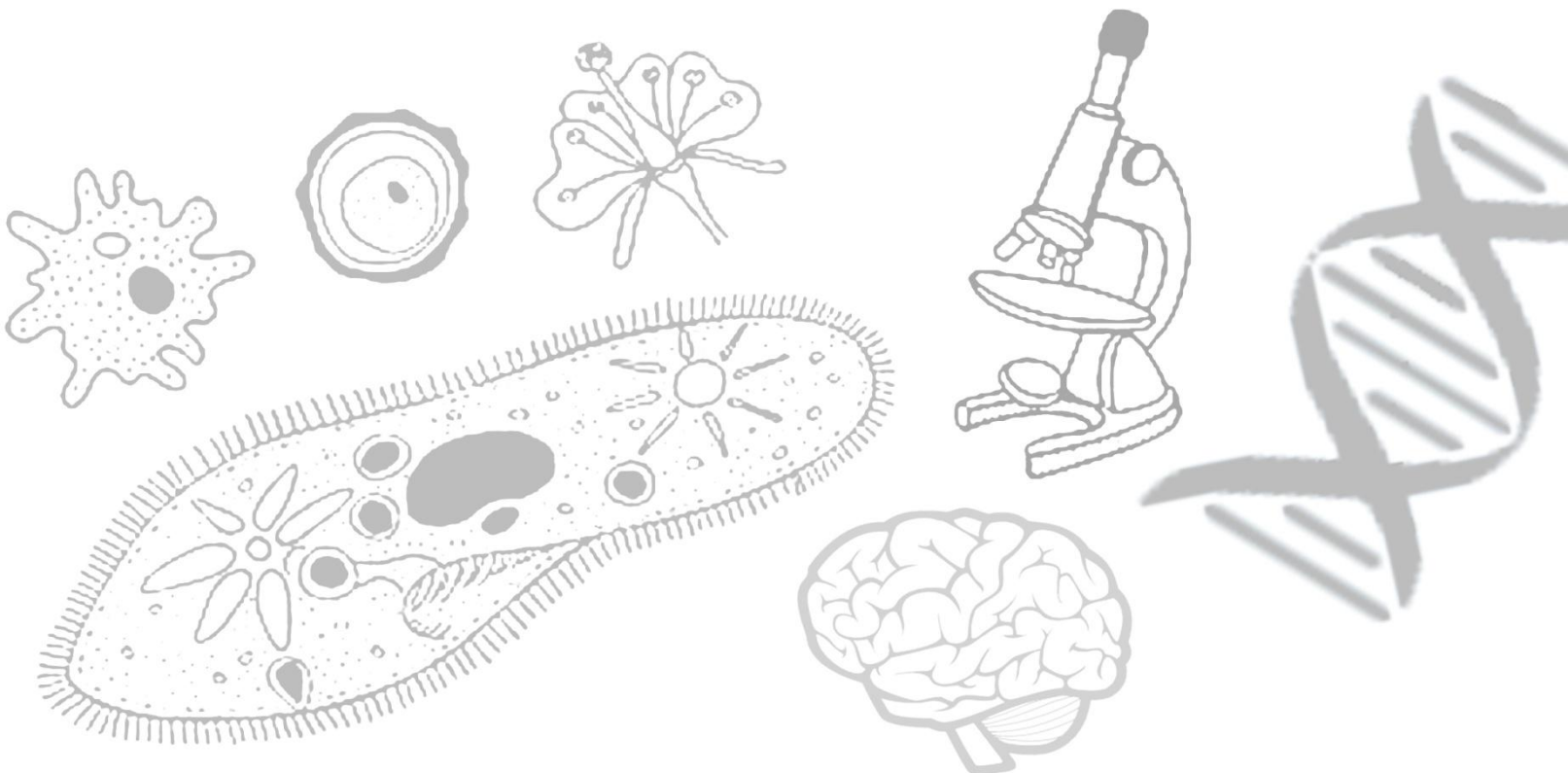
Chapter Notes

BIOLOGY



Excretory System

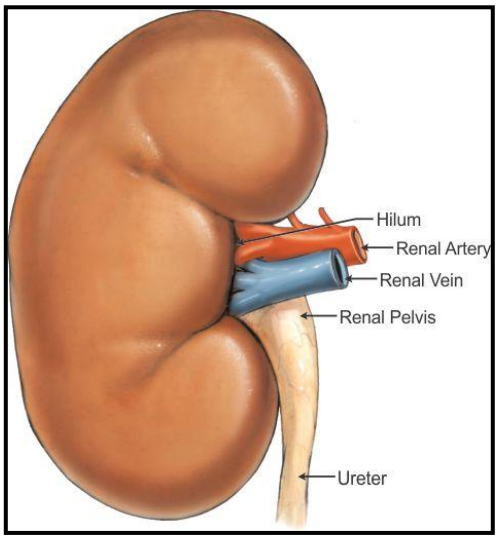
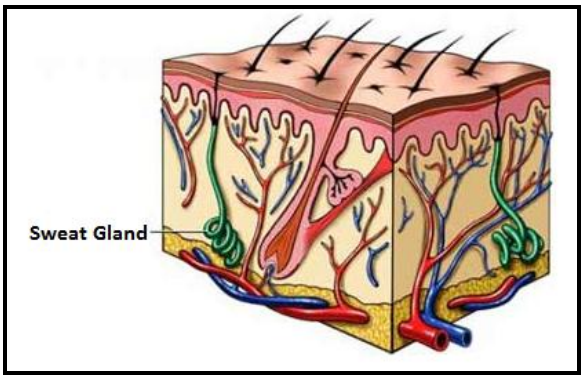
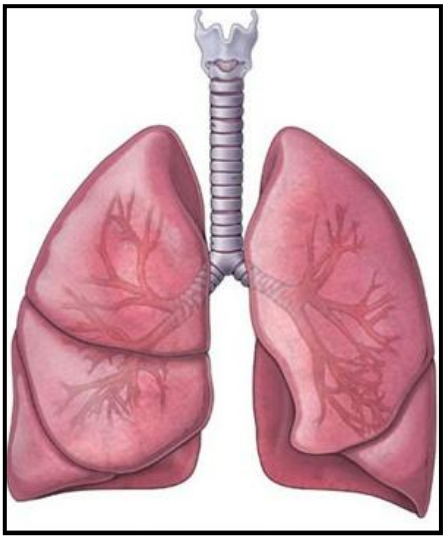
Excretion

- Excretion is the removal of harmful and unwanted substances, especially nitrogenous wastes from the body.

Substances to Get Rid Off

Carbon Dioxide and Water During respiration, oxidisation of glucose leads to the production of carbon dioxide and water.	• Carbon dioxide is eliminated through the lungs. • Water becomes part of the rest of the water in the body.
Nitrogenous Metabolic Wastes Urea, uric acid, ammonia Urea is highly poisonous; if allowed to accumulate in the blood to a certain level, it causes death.	• Urea is excreted through the kidneys.
Excess Salts Common salt (NaCl) and excess water soluble vitamins such as B and C.	• Salts are excreted through the kidneys.
Water	• The excess quantity of water is removed through the kidneys.
Bile Pigments Break down products of the haemoglobin of dead RBCs.	• Some of the bile pigments are excreted in the urine.

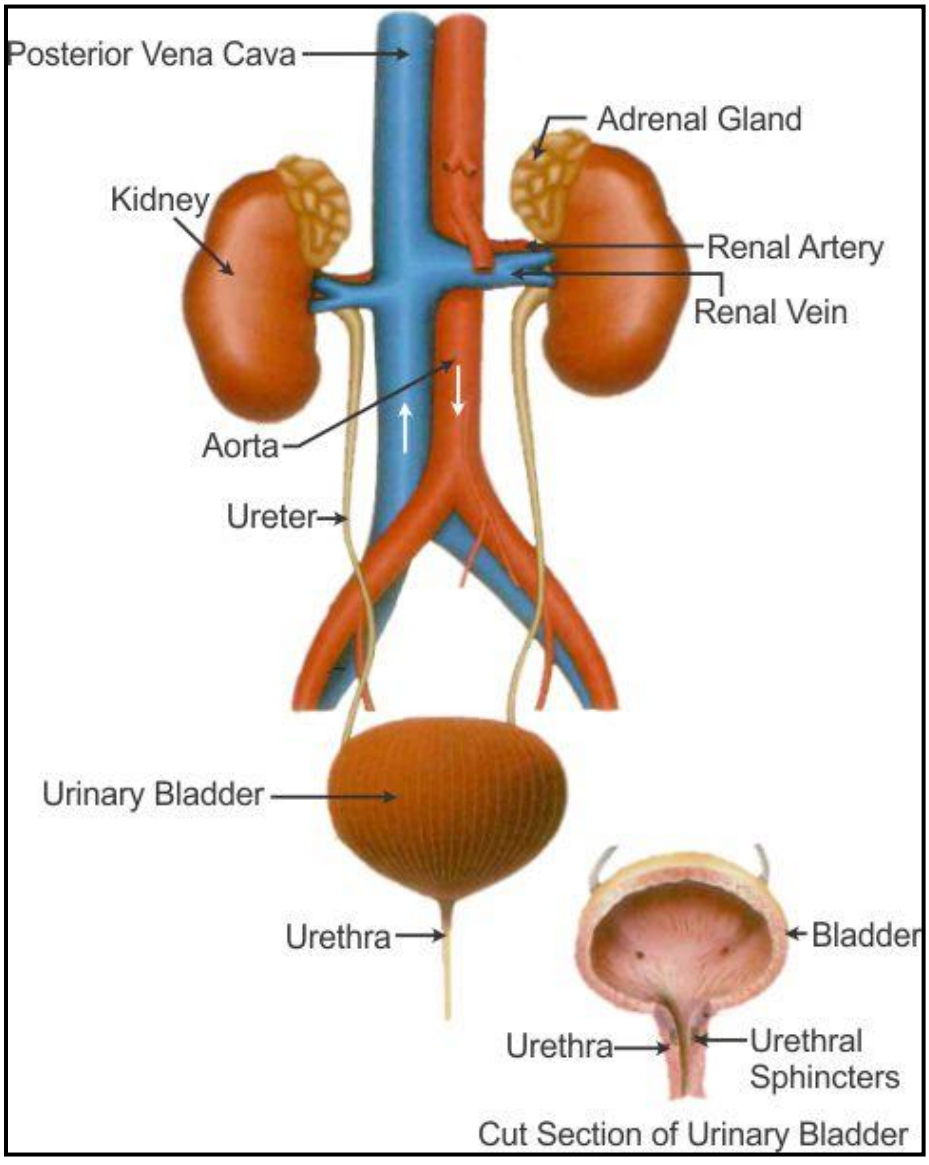
The Excretory Organs

1. The Kidneys 	• Primary excretory organ. • Removes unwanted substances, mainly urea in the form of urine.
2. Sweat Glands 	• Primarily concerned with thermoregulation (cooling of the body). • Excrete sweat which contains nitrogenous waste. • Sweat is excreted only when required, i.e. for cooling the body.
3. The Lungs 	• Carbon dioxide is expired by the lungs.

The Urinary System

The Human Urinary System consists of

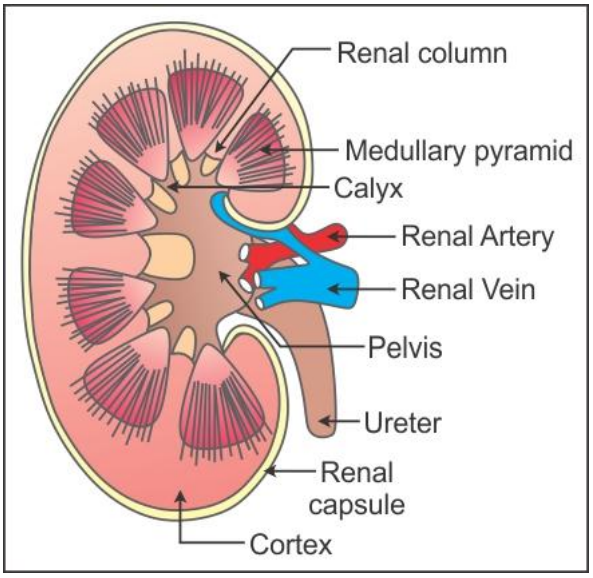
1. A pair of kidneys
2. A pair of ureters
3. Urinary bladder
4. Urethra



Human Urinary System

A Pair of Kidneys	• Dark red, bean shape, 10 cm long, 6 cm wide. • The right kidney is slightly lower in position due to the presence of the liver. • The renal artery supplies oxygenated blood to the kidneys. • The renal veins take away deoxygenated blood from the kidneys.
A Pair of Ureters	• Ureters are tube-like structures that arise from the notch, i.e. hilum of each kidney. • The front end of the ureters is somewhat expanded into each kidney and is called pelvis. • The ureters connect behind with the urinary bladder. • The ureters carry the urine produced to the urinary bladder. • At its distal end, valves are present which prevent backflow of the urine into the ureters when the bladder contracts.
Urinary Bladder	• Muscular sac-like structure. • It stores urine temporarily. • Its opening is guarded by muscular sphincters. • The sphincters open at the time of micturition (urination).
Urethra	• Short muscular tube which expels urine out of the body. • It is long in males and very short in females. • The opening is guarded by sphincters which open at the time of urination.

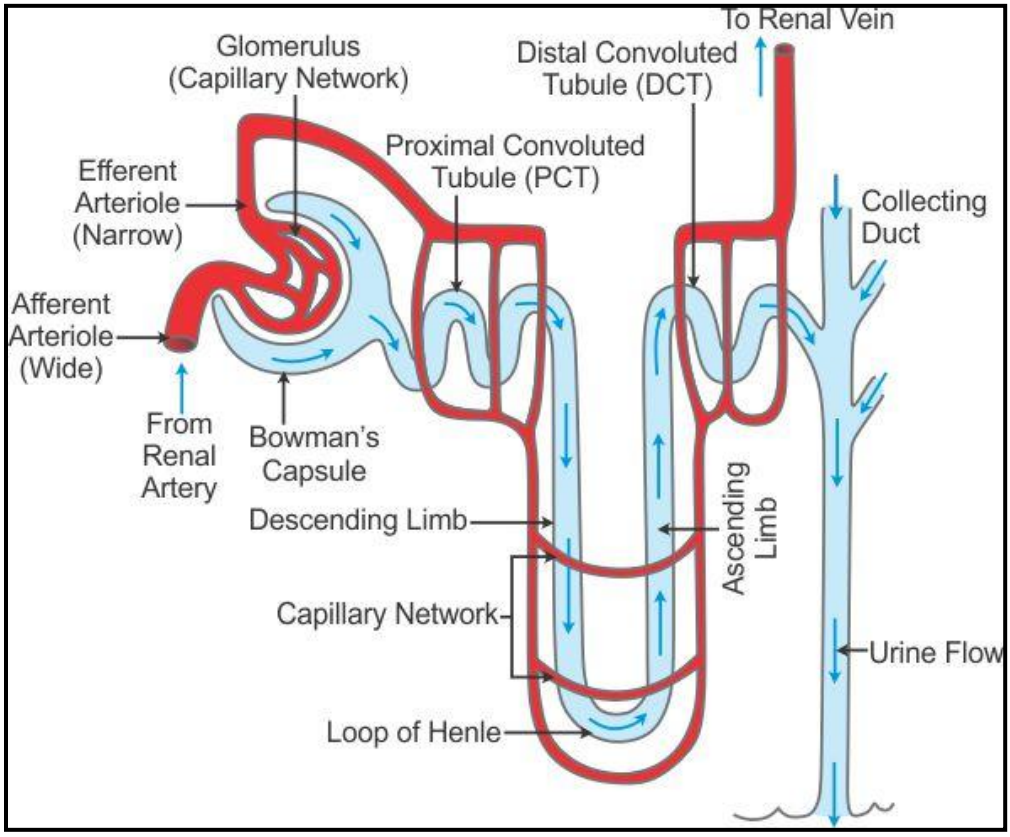
Internal Structure of the Kidney



L.S. of Kidney

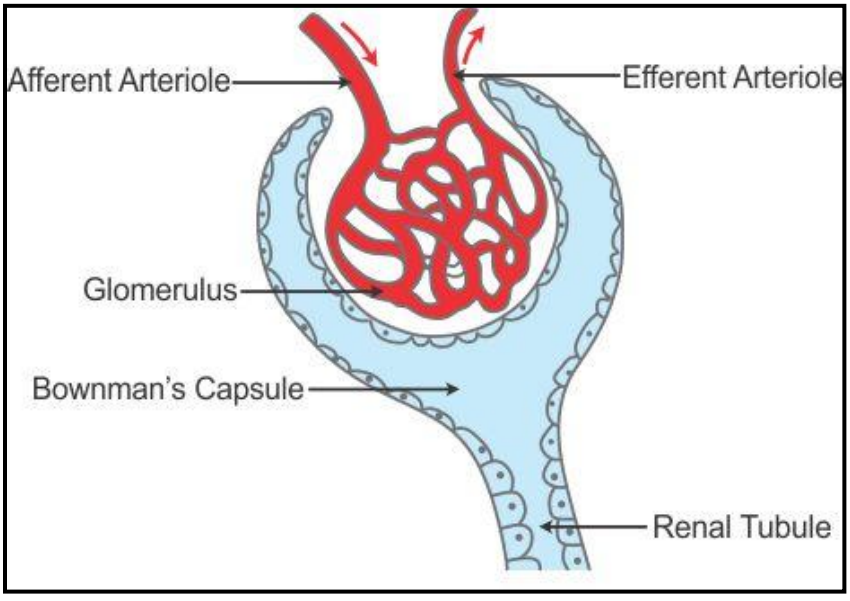
- The longitudinal section of the kidneys shows two regions—an outer dark cortex and an inner lighter medulla.
- The medulla is composed of conical pyramids.
- The apex of each pyramid, i.e. papilla, projects into the pelvis.

Uriniferous Tubule



Uriniferous Tubule

- The kidneys have an enormous number of uriniferous tubules.
- They are also known as nephrons, renal tubules or kidney tubules.
- Uriniferous tubules are the structural and functional units of the kidneys.



Malpighian Tubule

Bowman's Capsule	Proximal Convoluted Tubule (PCT)	Loop of Henle	Distal Convoluted Tubule (DCT)
• It is a thin-walled, cup-like depression. • It is lined by a single layer of epithelium (i.e. single-cell-thick epithelium). • A knot-like mass of blood capillaries called glomerulus is located in the concave depression of the Bowman's capsule. • The Bowman's capsule and the glomerulus together are called Malpighian tubule or renal tubule. • The renal tubule lies in the cortex.	• It is also known as the first convoluted tubule. • It is the first part of the convoluted region of the tubule. • PCT lies in the cortex.	• It is the U-shaped middle part of the tubule. • It is not convoluted. • It has a descending and ascending limb.	• It is the end part of the kidney tubule. • It opens into the collecting duct. • The collecting duct receives the contents of many renal tubules. • The collecting tubule pours this content as urine into the pelvis of the kidneys.

Approximately 2 million uriniferous tubules are present in both the kidneys.
Each single uriniferous tubule is 4 to 5 cm long.
The great length of uriniferous tubules provides a large surface area for reabsorption of usable substances such as water.
Blood flow through the kidneys per minute = 1 litre
Glomerular filtrate produced in 24 hours = 160 litres
Urine produced from glomerular filtrate after reabsorption per day = 1.2 litres

Blood Supply to the Kidneys

Dorsal aorta → renal artery → afferent arteriole → glomerulus → efferent arteriole → secondary capillary network (vasa recta) → renal vein → posterior

Formation of Urine

The process of urine formation occurs in two major steps:

Ultrafiltration	Reabsorption
• The efferent arteriole is narrower than the afferent arteriole. This develops a hydrostatic pressure on the blood. • Thus, the blood flows through the glomerulus with a great pressure. • Due to this pressure, the liquid part of the blood filters out from the glomerulus and passes into the Bowman's capsule. • This filtration under extraordinary force is called ultrafiltration. • The filtrate is known as glomerular filtrate. • The glomerular filtrate consists of water, urea, salts, glucose and other plasma solutes. • Blood corpuscles, proteins and other large molecules remain behind in the glomerulus. Therefore, the blood which is carried away by the efferent arteriole is relatively thick.	• The glomerular filtrate entering the renal tubule contains many useful substances. • Hence, as the filtrate passes down the tubule, water and other substances required by the body are reabsorbed. • This reabsorption occurs only to the extent that the normal concentration of the blood is undisturbed. • This entire process is called selective reabsorption. • Potassium ions and certain substances like penicillin are passed into the urine through the distal convoluted tubule. • The cells of the walls of DCT are involved in brining potassium ions and other substances back in the renal tubule; hence, this process is known as tubular secretion.
Part of the Renal Tubule	**Activity**
• Glomerulus	• Ultrafiltration
• Bowman's Capsule	• Receives glomerular filtrate
• Proximal Convoluted Tubule (PCT)	• Reabsorbs water, glucose, sodium and chloride ions
• Loop of Henle	• Absorption of water and sodium ions
• Distal Convoluted Tubule (DCT)	• Reabsorption of chloride ions and water. • Walls of DCT secrete potassium ions and other non-required substances such as drugs.

Urine Excretion

- The filtrate left after reabsorption and tubular secretion is called urine.
- The urine passes from the collecting duct to the pelvis of the kidneys. From there, it is sent to the urinary bladder through the ureters.
- By relaxing the sphincters present at the opening of the urethra, the urine is expelled out of the body. This process is known as micturition or urination.

Physical Properties of Urine

- Colour: Yellow. It is due to urochrome.
- Volume: 1 to 1.5 litres. However, the volume can vary depending on the liquid intake of the person.
- pH: 5 to 8. Slightly acidic.
- Odour: Faint smell. It is ammonia-like due to bacterial activity.
- Specific gravity: 3 to 1.035

Constituents of Urine

Water (95%)	
Solid Wastes (5%)	Organic Solid Wastes (in gm/litre of urine) • Urea (2.3) • Creatinine (1.5) • Uric Acid (0.7) • Others (2.6)
	Inorganic Solid Wastes (in gm/litre of urine) • Sodium chloride (9) • Potassium chloride (2.5) • Ammonia (0.6) • Others (2.5)

Abnormal Constituents in Urine

Blood Cells	Due to infection in the urinary tract, kidney stone or tumour, blood passes out with urine. This condition is known as haematuria.
Glucose	Excess glucose passes out with urine due to diabetes mellitus. This condition is known as glycosuria.
Albumin	Due to high blood pressure or increased permeability of the Bowman's capsule on account of bacterial infection.
Bile Pigments	Due to anaemia, hepatitis or liver cirrhosis.

Regulation of Urine Output

- The water content in urine is controlled by Anti-diuretic Hormone (ADH).
- It is secreted by the posterior lobe of the pituitary gland.
- Reduction in the secretion of ADH results in more production of urine. This condition is called diuresis.
- Substances which increase the production of urine are called diuretics.
- Examples of diurectics are tea, coffee and alcohol.

Gout and Kidney Stones

Uric acid is less soluble in water.

It may crystallise and deposit in joints which cause **gout.**

Uric acid and salts such as calcium oxalate may result in **kidney stones.**

Osmoregulation

- While removing urea from the blood, the kidneys also regulate the composition of blood, i.e. the water and salt concentration in the blood. This function is called osmoregulation, which implies the regulation of osmotic pressure of the blood.
- Drinking enough water helps the kidneys to function properly.

We drink a lot of water in summer. Yet we urinate fewer times in summer than in winter!

Our country experiences the tropical type of climate. In summer, we lose a considerable amount of water through perspiration which makes the urine thicker and concentrated. Hence, the kidneys have to reabsorb more water from the urine.

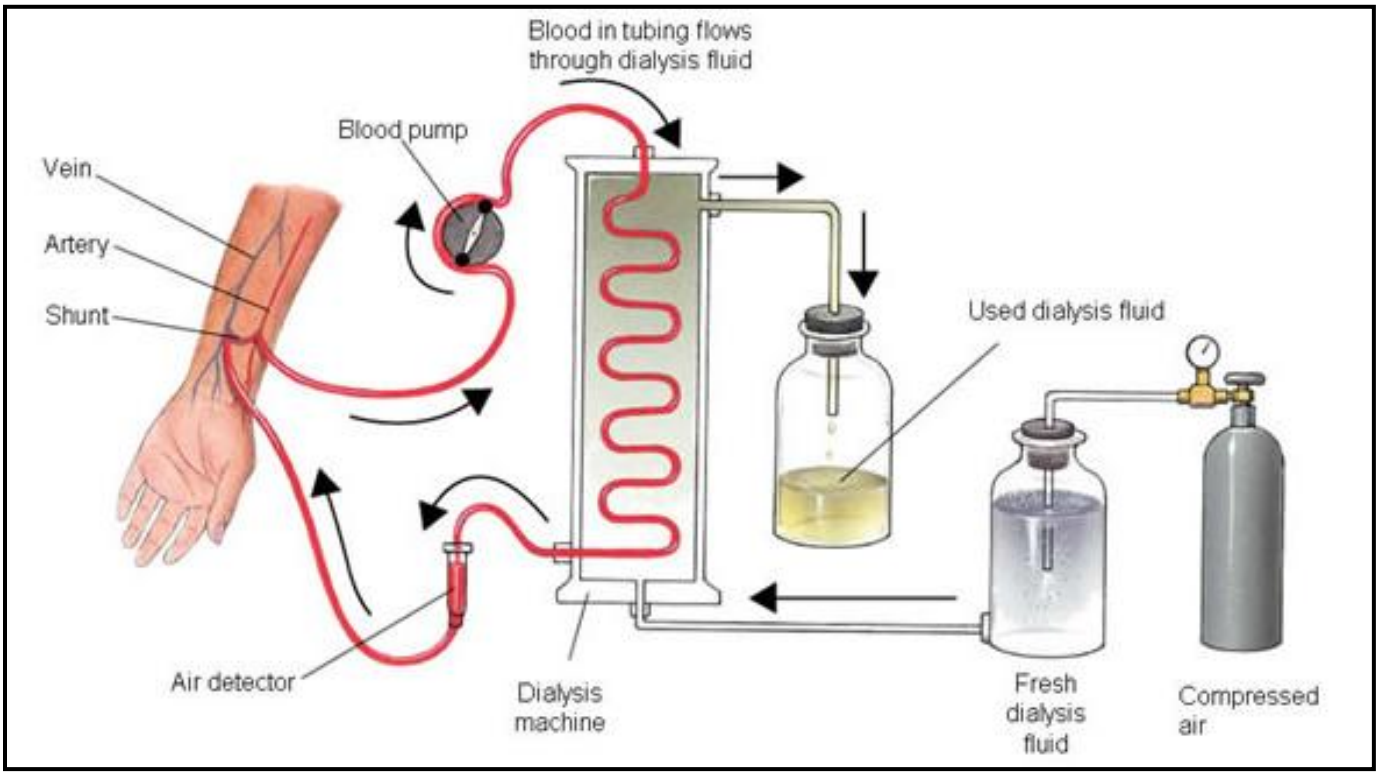
In cholera, the patient suffers from vomiting and watery bowels.

In cholera, the patient's intestines are unable to absorb enough water into the blood. This results in more reabsorption of water by the kidneys. The water reabsorbed by the kidneys also contains a high concentration of urea. This results in uremia, i.e. the accumulation of high quantities of urea in the blood. This may also cause death of patients.

The immediate treatment to replenish water is glucose-saline drip or Oral Rehydration Solution (ORS).

Artificial Kidney

- If one kidney is damaged or removed, the other kidney alone is capable of fulfilling the excretory needs of the patient.
- However, the failure of both kidneys would lead to death.
- Such a patient undergoes dialysis. The dialysis machine is an artificial kidney in which the patient's blood is led from the radial artery through the machine where excess salts and urea are removed.
- The purified blood returns to a vein in the same arm.



Dialysis