!! JAY AMBE !!

10. URINARY SYSTEM

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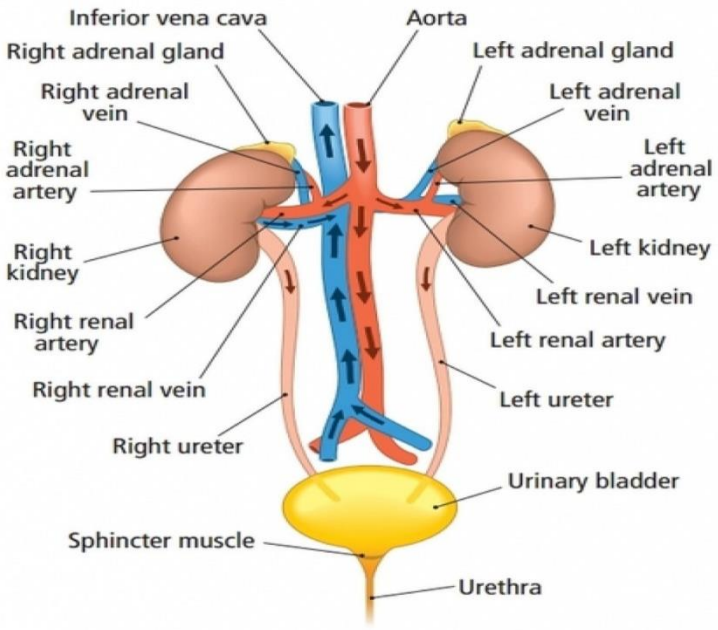


INTRODUCTION:

Urinary system is also known as the excretory system.

The organs of the urinary system include the kidneys, renal pelvis, ureters, bladder and urethra.

The purpose of the urinary system is to filtration of blood and eliminate waste from the body, regulate blood volume and blood pressure, control levels of electrolytes and metabolites, and regulate blood pH.

FUNCTIONS OF URINARY SYSTEM:

1. Removal of waste product:

- The kidneys remove a number of waste products and get rid of them in the urine. Two major compounds that the kidneys remove are:

i. urea, which results from the breakdown of proteins

ii. uric acid from the breakdown of nucleic acids

2. Reabsorption of electrolytes and nutrients:

- Kidney reabsorbed products include: glucose, amino acids, bicarbonate, sodium, water, phosphate, chloride, sodium, magnesium, and potassium ions.
- This product is essential to maintain the homeostasis.
- It also helps to maintain the osmolality, if osmolality rises in the blood plasma, the hypothalamus in the brain responds by passing a message to the pituitary gland. This, in turn, releases antidiuretic hormone (ADH).
- In response to ADH, the kidney makes a number of changes, including:
  - ✓ increasing urine concentration
  - ✓ increasing water reabsorption
  - ✓ reopening portions of the collecting duct that water cannot normally enter, allowing water back into the body
  - ✓ retaining urea in the medulla of the kidney rather than excreting it, as it draws in water

3. Maintaining pH

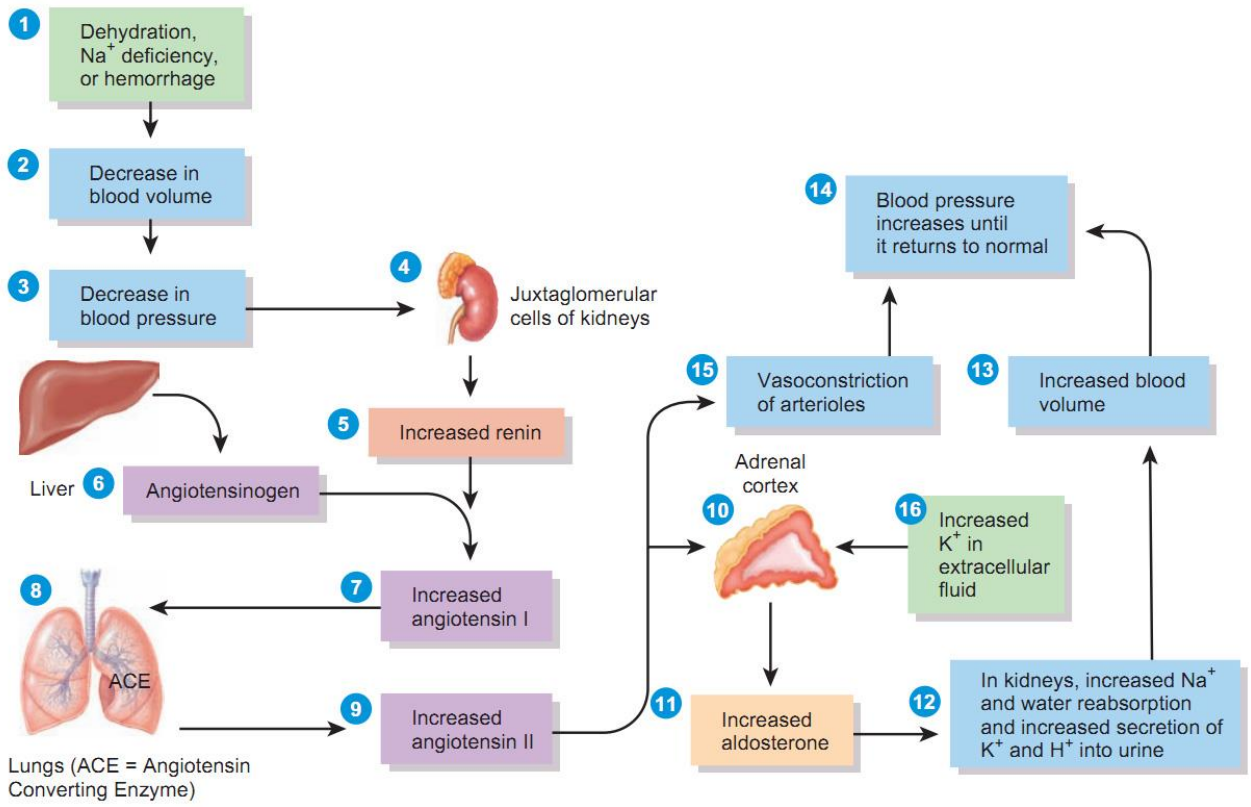
- Metabolic process of cell produce CO_2 and metabolic acid. CO_2 combine with the water molecules (H_2O) to form bicarbonate (H2CO3). Metabolic product excreted via kidney and lungs. Kidney excreted metabolic acid and lungs excreted CO_2. This factor maintain the blood pH between 7.3 to 7.4. Below this boundary, the body enters a state of acidemia, and above it, alkalemia.
- Outside this range, proteins and enzymes break down and can no longer function. In extreme cases, this can be fatal.

- The kidneys and lungs help keep a stable pH within the human body.
- The lungs maintain the pH by respiratory acidosis and respiratory alkalosis process.
- The kidneys manage the pH by metabolic acidosis and metabolic alkalosis process.

4. Maintain blood pressure and volume:

Regulation of aldosterone secretion by the renin–angiotensin–aldosterone (RAA) pathway.

Aldosterone helps regulate blood volume, blood pressure, and levels of Na^+, K^+, and H^+ in the blood.



- Decrease blood volume cause decrease blood pressure, lower blood pressure stimulate release of enzyme renin from the juxtaglomerular cell of kidneys. It increase the renin level into the blood.
- Renin act on angiotensinogen a plasma protein produce by the liver and convert into angiotensinogen I.
- Angiotensinogen I reach to lung through the blood flow and it convert into Angiotensinogen II by the help of angiotensinogen converting enzyme (ACE).
- Angiotensinogen II produce two effects:

i. It increase the secretion of aldosterone, this effect increase NA^+ reabsorption and K^+ secretion which produce water retention and increase the blood volume.

ii. It act on the smooth muscles of the atrial wall which produce contraction of arteries and increase the blood pressure.

- Above both mechanism helps to maintain normal blood pressure, from lower blood pressure to higher blood pressure to maintain the normal blood pressure.

5. Control the erythropoiesis (Formation of RBCs):

- Kidney secret the enzyme erythropoietin, which is useful in the production of red blood cell.

6. Maintain the calcium level:

- Kidney helps to synthesize the enzyme calcitriol which is the active form of vitamin D, It increases both the amount of calcium that the intestines can absorb and the reabsorption of phosphate in the kidney.

7. Provide the glucose during the fasting stage:

- Kidney perform the gluconeogenesis process during the fating or starvation conditions and synthesis the new glucose molecules

LAYERS OF KIDNEYS:

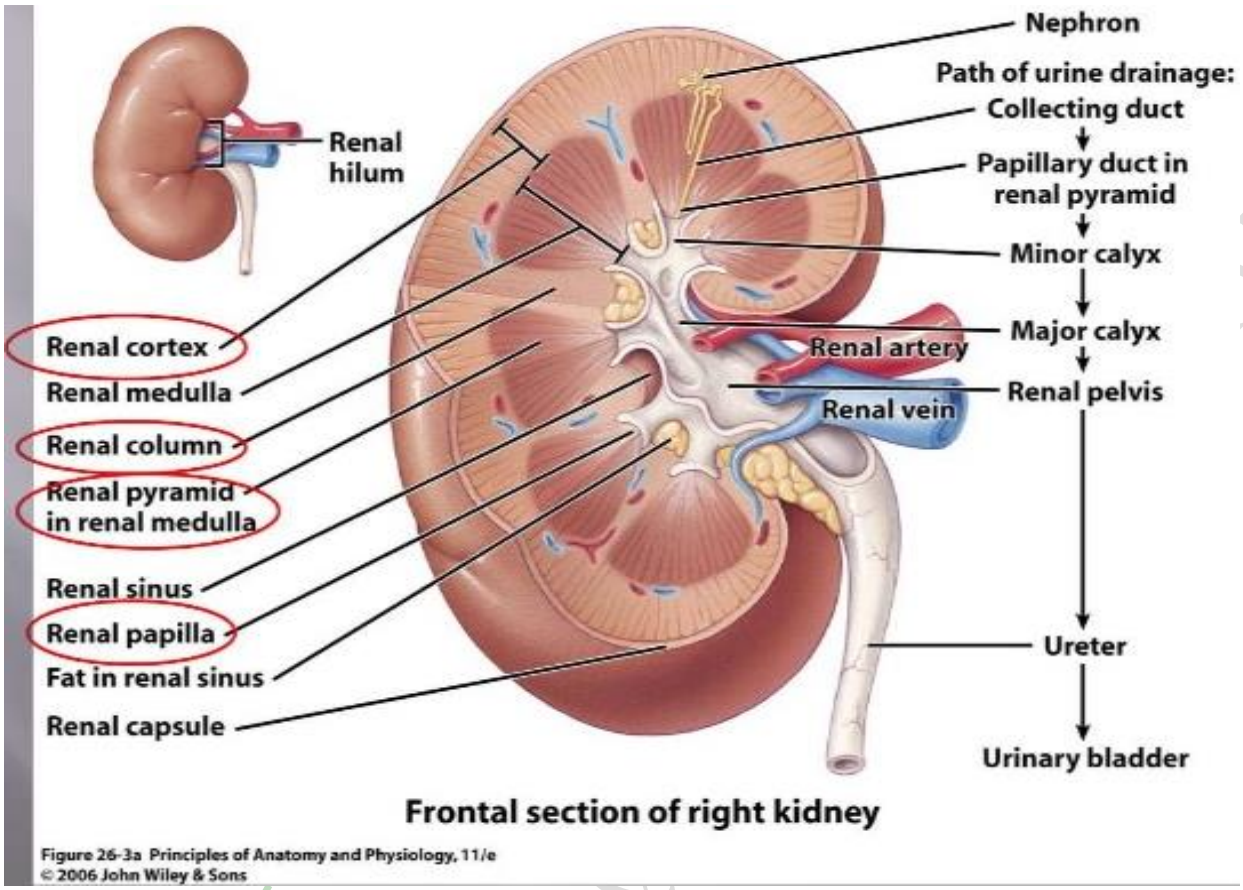
Kidney is surrounded by three layers.

1. **Renal Capsule:** It is the inner and deep layer of the kidney. It is transparent, fibrous membrane. It continue with the outer layer of the ureters. This layer maintain the shape of the kidney.
2. **Adipose capsule:** It is the middle layer of the kidney. It is made up by the fatty mass, it protect kidney from the trauma and it holds the kidney in its position.
3. **Renal fascia:** It is the outer layer of the kidney. It is made up by the dense irregular connective tissue.

ANATOMY OF KIDNEY: (EXTERNAL ANATOMY)

- The paired kidneys are reddish (purplish-brown organs) in color and it is bean shaped.
- They are located just above the waist between the peritoneum and posterior wall of the abdominal cavity so it is also known as retroperitoneal organs.
- It is located at the level of last thoracic and third vertebrae as well as it is partially protected by the eleventh and twelfth pair of ribs.
- Right kidney is slightly lower than the left kidney because right lobes of the kidney occupied more space than the left lobes.
- Adult kidney is 9-12 cm long, 6-9 cm wide and 3 cm thick.
- Each kidney weighs about 125–175 g in males and 115–155 g in females.
- The medial surface of the kidney is concave with a deep vertical fissure known as hilum through which ureters leaves kidney as well as blood, lymphatic vessels and nerves exit and entre the kidney through the renal hilus.

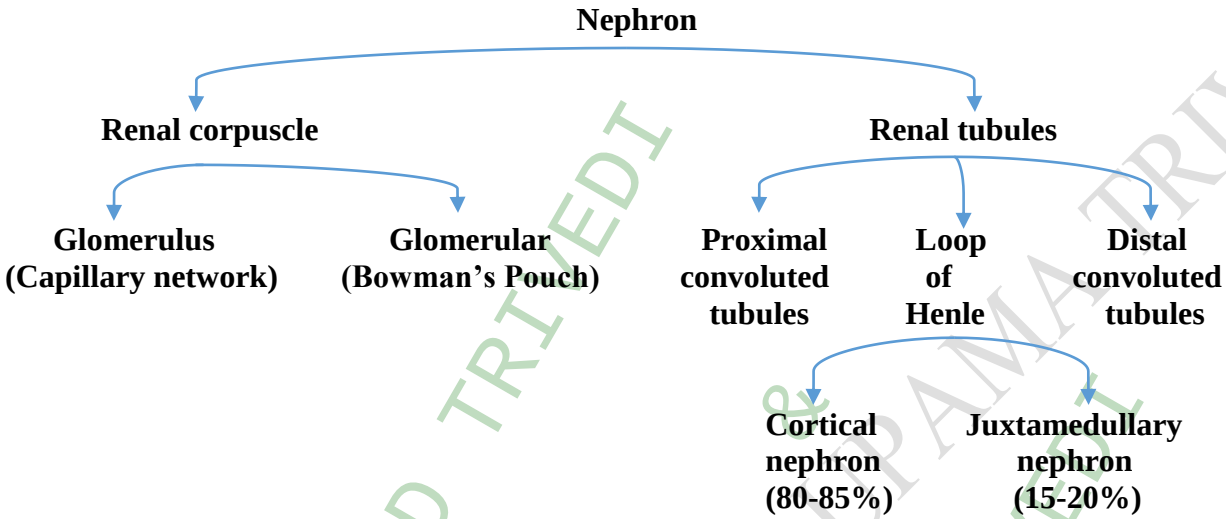
HISTOLOGY OF KIDNEY: (INTERNAL ANATOMY)



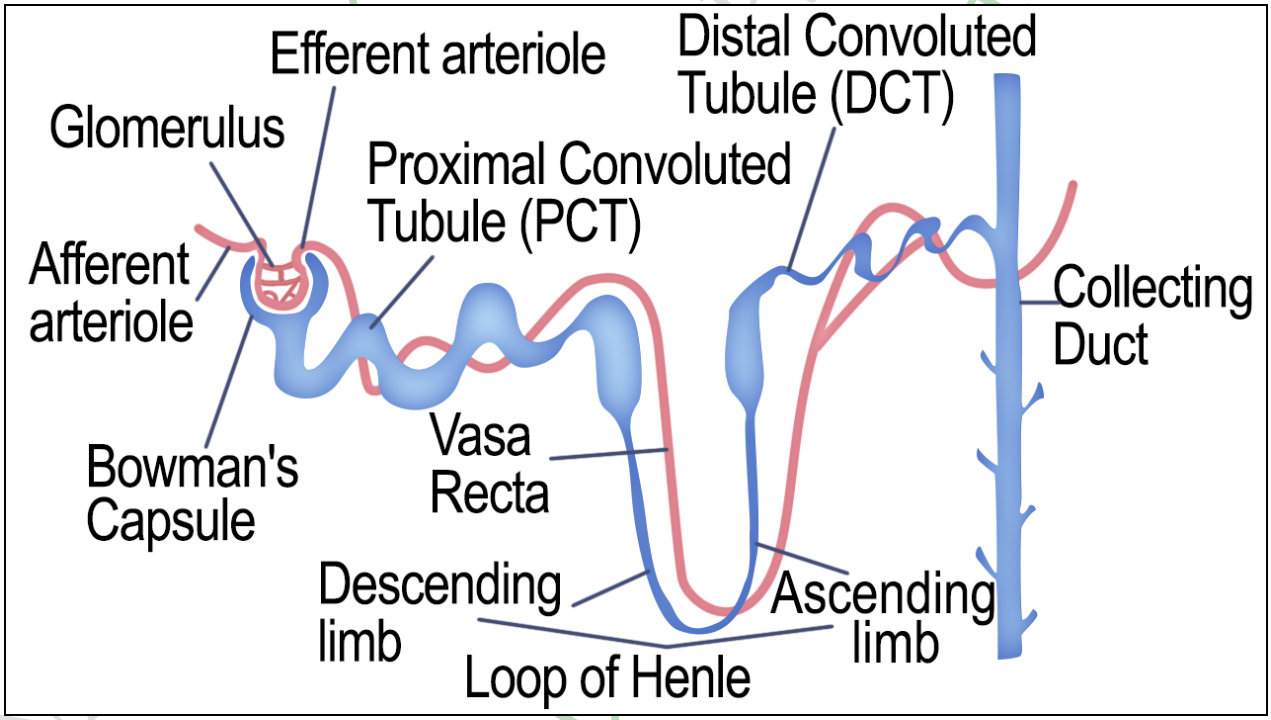
- Frontal section of the kidney shows two main region: a) renal cortex b) renal medulla
- Renal cortex is a superficial region and it is reddish in color.
- Renal medulla is a deep region and it is reddish brown in color.
- Renal medulla consist 8-18 cone shaped structure which is known as renal pyramid. Base of the renal pyramid faces towards the renal cortex side and apex of the renal pyramid towards centre of kidney side known as renal papilla.
- Between two pyramids there is a gap like portion is known as renal column.
- Renal pyramids and the portion of renal cortex combine together known as renal parenchyma where the functional units of kidney reside that is nephron.
- Each kidney's renal parenchyma consist about 1 million number of nephrons.
- The number of nephrons are constant from the birth, if nephrons are died due to injury or infection new nephron cannot form.
- Each kidney filtered blood at 50% rate, but if one kidney get failed other kidney compensate 80 % blood filtration rate.
- Urine formed by the nephron drains into papillary ducts, below that there is a cup like structure known as major and minor calyces.

- Each kidney consist 8-18 minor calyces and 2-3 major calyces.
- Formed urine pass from renal papillae to minor calyces to major calyces, then it flow in to renal pelvis to ureters and it finally drains in to urinary bladder.

NEPHRON:



- Each kidney consist about 1 million numbers of nephron.



- It is divided into two portion:

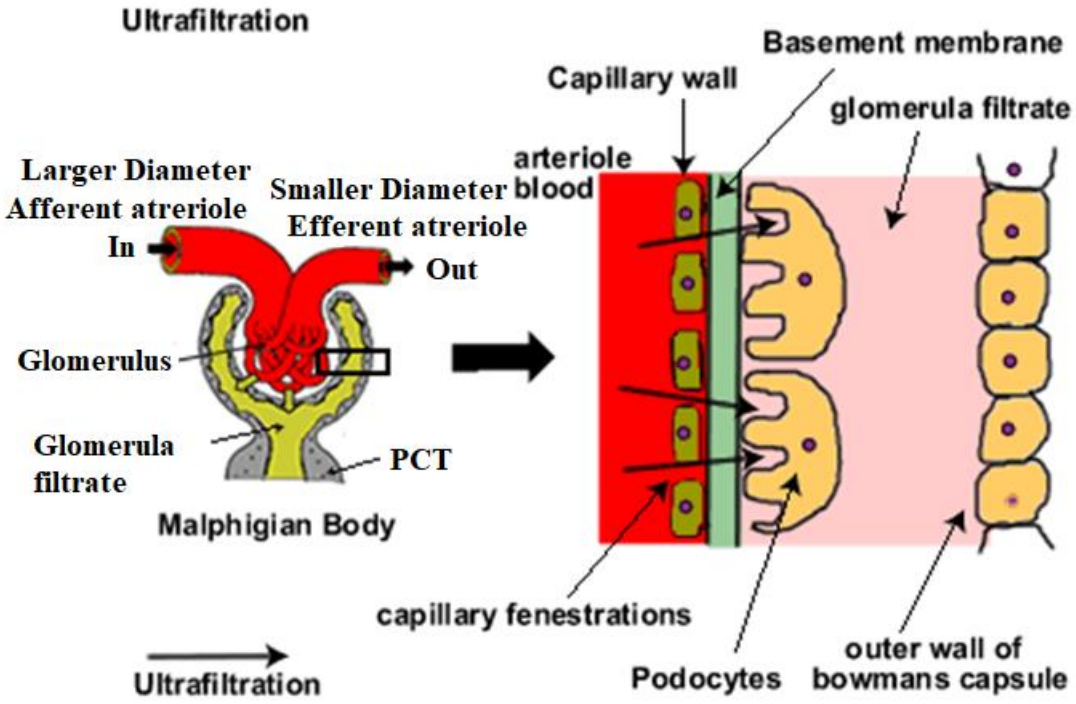
i. Renal corpuscle:

- ✓ Renal corpuscle is lie into the cortex region of kidney, It is also known as Malpighian body.
- ✓ It consist two portion:

a) **Glomerulus** - This is a cluster of capillaries that absorb protein from blood traveling through the renal corpuscle.

b) **Glomerular (The Bowman capsule) –** It is double layered walled that surround the glomerulus. The remaining fluid, called capsular urine, passes through the Bowman capsule into the renal tubules.

- ✓ Outer layer of the bowman's cup is formed by simple squamous epithelial cell.
- ✓ Inner layer of the bowman's cup is formed by the modified simple squamous epithelial cell known as podocytes.
- ✓ These podocytes cells adheres closely to the endothelial cell of glomerular capillary. This combination form the endothelial capsular membrane that act as a filter.
- ✓ This filter through water and most solutes filter from the blood plasma into couman's capsular space. But large plasma protein and formed elements like RBCs, Platelets etc do not pass by this membrane filter.
- ✓ This filter produce three different portion through which substances filter in following order:



a) **Endothelial fenestrations (pores) of glomerulus** – It is a single layer of endothelial cell which has large pores that prevent filtration of blood cell but it allow filtration of all blood plasma components.

b) **Basement membrane of the glomerulus** – This layer consist exracellular matrix and it lies between endothelium (inner layer) and outer layer of the glomerulr

capsule. Its matrix portion consist glycoprotein and prevent filtration of large proteins.

c) **Slit membrane** – the specialized epithelial cells covered the glomerular capillaries and it is known as podocytes. Each podocytes cell consist thousand of foot like structure on its surface known as pedicles. It prevents the filtration of medium size protein.

ii. Renal tubules:

- Filtered fluid from the capsular space enter into the renal tubules, which has three main section.

  a. Proximal Convoluted tubules b) Loop of Henle c) Distal convoluted tubules

- Convoluted means coiled shaped not straight, proximal means near, loops means hair pin like structure and distal means away.
- In nephron, loop of Henle consist descending loop of Henle and ascending loop of Henle.
- According to loop of Henle, nephron is divided into two main types:

  a. Cortical nephron:

  It is about 80 to 85 % of the total nephron.

  It mainly located in the superficial region of the kidney that is known as cortex.

  It consist short loop of Henle.

  Loop of Henle consists, thick and thin descending portion and thick ascending portion but no thin ascending portion.

  b. Juxtamedullary nephron:

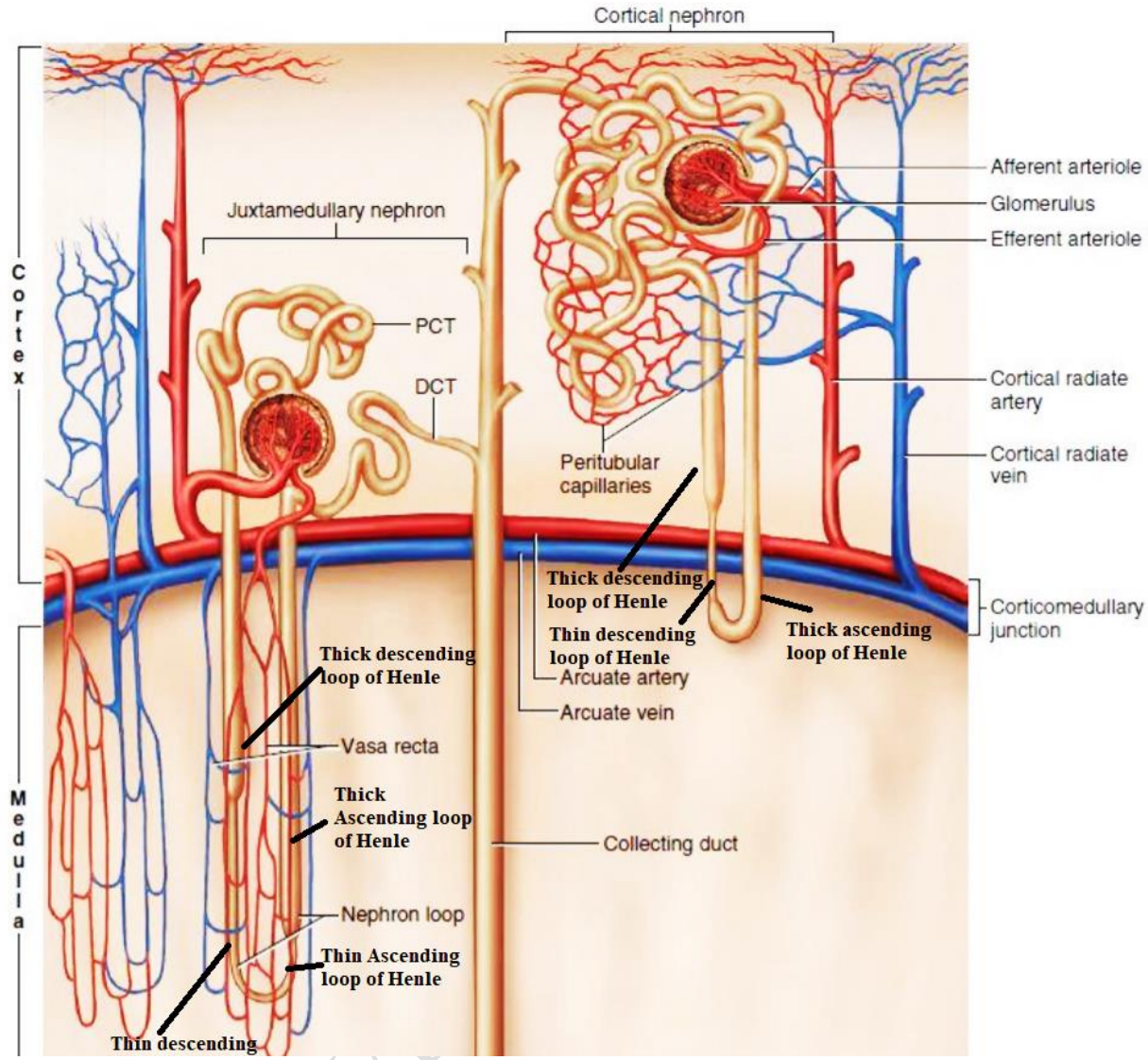
  It is about 15 to 20 % of the total nephron.

  It mainly located in the deep region of the kidney that is known as medulla.

  It consist long loop of Henle.

  Loop of Henle consists, thick and thin descending portion as well as thin and thick ascending portion.

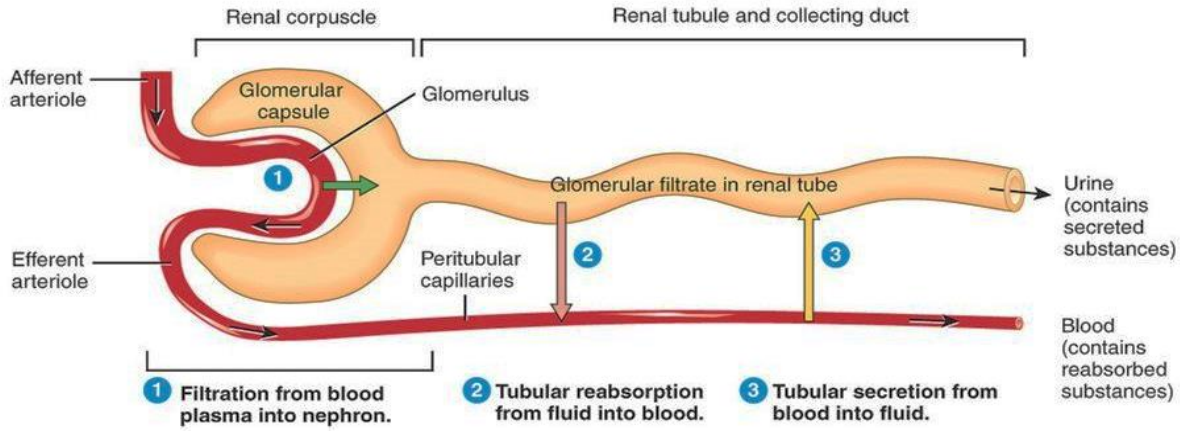
  It excreted very dilute or very concentrated urine.



PHYSIOLOGY OF URINE FORMATION:

Urine is formed by mainly three process:

1. Glomerular filtration, 2. Tubular reabsorption and 3. Tubular secretion.



1. Glomerular filtration:

- Afferent arteries have larger diameter than the efferent arteries so pressure is created into the glomerulus. Due to this about 180 liters/day of filtrate entre into the capsular space, with respect to the glomerular filtration rate (GFR) 125 mL/min for an adult male. This represent is 65 times the entire blood plasma volume.
- Out of 180 liters of filtrate 178-179 liters of filtrates get reabsorbed so finally 1-2 liters of urine excreted each day.
- Glomerular filtration is depend on net filtration pressure (NFP) created into the glomerulus.
- The net filtration pressure (NFP) is mainly describe by following three mechanism, in which one process promote the filtration and two oppose the filtration process.

i. Glomerular Blood Hydrostatic Pressure (GBHP):

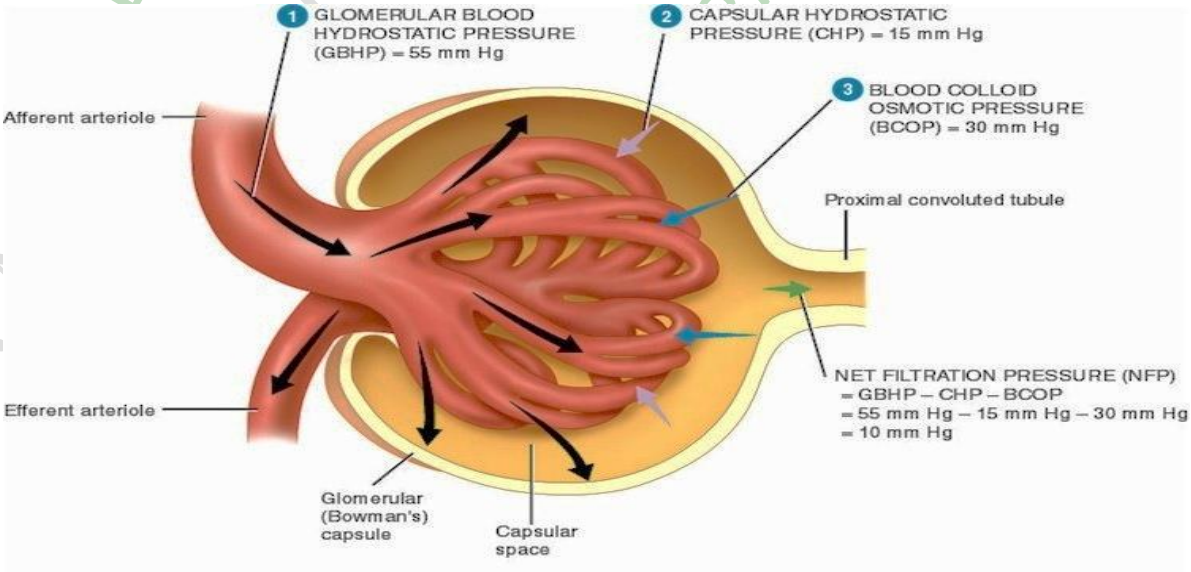
Afferent arteries have the larger diameter and efferent arteries have smaller diameter so large amount of blood comes into the glomerulus and small amount of blood out from the glomerulus it create pressure into the glomerulus that is 55 MmHg. Which is positive and it promote the filtration.

ii. Capsular Hydrostatic Pressure (CHP):

The wall of the capsule where there is no pores as well as the fluid filled into the capsule oppose the filtrate for filtration. This is the negative pressure which oppose the filtration rate that is 15 MmHg.

iii. Blood Colloidal Osmotic Pressure (BCOP):

Some of the protein of blood plasma cannot pass through the endothelial capsular membrane and it block the pore for filtration site, so it oppose the filtration rate and the pressure created by this oppose is 30 MmHg which is also the negative pressure.



- This Net Filtration Pressure helps plasma to filter from glomerulus to capsular space.
- Any factor that affect the NFR will affect the Glomerular Filtration Rate (GFR).
- Eg. Sever blood loss reduces systemic blood pressure, which ultimately reduce the GBHP and if GBHP drops below 45 MmHg filtration rate at glomerulus get affected. This kind of condition is known as anuria, in which daily urine output get below 50 mL. Inflammation at the glomeruli can also create such kind of conditions.
- To avoid such kind of condition it is essential to maintain normal GFR, because if GFR is too high substance may pass quickly from the glomerular so they are not reabsorbed and they get lost into the urine.
- Our homeostasis system regulate this GFR in normal range by following mechanism:

i. Renal Auto Regulation of GFR:

- ✓ Kidney has ability to regulate GFR automatically with the change of systemic atrial pressure, it is known as renal auto regulation.
- ✓ Renal auto regulation is operated by the negative feedback mechanism.
- ✓ If NFP or GFR goes down due to low blood pressure, proximal convoluted tubules and loop of Henle reabsorb more than the normal fraction of Na^+, Cl^- and water.
- ✓ Due to this process cell of the Juxtaglomerular Apparatus of Henle's loop detect delivery of Na^+, Cl^- and water at their end portion.
- ✓ This effect send message to the control centre and it inhibit the release of vasoconstrictor substance/chemicals. Less amount of vasoconstrictor substance/chemicals dilate the afferent arteries so it increase the NFP and GFR which maintain the normal homeostasis.
- ✓ Opposite event is occur when the NFP and GFR gets increases.

ii. Hormonal Regulation of GFR:

- ✓ Mainly two hormones:
  a) Angiotensinogen II
  b) Atrial Natriuretic Peptide (ANP) regulate the blood pressure and therefore GFR.
- ✓ When blood pressure and therefore GFR decreases, Juxtaglomerular Apparatus (JGA) of Henle's loop detect delivery of Na^+, Cl^- and water at their end portion.
- ✓ Due to this effects JGA cells secret enzyme renin into the blood.
- ✓ In the blood, renin act on angiotensinogen protein which is produced by the liver and it convert into the angiotensin I.
- ✓ When angiotensin I pass from lungs a second enzyme of the lungs Angiotensin Converting Enzyme (ACE) converts angiotensin I to Angiotensin II which is active

hormone and produce following action to maintain the NFR and GFR in normal level.

i. Vasoconstriction of arterioles:

Angiotensin II constrict the efferent arteries this effect increase the GBHP and GFR, so it comes into the normal level.

ii. Stimulation of aldosterone secretion by adrenal:

Angiotensinogen II stimulate the adrenal cortex to secrete aldosterone, which increase the retention of Na^+, Cl^- and water by the kidney. Water retention increase the blood volume and restore the blood pressure and maintain the normal GFR level.

iii. Stimulation of thirst centre in the hypothalamus:

Angiotensin II stimulate the thirst centre of hypothalamus and increase the water intake which increase the blood volume and restore the blood pressure and maintain the normal GFR level.

iv. Stimulation of Antidiuretic Hormone (ADH) secretion from the pituitary gland:

Angiotensin II stimulate the release of ADH hormone that promote the water retention by kidney and increase blood volume which restore the blood pressure and maintain the normal GFR level.

- ✓ Above all action of angiotensin II maintain normal NFP and GFR by maintaining the normal systemic and atrial blood pressure.
- ✓ Atrial Natriuretic Peptide (ANP) is the second enzyme that regulate the glomerular filtration rate.
- ✓ This enzyme is secreted by the atria of the heart.
- ✓ This enzyme promote the secretion/excretion of water as well as sodium.
- ✓ When blood volume get increase, it stretch the wall of atria so it secret the enzyme ANP.
- ✓ ANP increase the GFR by dilating the afferent arteries as well as it suppress the secretion of aldosterone, ADH and renin.
- ✓ So it reduce the water retention and reduce the blood pressure and make them in normal range with maintaining the NPF and GFR.

iii. Neural Regulation of GFR:

- ✓ Sympathetic fibers of the autonomic nervous system of the kidney regulate the constriction and relaxation of the afferent and efferent arteries of the kidney.

- ✓ When the sympathetic stimulation is less that time renal blood vessels get dilated but during the exercise or hemorrhagic type condition (Flight or Fight) sympathetic stimulation is more and it also release epinephrine from the adrenal medulla of the kidney which constrict afferent and efferent both the arteries so it decrease the GFR. So, more blood can reach to the other tissue to generate the energy.

2. Tubular reabsorption:

About 99% of Water and other useful small molecules in the filtrate are normally reabsorbed back into plasma by renal tubules.

In tubular reabsorption, water and solute moves from the tubuler lumen back into the blood with in a peritubular capillary or vasa recta.

Here, solutes like glucose, amino acids, urea, anions (Cl^-, HCO_3^-, HPO_4^{2-} etc) and cations (Ca^+, K^+, Na^+ etc) are reabsorbed by both the process active and passive mechanism.

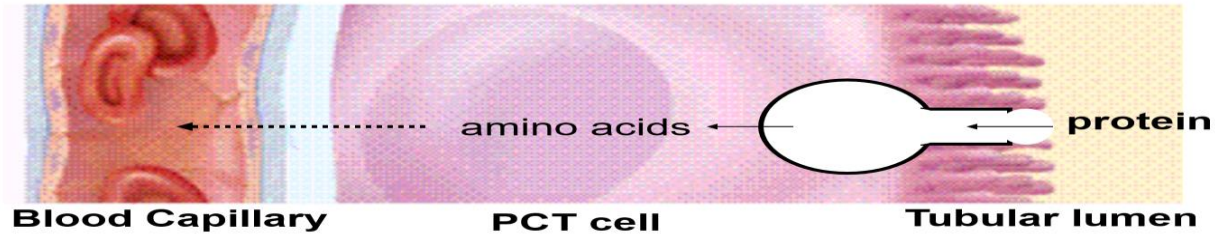
i. Reabsorption in Proximal Convoluted Tubules:

- ✓ The proximal convoluted tubule (PCT) is formed by one layer of epithelial cells with long apical microvilli.
- ✓ PCT reabsorbs about 65% of the glomerular filtrate and return it to the blood.
- ✓ PCT reabsorbed 100% of filtered glucose and amino acids, 80-90 % of HCO_3-, 65 % of the water, $^+$, K^+ and Na^+, and 50 % of the Cl^- and urea.

Mechanisms of Proximal Tubular Reabsorption

a) Solvent drag and endocytosis process for large molecules of protein:

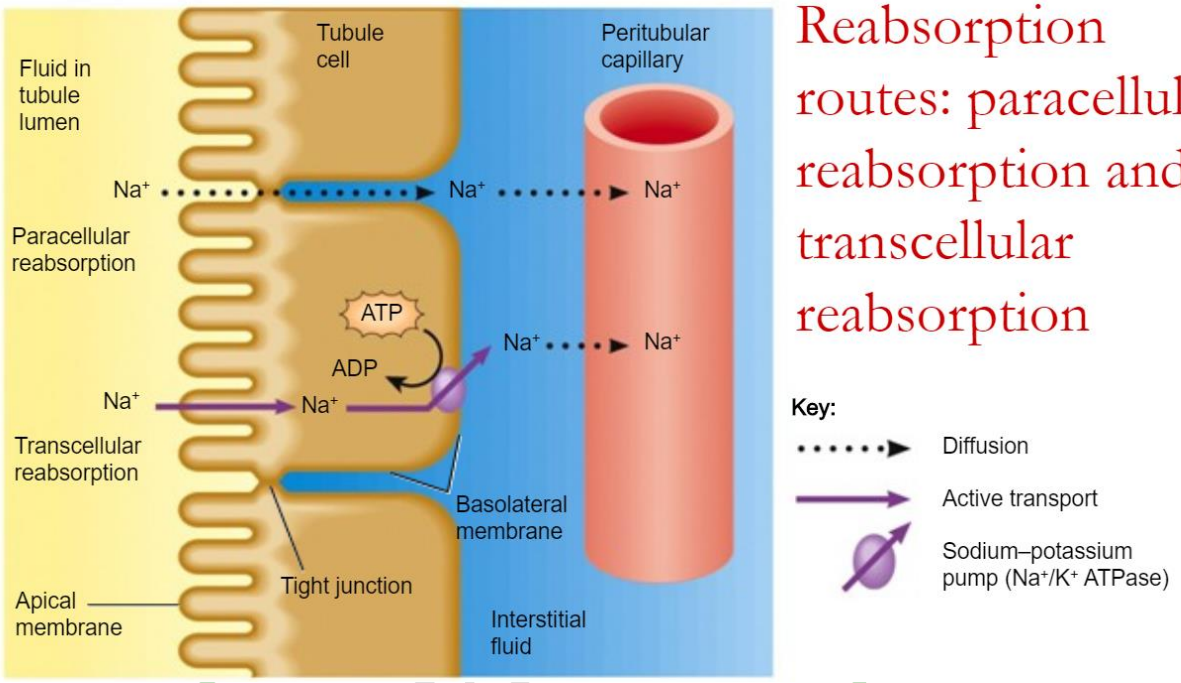
- Driven by high colloid osmotic pressure (COP) in the peritubular capillaries
- Water is reabsorbed by osmosis and carries all other solutes along.
- The glomerulus filters a small amount of protein from the blood. The PCT reclaims it by endocytosis, hydrolzes it to amino acids, and releases these to the ECF by facilitated diffusion.



b) Reabsorption of sodium.

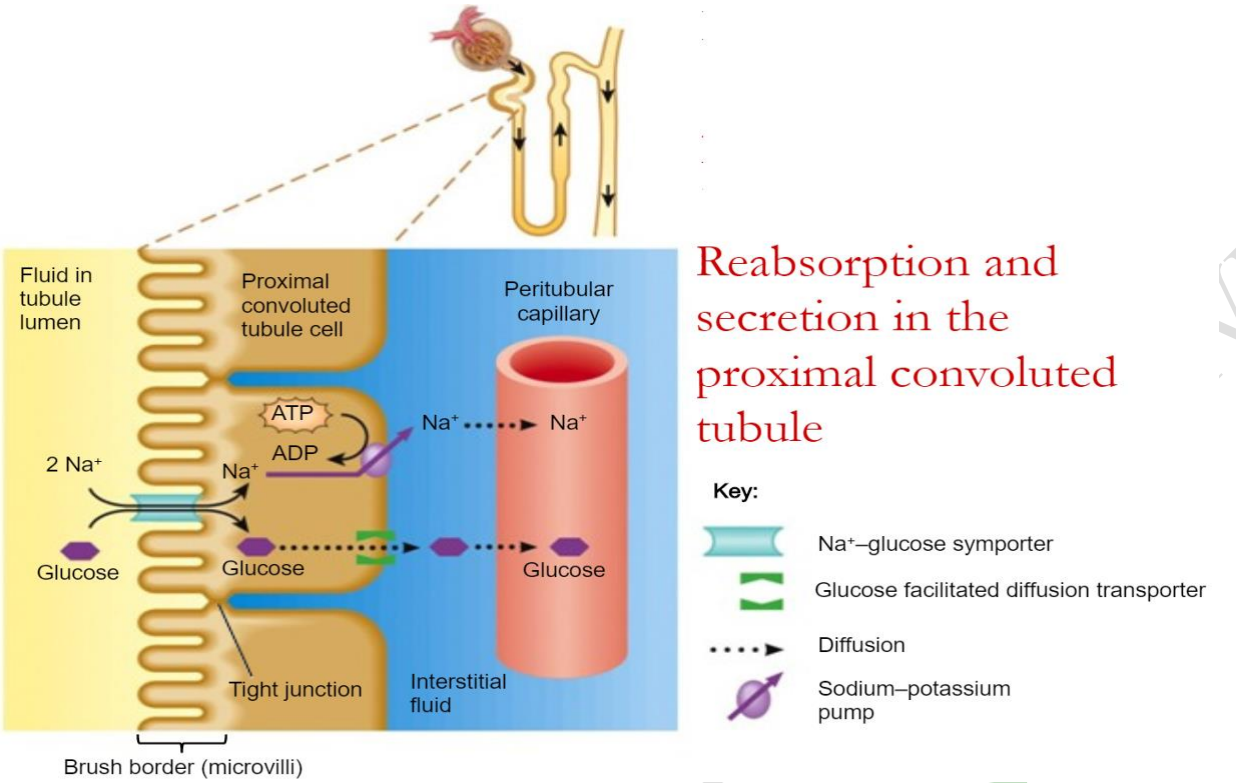
- Sodium is reabsorbed by passively diffusion and active transport mechanism.

- The concentration of Na+ inside the proximal tubule cell is low and interior the cell is negatively charged with respect to exterior. Due to this difference, Na+ passively diffuse from the fluid in the tubule lumen through leakage channels to PCT cells.
- At the same time Na+ is expel actively from tubule lumen to paritubuler capillary (Blood capillary) by active transport mechanism.
- Sodium pumps (Na-K ATPase) in basolateral membranes transport sodium out of the cells against its concentration gradient using ATP.



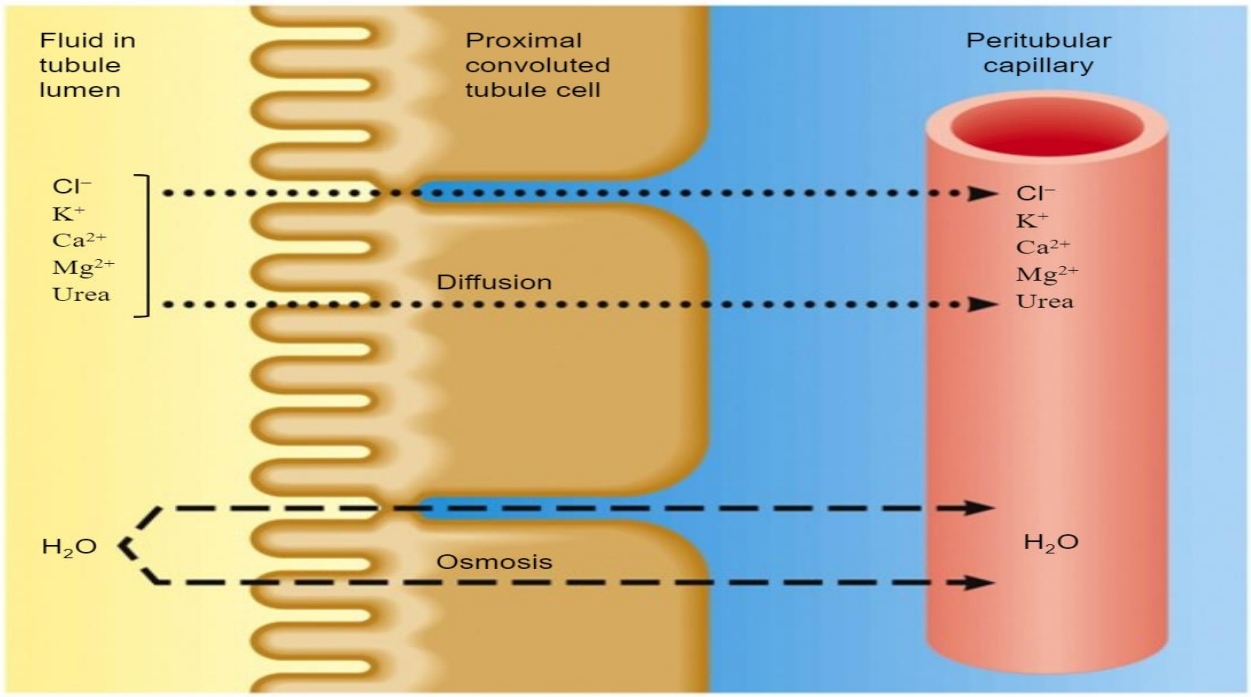
c) Secondary active transport of glucose, amino acids, and other nutrients.

- Various symporter can carry both Na+ and other solutes. For example, the sodium-dependent glucose transporter (SDGT) can carry both Na+ and glucose.
- PCTs reabsorb 100% of the filtrate glucose, amino acids, lactic acid and other useful nutrients.
- The membrane proteins that perform secondary active transport are known as symporters, they move two substances same direction across a membrane.



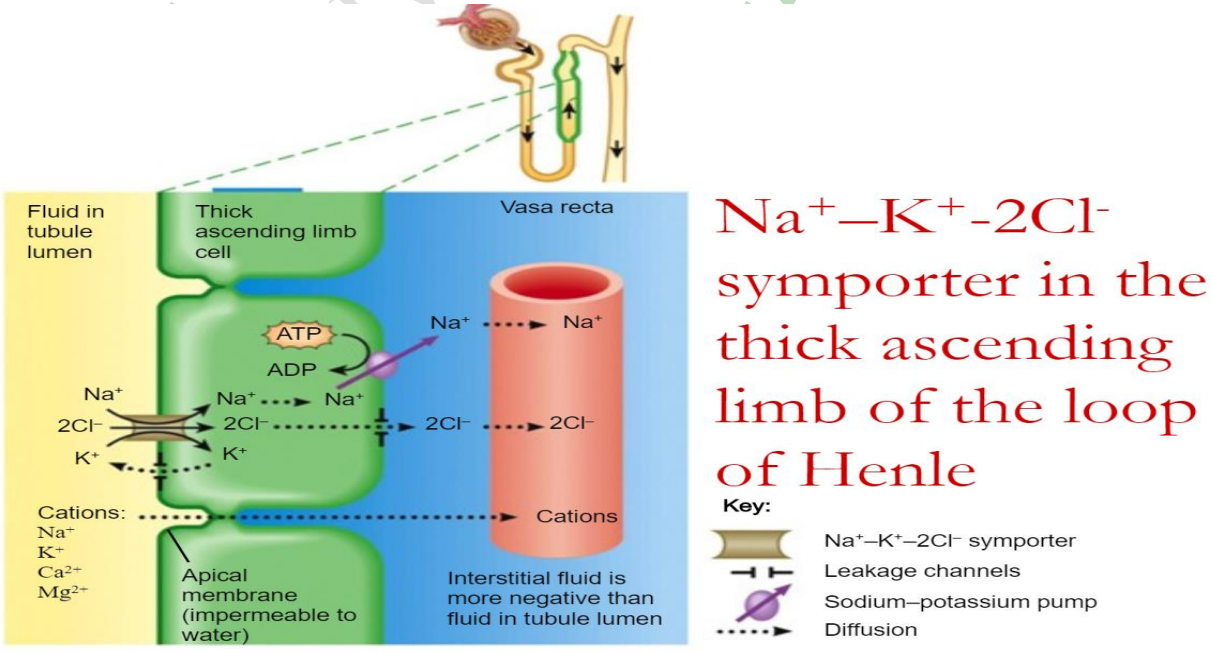
d) Secondary ions reabsorption via electrostatic attraction and water reabsorption via osmosis:

- Sodium reabsorption makes both intracellular and extracellular fluid hypertonic to the tubular fluid. Water follows sodium into the peritubular capillaries.
- Negative ions tend to follow the positive sodium ions by electrostatic attraction.



ii. Reabsorption in the Loop of Henle:

- ✓ PCT reabsorb about 65% of the filtered water at the 40-45 mL/min rate, remaining fluid enters into the Loop of Henle.
- ✓ The chemical compositions of this fluid is different from the blood plasma as well as glomerular filtrate because glucose, amino acids and other nutrients are no longer present due to 100 % reabsorption into PCT.
- ✓ The Loop of Henle reabsorbs about 30 % of the filtered K+, 20 % of the filtered Na+, 35 % of the filtered Cl- and 15 % of the filtered water.
- ✓ The thick ascending limb reabsorbs solutes but is impermeable to water. Thus, the tubular fluid becomes very diluted while extracellular fluid becomes very concentrated with solutes.
- ✓ The thick ascending limb have symptores that simultaneously reclaim one Na+, one K+ and two Cl- from the fluid in tubular lumen.
- ✓ From the lumen to blood capillary Na+ transported through primarily active transport mechanism, while K+ transported by the diffusion process according to concentration gradient and Cl- follows Na+ and K+ and transported by passive diffusion mechanism.
- ✓ Some water is reabsorbed in the descending Loop of Henle, about 90 % of the filtered solutes and water have been returned to the blood stream.
- ✓ After this process about 20 litres of fluids enter into the collecting duct whereas urine formation rate is 1-2 litres/day.
- ✓ So, remaining amount of filtered is reabsorbed by the aldosterone and antidiuretic hormone (ADH).

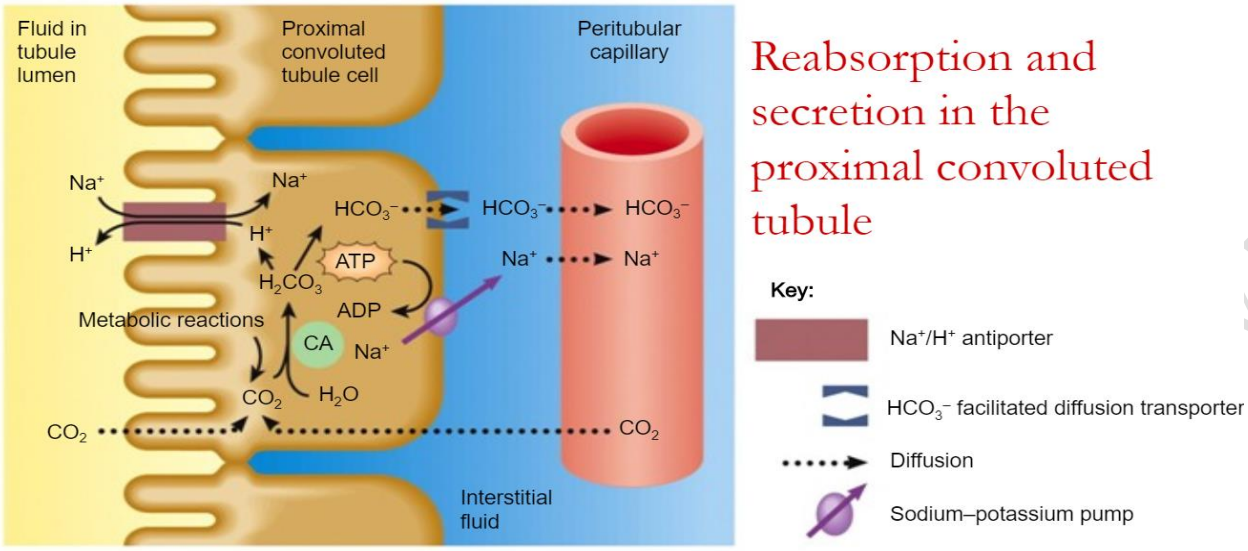


iii. Tubular Secretion:

- ✓ Some of the substances which not filtered through the PCT get directly secreted from blood capillary to tubules.
- ✓ Tubular secretion removes Hydrogen ions (H+), Potassium ions (K+), Ammonium ions (NH_4+), creatinine and some drugs like penicillin.
- ✓ Tubular secretion of Hydrogen ions (H+) helps to maintain blood pH and secretion of other substances helps eliminate them from the body.

a) Secretion of Hydrogen ions (H+):

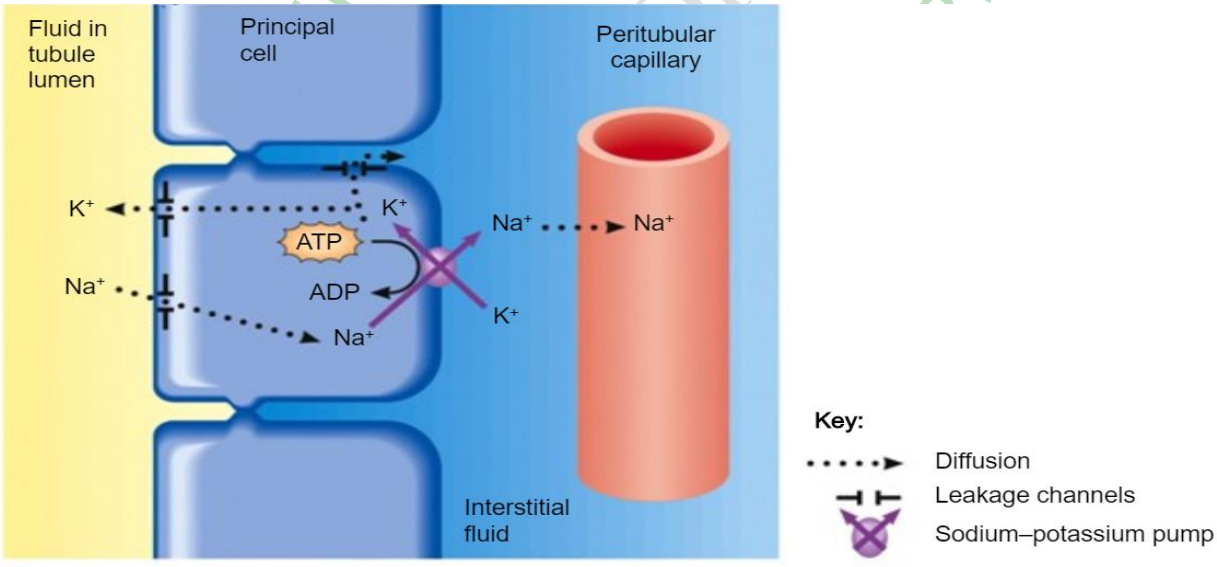
- Carbon dioxide (CO_2) from tubular lumen or from blood capillary diffuse into the tubular cell where it combine with the water (H_2O) by the help of carbonic anhydrase (CA) enzyme and form carbonic acid (H_2CO_3).
- Dissociation of H_2CO_3 form H+ and HCO_3^- , dissociated H+ secreted from tubular cell to tubular lumen. As well as H+ secretion produce reabsorption of the Na+ by the help NA+/H+ antiporters (It is the protein that moves one ion inside and one outside means in opposite direction).
- For every H+ secretion from tubular cell to tubular lumen, one HCO_3^- goes from tubular cell to blood capillary.
- In PCT, secreted H+ cell combine with filtered HCO_3^- of lumen and again carbonic anhydrase (CA) enzyme form H_2CO_3. Which further dissociated into CO_2 and H_2O. CO_2 diffuse into the tubular cell and join with the H_2O of tubular cell and form again H_2CO_3 which dissociate H+ ions and HCO_3^-. H+ secreted from tubular cell to tubular lumen make urine acidic and HCO_3^- goes from tubular cell to blood capillary make blood slightly basic.
- In the collecting ducts, H+ ions are secreted by the help of H+ ATPase pump that makes urine 1000 times more acidic than the blood. As well as in collecting duct HCO_3^- reabsorbed by the HCO_3^-/Cl^- antiporter.
- Secreted H+ into lumen of the collecting tubules combine with the HPO_4^- and form H_2PO_4 and combined with NH_3 to form NH_4+. These ions cannot go back from tubular lumen to blood capillary so it excreted into the urine.



(a) Na^+ reabsorption and H^+ secretion

b) Secretion of K+:

- Normally, 100% of the filtered K+ is reabsorbed in PCT, Loop of Henle and DCT.
- Secretion of K+ is controlled by aldosterone, K+ concentration in plasma, Na+ concentration in distal convoluted tubules.



c) Secretion of NH_3 and NH_4+:

- Ammonia is the poisonous product form from the deamination of amino acid by liver cells.
- The liver converts poisonous ammonia to urea. Generated urea and ammonia excreted from blood to urine.
- Where NH_3 combine with the secreted H+ ions and form NH_4+ (Ammonium Ion) that cannot be reabsorbed and excreted with the urine from body.

BLOOD SUPPLY TO THE KIDNEY:

Main functions of the kidney is to remove waste product from the blood, maintain blood pressure and volume of blood so they receive 20-25% of the resting cardiac output via the **renal arteries** and this amount is nearly 1200 mL of blood per minute.

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Renal arteries divide into the **segmental arteries** and supply blood to renal segmental region of the kidney.

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Renal segmental arteries divided into several branches that enter into the renal parenchyma and form **interlobar arteries** which into the renal column between the renal pyramid.

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Interlobar arteries known as **arcuate arteries** at the region of renal medulla and cortex.

↓

Division of **arcuate arteries** produce a series of interlobular arteries which enter into the renal cortex and further divided into the several branches known as **afferent arterioles.**

↓

Each nephron receives one **afferent arterioles** which divides into tangle or ball shaped capillary network known as **glomerulus. Glomerulus** reunite to form **efferent arterioles** that drains blood out of the glomerulus.

↓

The **efferent arterioles divide** to form a network of capillary surrounds tubular portion of the nephron in the renal cortex known as **peritubular capillaries** and some of **efferent arterioles** are long shaped and surround the tubular portion of the nephron in the renal medulla known as **vasa recta.**

↓

Peritubular capillaries reunite to form **peritubular venules** and then **interlobular veins.**

↓

Interlobular veins also receive the blood from **vasa recta.**

↓

From the **interlobular veins** blood drains into the **arcuate veins** to the **interlobular veins.**

↓

Interlobular vein drains the blood in **segmental veins** near the region of renal pyramids.

↓

Finally blood leaves from the kidney through segmental veins to the **single renal vein**.


Renal artery
Segmental arteries
Interlobar arteries
Arcuate arteries
Interlobular arteries
Afferent arterioles
Glomerular capillaries
Efferent arterioles
Peritubular capillaries and/or vasa recta
Interlobular veins
Arcuate veins
Interlobar veins
Segmental veins
Renal vein
(b) Path of blood flow
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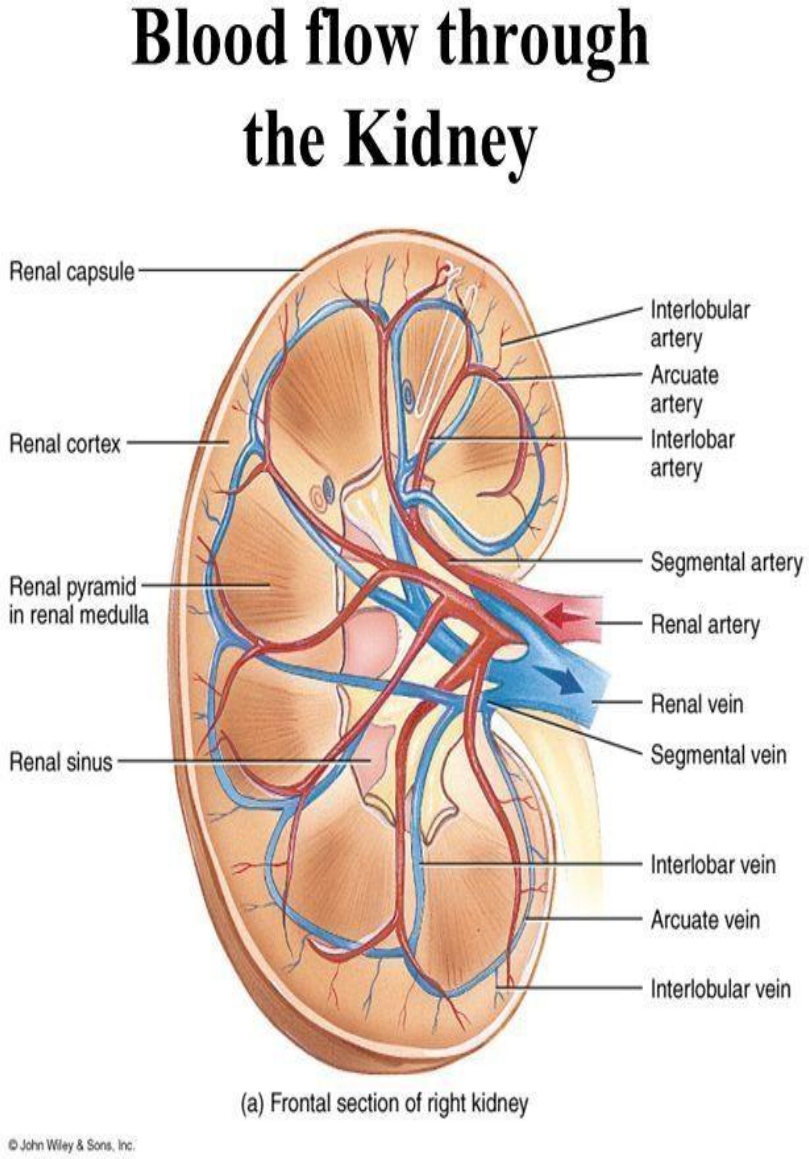
Blood flow through the Kidney
Renal capsule
Renal cortex
Renal pyramid in renal medulla
Renal sinus
Interlobular artery
Arcuate artery
Interlobar artery
Segmental artery
Renal artery
Renal vein
Segmental vein
Interlobar vein
Arcuate vein
Interlobular vein
(a) Frontal section of right kidney
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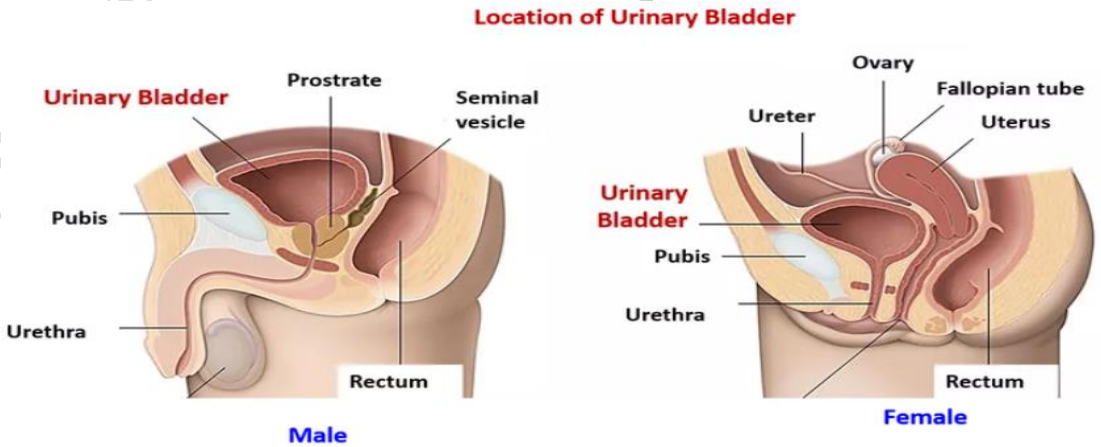
10. URINARY SYSTEM

URETERS:

- The ureters are a pair of tubes that carry urine from the kidneys to the urinary bladder.
- The ureters are about 10 to 12 inches long and run on the left and right sides of the body parallel to the vertebral column**.**
- Gravity and peristalsis of smooth muscle tissue in the walls of the ureters move urine toward the urinary bladder. The ends of the ureters extend slightly into the urinary bladder and are sealed at the point of entry to the bladder by the ureterovesical valves.
- These valves prevent urine from flowing back towards the kidneys.
- About every 10 to 15 seconds, small amounts of urine are emptied into the bladder from the ureters.

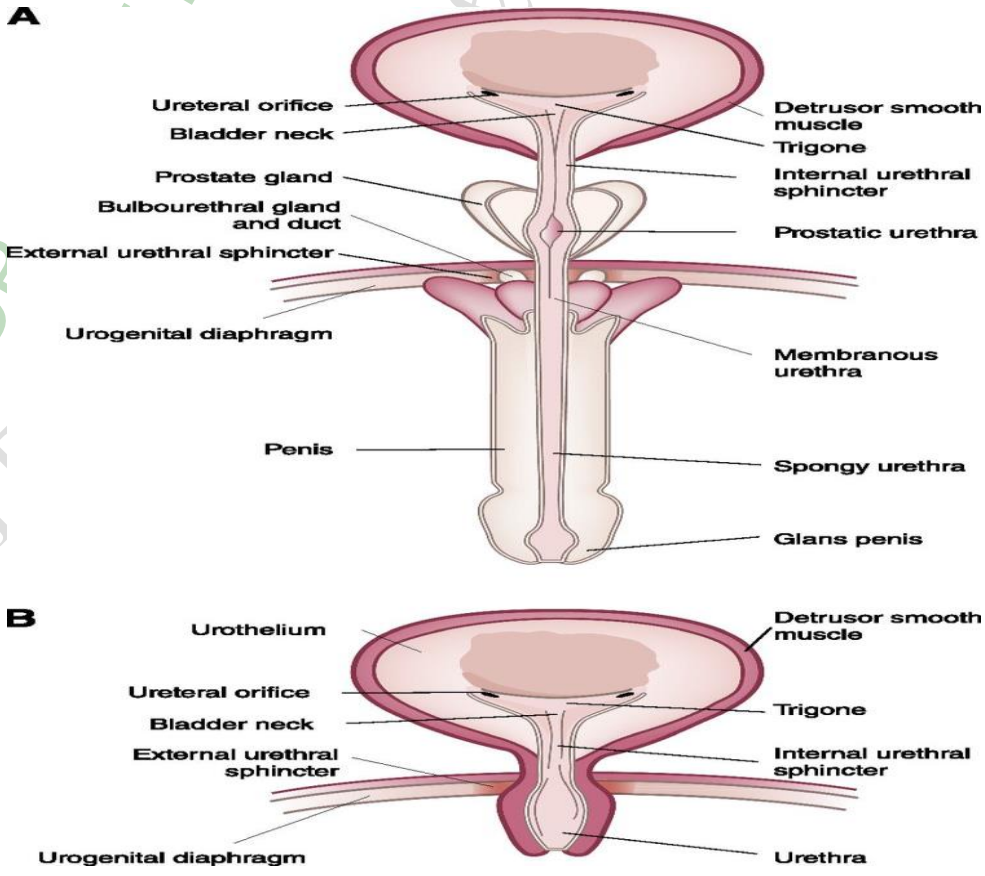
URINARY BLADDERS:

- This triangle-shaped, hollow organ is located in the lower abdomen.
- In the male it is directly anterior to the rectum and in the female it is directly anterior to the vagina and inferior to the uterus.
- In general urinary bladder have less capacity to store urine in female than male because in female uterus occupies the space just above the bladder in female.
- Expulsion of urine from urinary bladder is known as micturition, commonly known as urination.
- The average capacity of urinary bladder to store urine is 600-7000 mL, but when the urine reached near the volume of 200-300 mL in urinary bladder, the stretch receptors in the wall of bladder send message/impulse via sensory response to spinal cord that response analyze by the integrated centre of CNS and generate the reflex action to expel urine known as micturition.

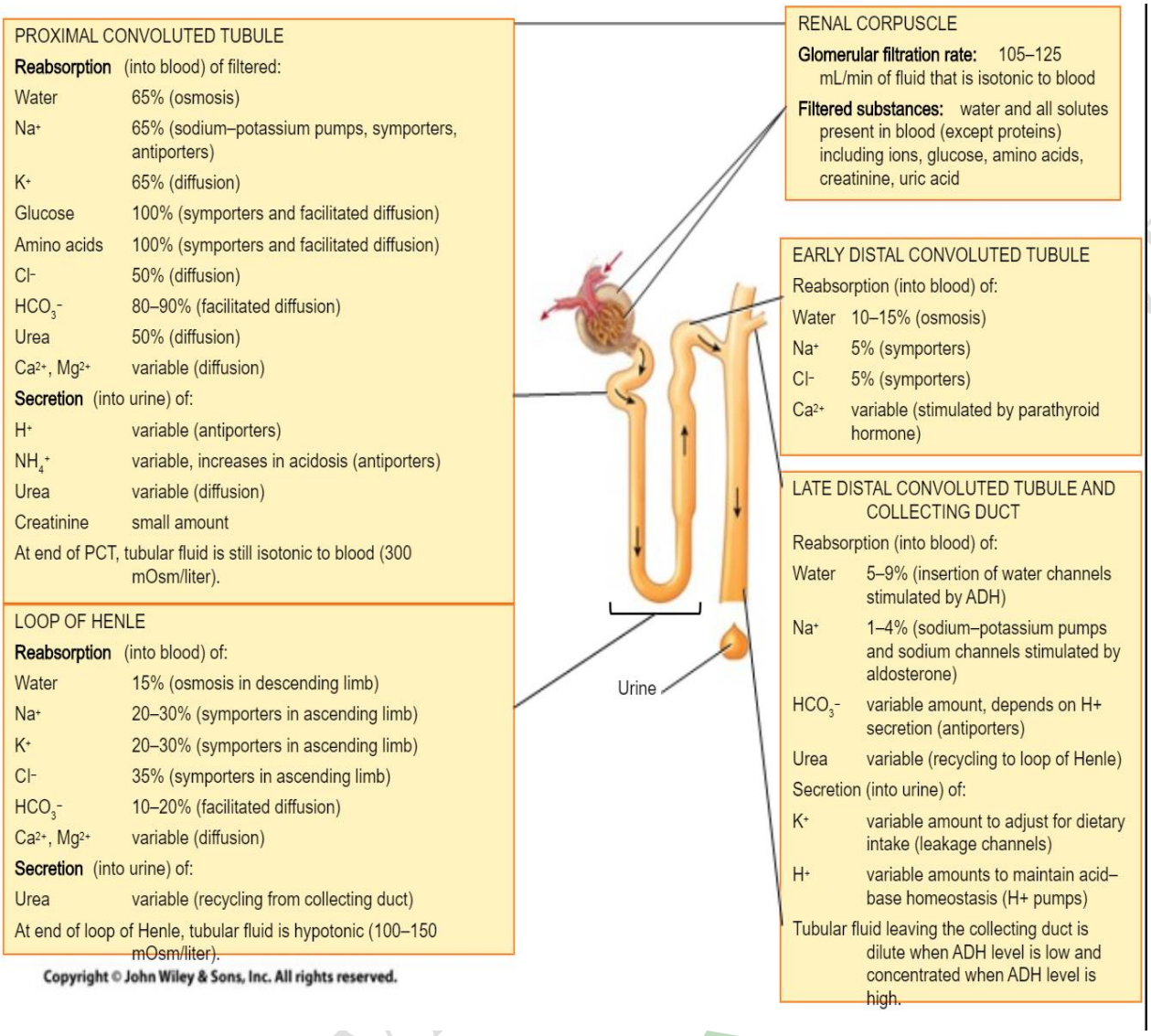


URETHRA:

- The urethra is the tube through which urine passes from the bladder to the exterior of the body.
- The female urethra is around 2 inches long and ends inferior to the clitoris and superior to the vaginal opening.
- In males, the urethra is around 8 to 10 inches long and ends at the tip of the penis. The urethra is also an organ of the male reproductive system as it carries sperm out of the body through the penis.
- The male urethra has three regions: 1. prostatic urethra 2. Membranous urethra 3. Penile urethra.
- The flow of urine through the urethra is controlled by the internal and external urethral sphincter muscles.
- The internal urethral sphincter is made of smooth muscle and opens involuntarily when the bladder reaches a certain set level of distention.
- The opening of the internal sphincter results in the sensation of needing to urinate.
- The external urethral sphincter is made of skeletal muscle and may be opened to allow urine to pass through the urethra or may be held closed to delay urination.



A. Male Urethra **B. Female Urethra**



DISEASES OF EXCRETORY SYSTEM/URINARY SYSTEM

1. KIDNEY STONE:

- Kidney stones (are hard deposits made of minerals and salts that form inside the kidneys.
- The stones may be small and pass unnoticed through the urinary tract, but they can also cause extreme pain as they leave the body.

Types of kidney stones include:

- Calcium stones. Most kidney stones are calcium stones, usually in the form of calcium oxalate. Oxalate is a naturally occurring substance found in food and is also made daily by liver. Some fruits and vegetables, as well as nuts and chocolate, have high oxalate content.
- Dietary factors, high doses of vitamin D, intestinal bypass surgery and several metabolic disorders can increase the concentration of calcium or oxalate in urine.

- Calcium stones may also occur in the form of calcium phosphate. This type of stone is more common in metabolic conditions, such as renal tubular acidosis. It may also be associated with certain migraine headaches or with taking certain seizure medications, such as topiramate (Topamax).
- Struvite stones. Struvite stones form in response to an infection, such as a urinary tract infection. These stones can grow quickly and become quite large, sometimes with few symptoms or little warning.
- Uric acid stones. Uric acid stones can form in people who don't drink enough fluids or who lose too much fluid, those who eat a high-protein diet, and those who have gout. Certain genetic factors also may increase your risk of uric acid stones.
- Cystine stones. These stones form in people with a hereditary disorder that causes the kidneys to excrete too much of certain amino acids (cystinuria).

Symptoms:

- ✓ Severe pain in the side and back, below the ribs
- ✓ Pain that radiates to the lower abdomen and groin
- ✓ Pain that comes in waves and fluctuates in intensity
- ✓ Pain on urination
- ✓ Pink, red or brown urine
- ✓ Cloudy or foul-smelling urine
- ✓ Nausea and vomiting
- ✓ Persistent need to urinate
- ✓ Urinating more often than usual
- ✓ Fever and chills if an infection is present
- ✓ Urinating small amounts

Causes:

- ✓ The leading cause of kidney stones is a lack of water in the body.
- ✓ Stones are more commonly found in individuals who drink less than the recommended eight to ten glasses of water a day.
- ✓ When there is not enough water to dilute the uric acid, a component of urine, the urine becomes more acidic.
- ✓ An excessively acidic environment in urine can lead to the formation of kidney stones.
- ✓ Medical conditions such as Crohn's disease, urinary tract infections, renal tubular acidosis, hyperparathyroidism, medullary sponge kidney, and Dent's disease increase the risk of kidney stones.

Treatment:

- ✓ Treating kidney stones is primarily focused on symptom management. Passing a stone can be very painful.
- ✓ If a person has a history of kidney stones, home treatment may be suitable. Individuals who have never passed a kidney stone should speak with a doctor.
- ✓ If hospital treatment is needed, an individual may be rehydrated via an intravenous (IV) tube, and anti-inflammatory medication may also be administered.
- ✓ Narcotics are often used in an effort to make the pain of passing the stone tolerable. Antiemetic medication can be used in people experiencing nausea and vomiting.
- ✓ In some cases, a urologist can perform a shock wave therapy called lithotripsy. This is a treatment that breaks the kidney stone into smaller pieces and allow it to pass.
- ✓ People with large stones located in regions that do not allow for lithotripsy may receive surgical procedures, such as removal of the stone via an incision in the back or by inserting a thin tube into the urethra.

2. URINARY TRACT INFECTION (UTI)

- It is an infection in any part of your urinary system like kidneys, ureters, bladder and urethra.
- Most infections involve the lower urinary tract that is the bladder and the urethra.
- Women have greater risk for UTI than men.

Symptoms

- Urinary tract infections don't always cause signs and symptoms, but when they do they may include:
- ✓ A strong, persistent urge to urinate
- ✓ A burning sensation when urinating
- ✓ Passing frequent, small amounts of urine
- ✓ Urine that appears cloudy
- ✓ Urine that appears red, bright pink or cola-colored — a sign of blood in the urine
- ✓ Strong-smelling urine
- ✓ Pelvic pain, in women — especially in the center of the pelvis and around the area of the pubic bone

Types of urinary tract infection:

a. Acute pyelonephritis:
   - Affected part is kidney.

- Sign and symptoms are Upper back and side (flank) pain, High fever, Shaking and chills, Nausea, Vomiting

b. Cystitis:

- Affected part is bladder.
- Sign and symptoms are Pelvic pressure, Lower abdomen discomfort, Frequent, painful urination, Blood in urine

c. Urethritis:

- Affected part is urethra.
- Sign and symptoms are Burning with urination, Discharge.

Causes

- Urinary tract infections is generally the bacterial infection. The most common UTIs occur mainly in women and affect the bladder and urethra.
- **Infection of the bladder (cystitis):**
  - ✓ This type of UTI is usually caused by Escherichia coli (E. coli), a type of bacteria commonly found in the gastrointestinal (GI) tract. However, sometimes other bacteria are responsible.
  - ✓ Sexual intercourse may lead to cystitis, but you don't have to be sexually active to develop it. All women are at risk of cystitis because of their anatomy — specifically, the short distance from the urethra to the anus and the urethral opening to the bladder.
- Infection of the urethra (urethritis):
- This type of UTI can occur when GI bacteria spread from the anus to the urethra. Also, because the female urethra is close to the vagina, sexually transmitted infections, such as herpes, gonorrhea, chlamydia and mycoplasma, can cause urethritis.

Treatment:

- Antibiotics drug therapy with or without analgesic medication.
- IV infusion with antibiotics

3. KIDNEY FAILURE:

- Kidney failure, also known as end-stage kidney disease, is a medical condition in which the kidneys no longer function.
- It is divided into acute kidney failure (cases that develop rapidly) and chronic kidney failure (those that are long term).

Symptoms:

- Leg swelling, feeling tired, vomiting, loss of appetite, or confusion etc

Causes of acute kidney failure:

- Low blood pressure, blockage of the urinary tract, certain medications, muscle breakdown, and hemolytic uremic syndrome.
- Causes of chronic kidney failure include diabetes, high blood pressure, nephrotic syndrome, and polycystic kidney disease.

Treatment:

- Acute disease typically depends on the underlying cause.
- Treatment of chronic disease may include hemodialysis, peritoneal dialysis, or a kidney transplant.
- Hemodialysis uses a machine to filter the blood outside the body.
- In peritoneal dialysis specific fluid is placed into the abdominal cavity and then drained, with this process being repeated multiple times per day.
- Kidney transplantation involves surgically placing a kidney from someone else and then taking immunosuppressant medication to prevent rejection.
- Other recommended measures from chronic disease include staying active and specific dietary changes.