
Micturition is the process by which urine is eliminated from the urinary bladder. It is a reflex process.

- Urinary bladder— It is the triangular hollow organ, in which ureters open. It is formed by smooth muscles called detrusor muscle and it open into urethra via internal urethral sphincter.
- Urethra— Urethral structure and function different in the male and female. In both, two urethral sphincters present in urinary tract.
  - Internal urethral sphincter.
  - External urethral sphincter.
- Urinary bladder and the internal urethral sphincter are supplied by sympathetic and parasympathetic divisions of autonomic nervous (Pelvic nerve) system. The external sphincter is supplied by somatic nerves fibres (pudendal nerve).



ECF-Extracellular fluid., ACE-Angiotensin-converting enzyme, GFR-Glomerular filtration rate, ADH-Antidiuretic hormone, CRH-Corticotropin-releasing hormone, ACTH-Adrenocorticotropic hormone.

Micturition reflex—



- Micturition reflex initiated by the stimulation of stretch receptors situated on the wall of urinary bladder and urethra. When about 300 to 400 ml of urine is collected in the urinary bladder.
- Then sensory impulses reach to spinal cord through the sensory fibres of pelvic nerve and motor impulse produce in the bladder and internal urethral sphincter.
- Motor impulse cause the contraction in detrusor muscle and relaxation in internal sphincter so that, urine enters the urethra from the urinary bladder.
- Once urine enters in urethra, then urethral stretch receptors sense the change and send sensory impulse to spinal cord via pelvic nerve.
- Now the impulses generated from spinal centres inhibit pudendal nerve.
- So, the external sphincter relaxes and micturition occurs.
- During micturition, the flow of urine is facilitated by the increase in the abdominal pressure due to the voluntary contraction of abdominal muscle.

Clearance test/Renal function test.

Properties of urine—

- **Volume— 1-1.5 L/day.**
- **Reaction— Slightly acidic with PH 4.5-6.**
- **Specific gravity—1.010 to 1.025.**
- **Osmolarity— 1200 mOsm/L.**

Examination of urine.

Routine examination of urine or urinalysis is a group of diagnostic tests performed on the sample of urine.

1. Physical examination.
2. Microscopic examination.
3. Chemical examination.

Physical examination—

- Colour— Abnormal colouration of urine than straw colour is due to several causes such as Jaundice, haematuria, haemoglobinuria.
- Appearance— Turbidity appears in both the physiological and pathological conditions.
- Volume— Increase in urine volume indicates increase in protein catabolism and renal disorders such as chronic renal failure, diabetes insipidus and glycosuria.
- Specific gravity— It is low in diabetes insipidus, and high in diabetes mellitus, acute renal failure and excess medication.
- PH— PH is useful in determining the metabolic or respiratory acidocis or alkalosis.

Microscopic examination—

- Red blood cells— presence of red blood cells in urine indicates glomerular disease such as glomerulonephritis.
- White blood cells— Number increase in acute glomerulonephritis, infection of urinary tract, vagina or cervix.

- Crystals— Abnormal crystals such as crystals of cystine and tyrosine appear in liver diseases.
- Bacteria— Bacterial growth appears during the infections conditions.

Chemical examination—

- Glucose— Normal- 180 mg/dL
- Protein— Normal- 30 mg/day
- Ketone bodies—
- Urobilinogen— 1 to 3.5 mg/daily
- Bile salts, bilirubin, blood.

Plasma clearance—

- It is defined as the amount of plasma that is cleared off a substance in a given unit of time. It is also known as renal clearance. It is based on Fick principle.

  $$C = UV/P$$

  Where, C= clearance, U= concentration of substance in urine, V= volume of urine flow, P= concentration of substance in plasma.