

EXCRETION

- **Excretion is the removal of waste products from the body formed during metabolism, e.g. carbon dioxide, water and nitrogenous waste products.**
- **The following are the body organs and the waste products they excrete:**
- **Lungs – CO₂, water, water vapour and heat**
- **Kidneys – urine**
- **Liver – urea and bile pigments**
- **Alimentary canal – bile pigments and bile salts**
- **Skin - sweat**

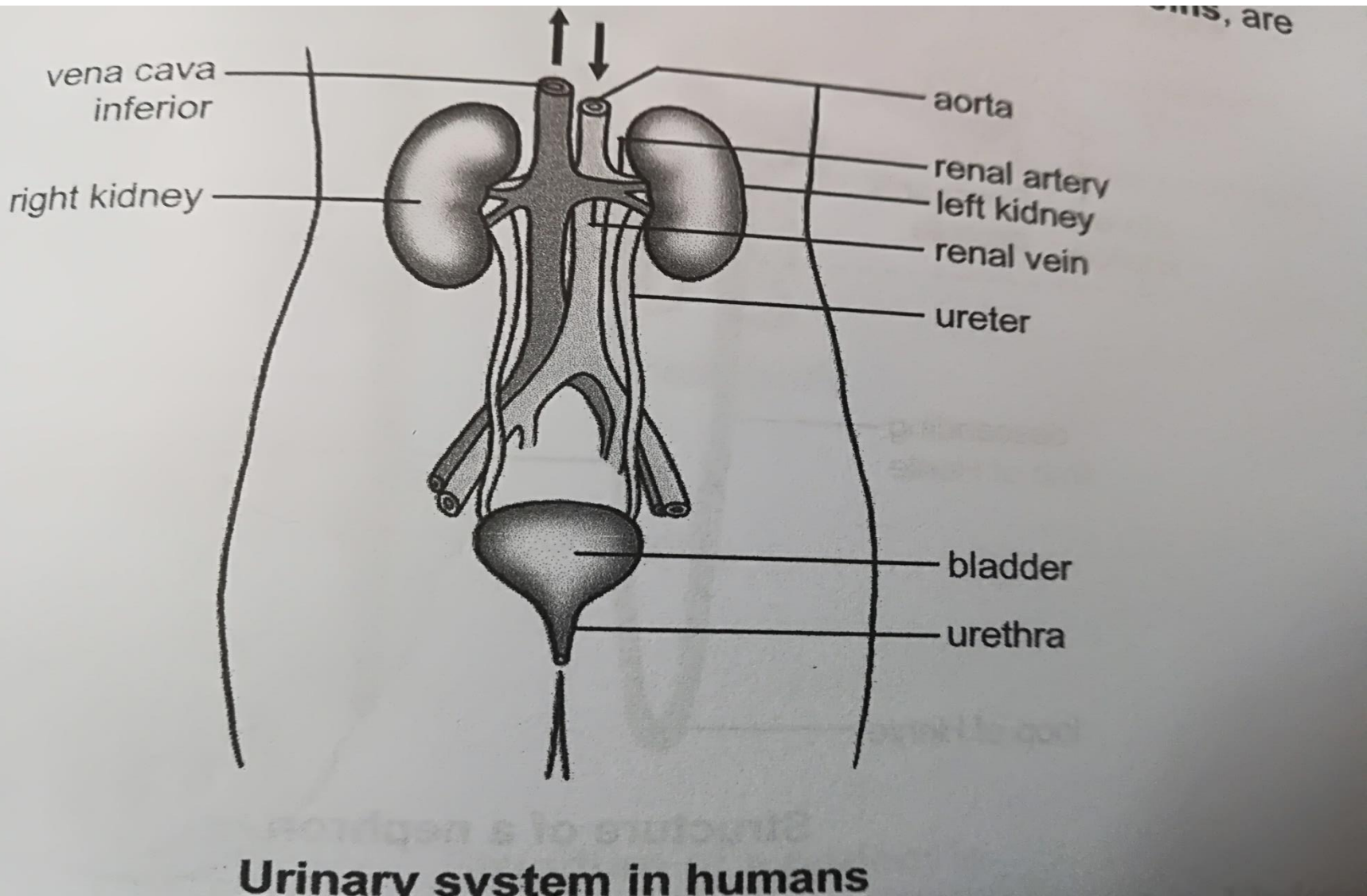
METABOLIC WASTES AND THEIR ORIGIN

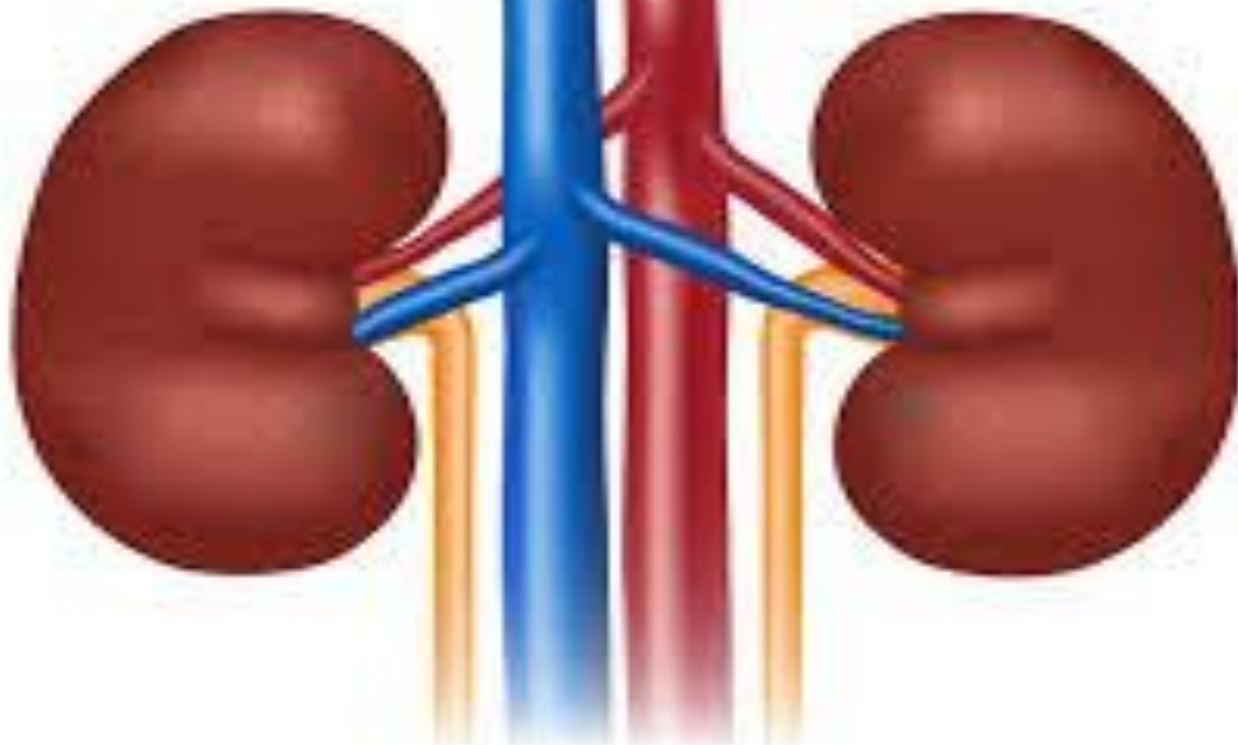
- **CO₂ - cellular respiration**
- **Excess water – food and a product of cellular respiration**
- **Urea – formed in the liver during deamination of excess amino acids**
- **Uric acid – metabolism of nucleic acids**
- **Bile pigments – breakdown of haemoglobin in the liver**

URINARY SYSTEM IN HUMANS

- **The human urinary system consists of the following parts:**
- **Two kidneys situated at the back of the abdominal cavity at about waist level.**
- **Two ureters**
- **Urinary bladder and**
- **Urethra**
- **The following blood vessels are connected to the urinary system:**
 - **Two renal arteries – bring oxygenated blood with a lot of nitrogenous waste to the kidneys.**
 - **Two renal veins – carry deoxygenated blood with little nitrogenous waste away from the kidneys.**

URINARY SYSTEM IN HUMANS (Cont...)





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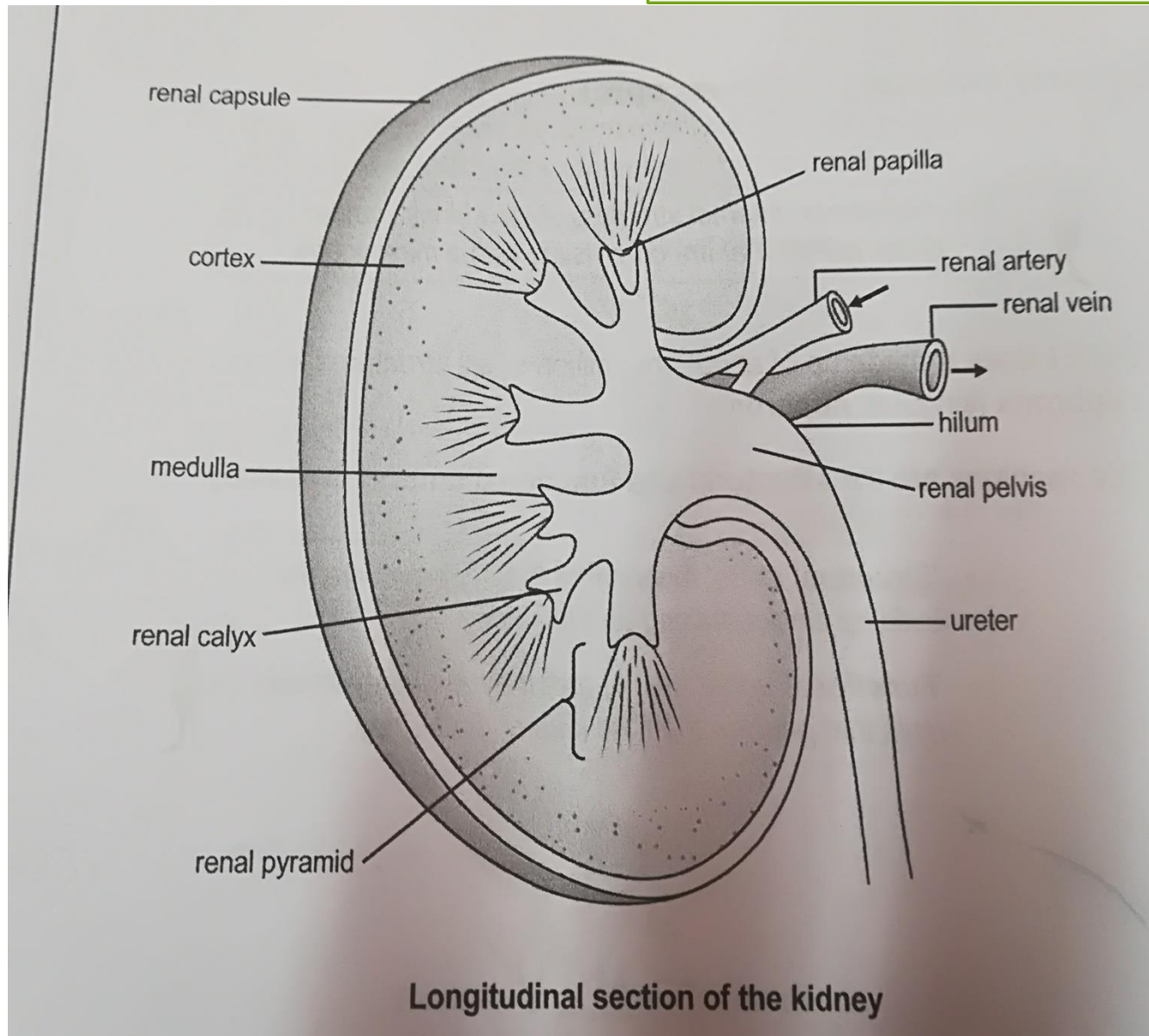
EXTERNAL STRUCTURE OF THE HUMAN KIDNEY

- A human kidney is bean-shaped and dark red in colour.
- The right kidney is slightly lower than the left kidney.
- The concave side of each kidney faces the vertebral column.
- In the middle of the concave side is an indentation called the hilum, where the renal artery, renal vein and ureter are connected to the kidney.
- A thick layer of fat covers and protects each kidney.
- Each human kidney is covered by a membrane called the renal capsule.



INTERNAL STRUCTURE

- As indicated earlier on, the kidney is covered by a thin membrane, the renal capsule.
- Directly under the renal capsule is a reddish brown section called the cortex.
- Below the cortex is a light brown region called the medulla.
- The medulla contains small tubes arranged in groups.
- Each group of tubes forms a pyramid.
- The base of each pyramid, the papilla



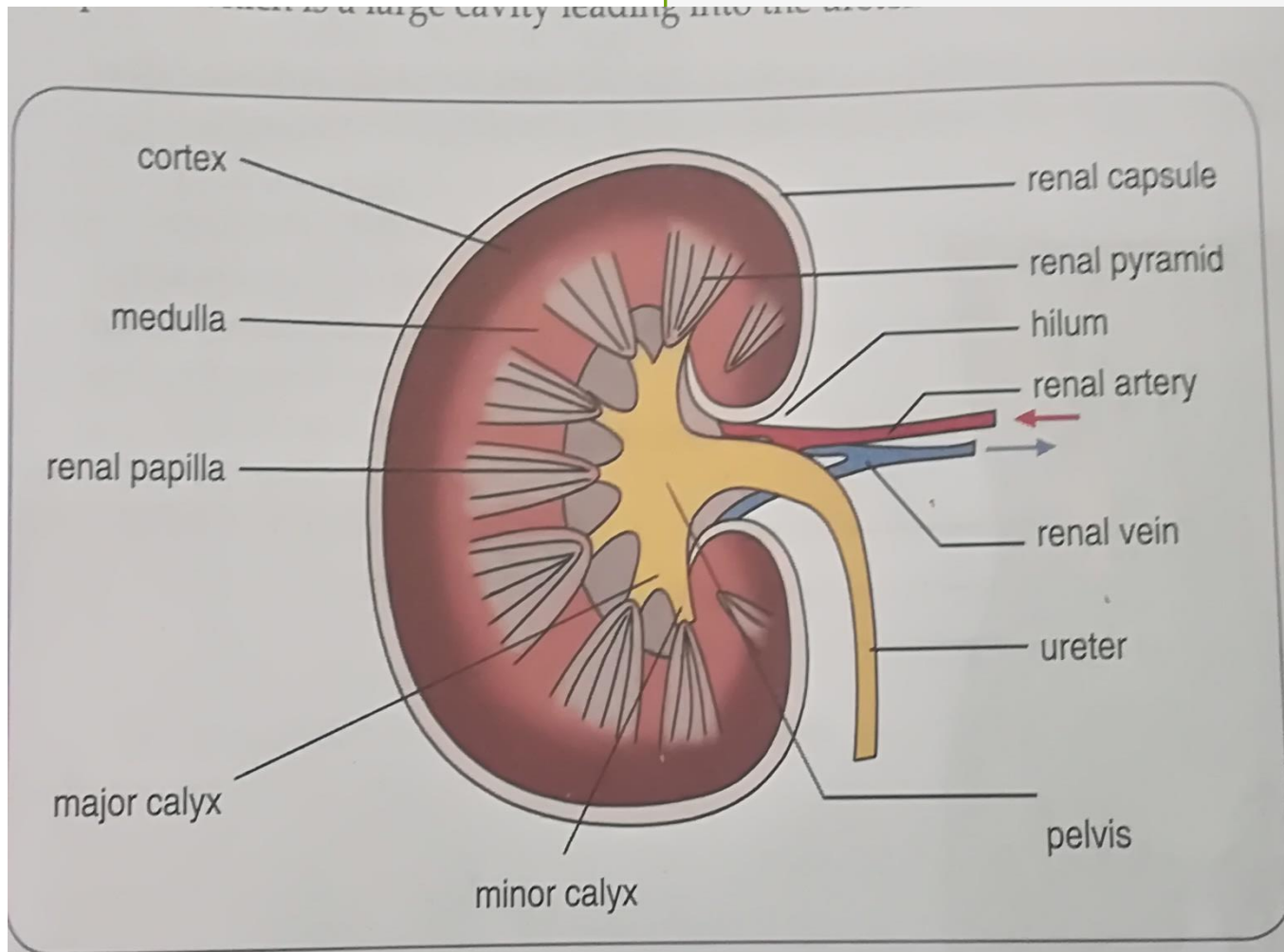
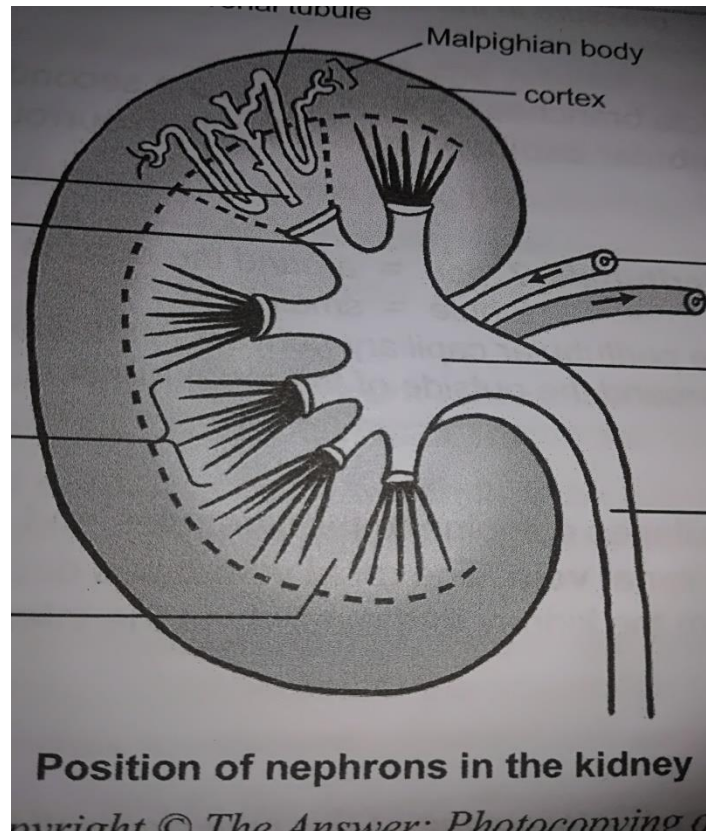


Fig. 8.4 Longitudinal section of a kidney showing its internal structure

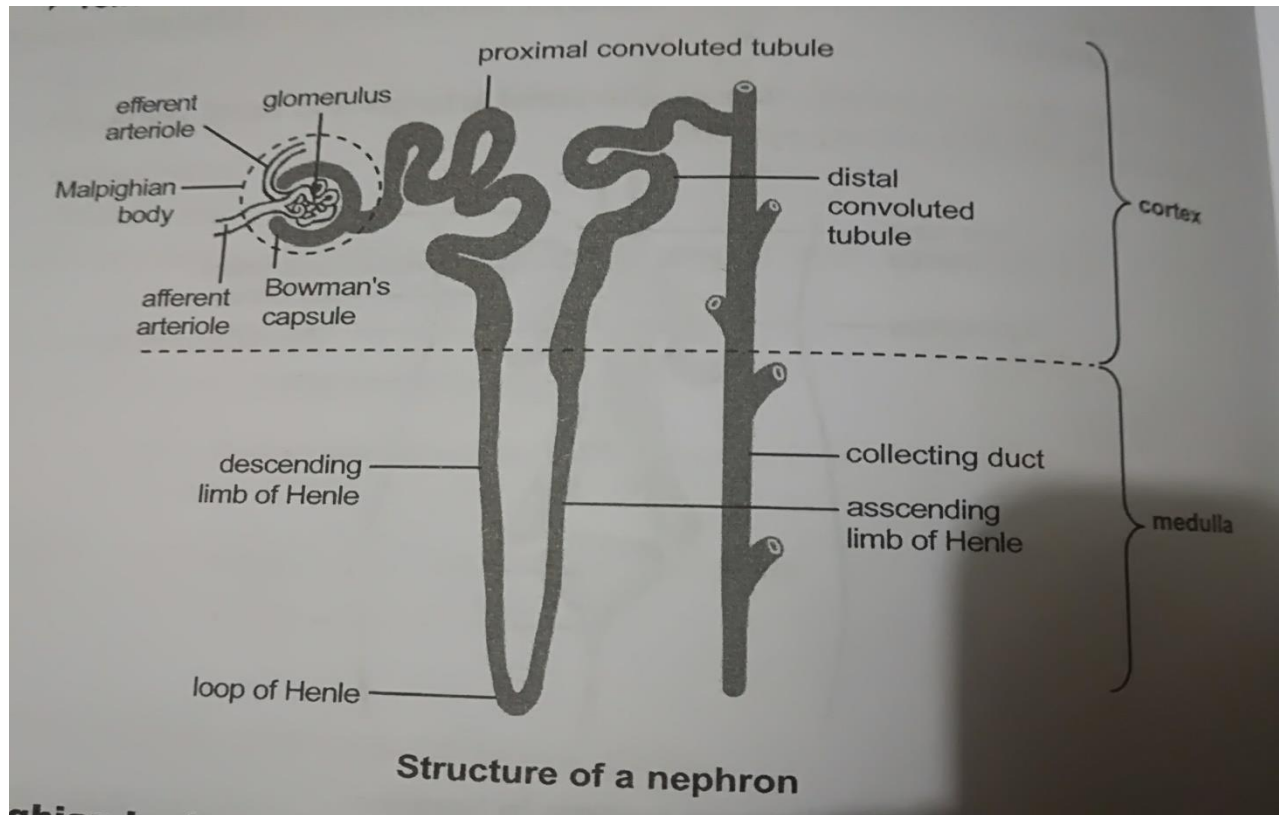
MICROSCOPIC STRUCTURE OF THE KIDNEY

- Each human kidney consists of about a million of structures called nephron.
- A nephron is a functional unit of the kidney.



STRUCTURE OF A NEPHRON

- A nephron consists of two main parts, namely:
 - the Bowman's capsule and
 - the renal tubule



STRUCTURE OF A NEPHRON (Cont...)

- The Bowman's capsule
- It is double-walled cup-shaped part of the nephron.
- Its outer wall consists of one layer of flat squamous epithelial cells.
- The inner wall of the Bowman's capsule is made of specialised cells called the podocytes.
- Between the two layers of the Bowman's capsule is cavity called the cavity of the Bowman's capsule

STRUCTURE OF A NEPHRON (Cont...)

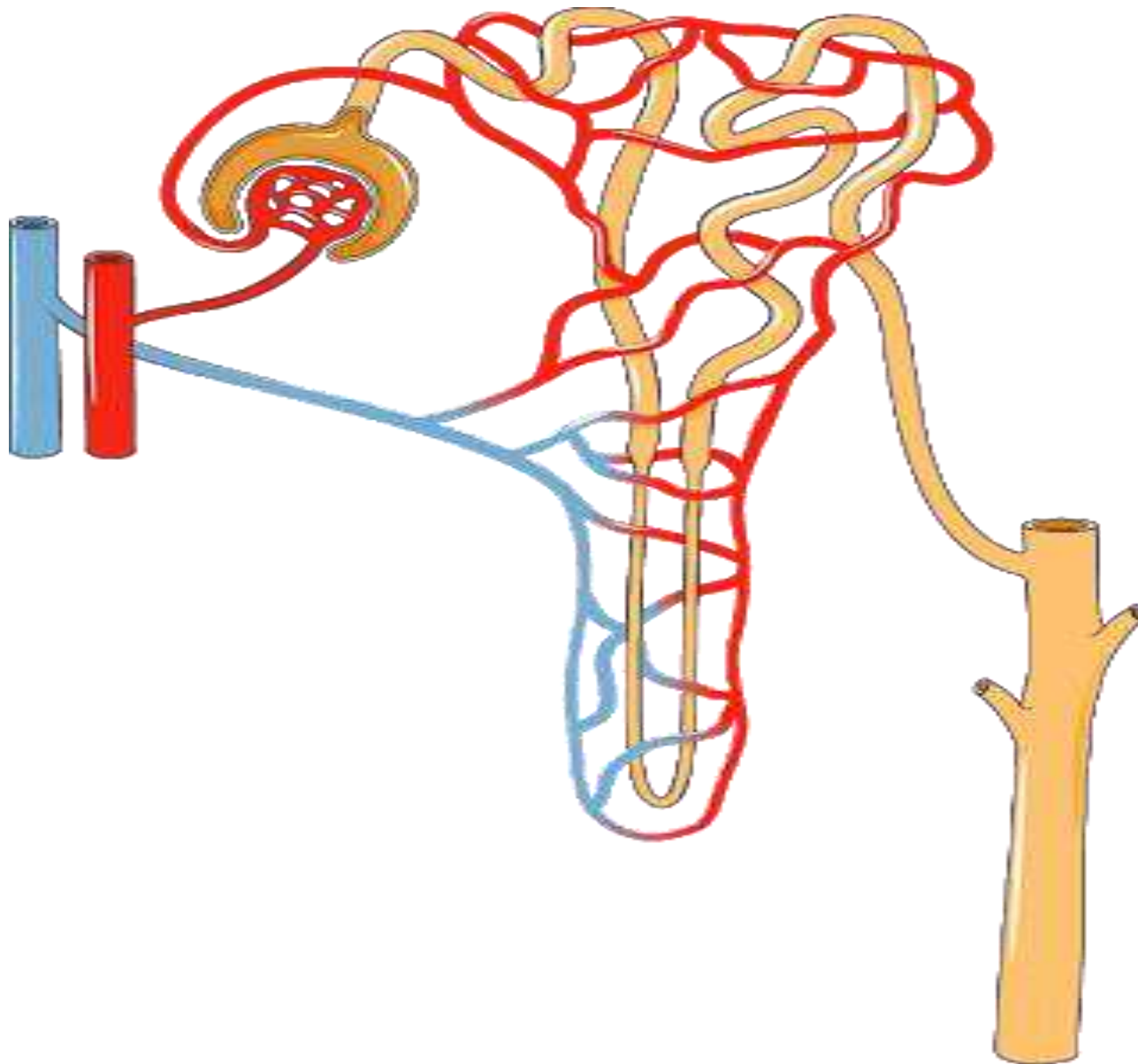
- **The renal tubule**
- **This is a long convoluted (coiled) tubule found partially in the cortex and partially in the medulla.**
- **It consists of the following parts:**
 - **the proximal convoluted tubule**
 - **the loop of Henle**
 - **the distal convoluted tubule and**
 - **the collecting duct**
- **The proximal convoluted tubule is found directly after the Bowman's capsule.**
- **This is the widest part of the renal tubule and it consists of a single layer of cuboidal epithelial cells.**

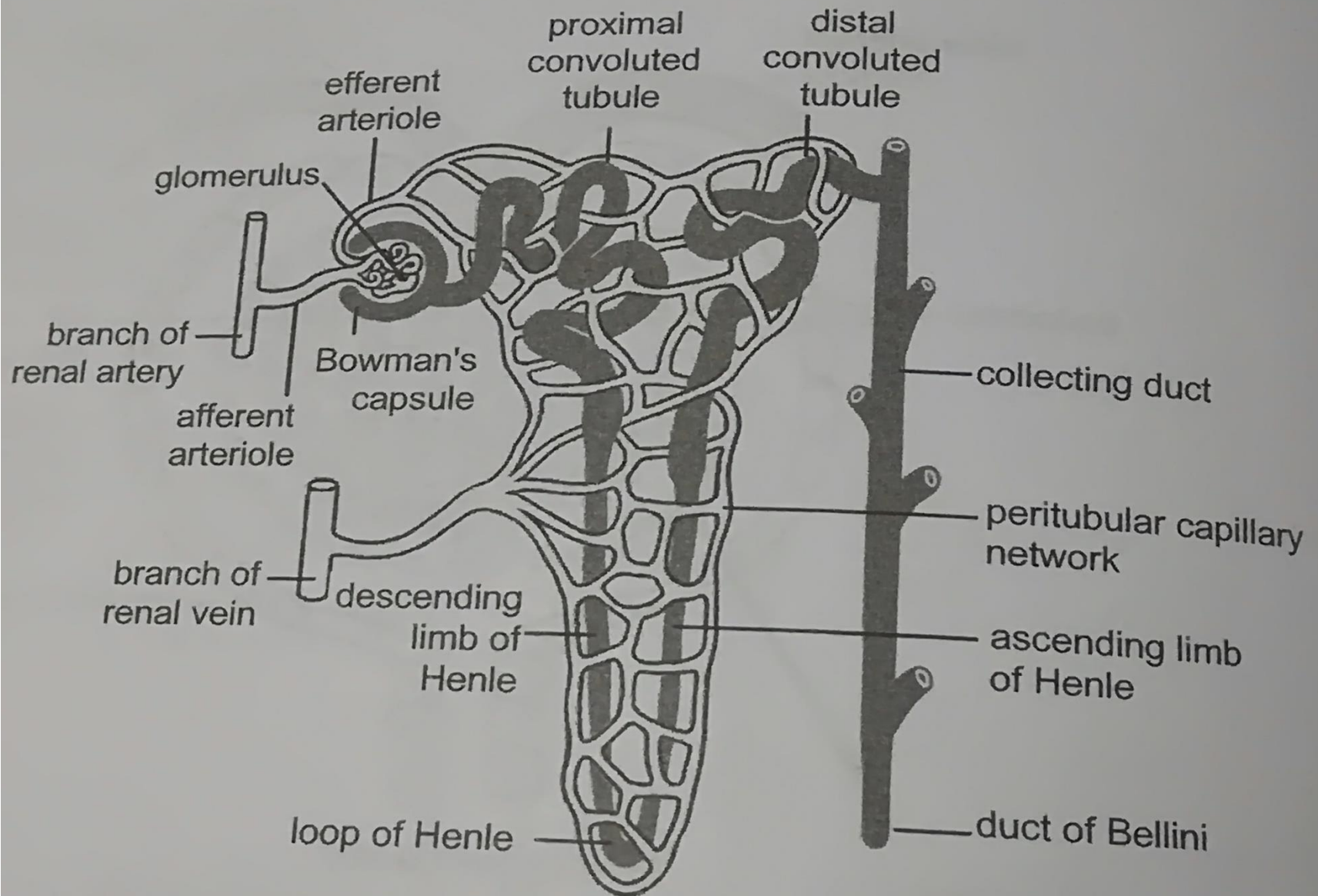
STRUCTURE OF A NEPHRON (Cont...)

- **The renal tubule (conti...)**
- **Following the proximal convoluted tubule is the loop of Henle.**
- **The loop of Henle consists of two parts, namely:**
 - **the descending limb which extends from the cortex down to the medulla and forms a hairpin bend and**
 - **the ascending limb that extends from medulla upward to the cortex.**
- **The distal convoluted tubule is a coiled tubule just like the proximal convoluted tubule.**

BLOOD VESSELS ASSOCIATED WITH THE NEPHRON

- **The following blood vessels are connected to the nephron:**
- **the afferent arteriole**
- **Glomerular capillaries (glomerulus)**
- **the efferent arteriole**
- **the peritubular capillaries and**
- **the vasa recta**
- **The afferent arteriole transports oxygenated blood to the Bowman's capsule.**
- **In the Bowman's capsule, the afferent arteriole branches into a network of blood capillaries called the glomerulus.**
- **The Bowman's capsule and the glomerulus together form the Malpighian body**





BLOOD VESSELS ASSOCIATED WITH THE NEPHRON

- **From the Bowman's capsule, the glomerulus leaves as a single a small blood vessel called the efferent arteriole.**
- **The efferent arteriole has narrower diameter than the afferent arteriole .**
- **Outside the Bowman's capsule, the efferent arteriole branches into a number of thinner blood vessels called the peritubular capillaries.**
- **The peritubular capillaries surround the renal tubule and eventually unite or combine to form larger veins which eventually form the renal vein.**
- **The renal vein carries deoxygenated blood, minus waste products, from the kidney to the inferior vena cava.**

FUNCTIONING OF THE KIDNEY

- **There are three processes that are involved in the functioning of the kidney, namely:**
- **Glomerular filtration/ultrafiltration**
- **Tubular reabsorption and**
- **Tubular excretion**

FUNCTIONING OF THE KIDNEY

- **Glomerular filtration/ultrafiltration**
- **This process occurs in the Malpighian bodies as follows:**
- **Since the afferent arteriole has a wider diameter than the efferent arteriole, blood entering the glomerulus is forced to leave slowly.**
- **This creates high pressure in the glomerulus.**
- **This high pressure forces some blood plasma to seep out of the glomerular capillaries.**
- **The blood plasma moves out through the small pores on the walls of the blood capillaries and then through the slits of the Bowman's capsule into the cavity in the Bowman's capsule.**
- **That part of the blood that moves out of the glomerulus is called the glomerular filtrate.**

FUNCTIONING OF THE KIDNEY(Cont...)

- **The glomerular filtrate contains the following substances:**
- **Water**
- **Salts**
- **Useful substances like glucose, amino acids, fatty acids, glycerol and vitamins.**
- **Waste substances such as urea and uric acid.**
- **The blood corpuscles and plasma proteins do not filter through as they are too large.**

FUNCTIONING OF THE KIDNEY

- Adaptations of the Malpighian body for filtration
- The afferent arteriole has a wider diameter than the efferent arteriole; this creates high blood pressure in the glomerulus, promoting filtration.
- The capillary network of the glomerulus has a large surface area; this increases the efficiency of filtration.
- The Bowman's capsule is cup-shaped; this provides a large surface area for effective filtration.
- The endothelial layer of the glomerular capillaries has pores to allow smaller parts of the blood to filter through.

TUBULAR REABSORPTION

- In the proximal convoluted tubule
- All the glucose, amino acids, vitamins, fatty acids, glycerol and part of the water are selectively reabsorbed by the peritubular capillaries.
- All the above substances, except water, are reabsorbed through active transport.
- Water is reabsorbed passively through osmosis.

FUNCTIONING OF THE KIDNEY

- **Adaptation of the proximal convoluted tubule for selective reabsorption.**
 - **Its wall is thin as it consists of one layer of cells, this facilitates diffusion.**
 - **The cells on the wall of the proximal convoluted tubule have microvilli to increase the surface area for reabsorption.**
 - **The cells forming the wall of the proximal convoluted tubule consist of many mitochondria to provide energy for active transport.**
 - **The tubule is coiled to slow down the movement of the filtrate to allow ample time for reabsorption.**

TUBULAR REABSORPTION (Conti...)

- **In the loop of Henle**
- **This is where salts and ions are reabsorbed according to the needs of the body.**
- **If the blood pH, which is normally slightly alkaline, decreases, more bicarbonate ions (HCO_3^-) will be reabsorbed.**
- **If the blood becomes too alkaline, more hydrogen ions will be reabsorbed.**
- **More sodium ions are actively reabsorbed in the loop of Henle**

FUNCTIONING OF THE KIDNEY

- **Tubular excretion**
- **As the filtrate passes along the nephron, additional waste substances such creatinine, certain drugs such penicillin, hippuric acid, hydrogen ions and potassium are actively added to the filtrate/**
- **Tubular epithelial cells also excrete ammonium ions, which they produce as a waste product, directly into the filtrate to become part of the urine.**

FUNCTIONING OF THE KIDNEY

- **Urine formation**
- **Once the filtrate flows into collecting tubule, it becomes more concentrated and is known as urine.**
- **From the collecting tubes, the urine passes out of the kidney through the ureter to the bladder.**
- **Urine eventually passes out of the body through the urethra.**

COMPOSITION OF URINE

- **Urine is yellowish in colour with a characteristic smell.**
- **Its composition depends on the level of activity, health, amount of fluid intake, type of food eaten, medication, etc.**
 - **Urine consists of:**
 - **Water – main component**
 - **Inorganic salts – e.g. sodium, chloride, phosphate, magnesium, etc.**
- **Metabolic wastes – e.g. urea, uric acid, ammonia, creatinine.**
- **Foreign substances – e.g. flavourants, colourants, preservatives taken with food and drugs**

pH CONTROL

- The pH of the blood is regulated in the distal convoluted tubule
- When the blood is too acidic (pH is too low)
- Fewer hydrogen ions are excreted from the blood into the renal tubule.
- Fewer bicarbonate ions are reabsorbed into the blood.
- This decreases the pH of the blood until it returns to normal.
- The hydrogen ions combine with the phosphate ions present in the filtrate to form hydrogen phosphate.
- Hydrogen phosphate prevents the pH in the urine from becoming too low (i.e. it prevents urine from becoming too acidic).
- In other words phosphate ions in the filtrate act as a buffer.

pH CONTROL

- The pH of the blood is regulated in the distal convoluted tubule
- When the blood is too alkaline(pH is too high)
- More bicarbonate ions are excreted from the blood into the renal tubule.
- More hydrogen ions are reabsorbed into the blood.
- This decreases the pH of the blood until it returns to normal.
- More bicarbonate ions are therefore excreted with the urine

REABSORPTION OF WATER

- **This occurs mainly in the distal convoluted tubule and is regulated by the ADH whose release is controlled by the hypothalamus.**
- **When there is too little water in the body, more ADH is released into the blood.**
- **ADH increases the permeability of the walls of the distal convoluted tubule.**
- **As the filtrate passes the distal convoluted tubule more water is reabsorbed into blood and water is conserved.**
- **The amount of water in the blood therefore increases.**
- **Urine becomes more concentrated and its volume decreases (i.e. less urine is excreted).**

REABSORPTION OF WATER

- **When there is too much water in the body, less ADH is released into the blood.**
- **This decreases the permeability of the walls of the distal convoluted tubule.**
- **Less water is reabsorbed from the filtrate as it passes through the distal convoluted tubule.**
- **This results in large amounts of water being excreted in the urine.**
- **The urine excreted will be more dilute because of the large amount of water it contains.**
- **The water content of the blood decreases and returns to normal**

DISEASES AFFECTING THE KIDNEYS

- **Kidney stones**
- **They result from nitrogenous wastes that crystalize .**
- **Smaller crystals are passed out of the body with urine.**
- **Larger crystals or kidney stones can however block the ureter causing serious pain.**
- **Symptoms include pain in the back or side of the abdomen.**
- **People have to drink a lot of water to prevent kidney stones from being formed.**
- **Kidney stones may be removed surgically or they may be broken down into smaller pieces using laser treatment.**

DISEASES AFFECTING THE KIDNEYS

- **Kidney infections**

- **These infections are common, mostly among women.**
- **They are usually caused by bacterial infections of the bladder that spread to the urinary tract.**
- **Symptoms include the following:**
 - 1. Very high temperature**
 - 2. Back and side pain**
 - 3. Frequent urination**
 - 4. Pain while urinating**
 - 5. Blood/pus in the urine**
- **Kidney infections can be treated with antibiotics**

DISEASES AFFECTING THE KIDNEYS

○ Bilharzia

- This is a disease caused by a parasitic worm, schistosoma, found in infected water.
- It enters the body via cuts in the skin.
- Once infected, the worms live in the blood vessels around the intestines and the urinary bladder.
- You can become infected with bilharzia when swimming or touching infected water.
- Symptoms of bilharzia include:
 1. A fever
 2. Fatigue and
 3. Blood in the urine
 4. Bilharzia can
- Bilharzia can be treated with pharmaceutical drugs.



DISEASES AFFECTING THE KIDNEYS

- Renal failure/kidney failure
- This occurs when the kidneys fail to remove water, salts and nitrogenous wastes from the blood.
- Failure of the kidneys to function results in death.
- One way of saving a person's life is to link them to a dialysis machine (an artificial kidney).

Hemodialysis

