# URINARY SYSTEM OF MAN

**Students' learning outcomes**
**After studying this chapter, students will be able to:**

1. [B-12-R-09] List various nitrogenous compounds excreted during the process of excretion.
2. [B-12-R-10] Explain the nature of excretory products in relation to habitats.
3. [B-12-R-11] Outline different organs of the urinary system.
4. [B-12-R-12] Describe the structure of the kidney.
5. [B-12-R-13] Relate the structure of kidney with its function.
6. [B-12-R-14] Explain the detailed structure of a nephron.
7. [B-12-R-15] Explain the process of glomerular filtration, selective re-absorption and tubular secretion ass the events in kidney functioning.
8. [B-12-R-16] Explain regulatory mechanism involved in concentration of urine.
9. [B-12-R-17] Justify the functioning of kidneys as both excretion and osmoregulation.
10. [B-12-R-18] Compare the function of two major capillary beds in kidneys i.e., glomerular capillaries and peritubular capillaries.
11. [B-12-R-19] List the urinary tract infections and the bacteria responsible.
12. [B-12-R-20] Explain the causes and treatments of kidney stones.
13. [B-12-R-21] Outline the causes of kidney failure.
14. [B-12-R-22] Explain in detail the mechanism and problems related to dialysis.
15. [B-12-R-23] Describe the principles and the problems associated with kidney transplant.

The body cells form a variety of wastes, and if these substances are allowed to accumulate, their effects are likely to be toxic. The body fluids, such as the blood and lymph, carry wastes away from the tissues that produce them. Other parts remove these wastes from the blood and transport them to the outside. The respiratory system, for example, removes carbon dioxide from the blood and the urinary system removes various salts and nitrogenous wastes.

The urinary system also helps to maintain the normal concentrations of water and electrolytes within the body fluids, to regulate the pH and volume of body fluids, and to control red blood cell production and blood pressure.

# 4.1 EXCRETION

Metabolism produces a number of toxic by-products, particularly the nitrogen containing compound. The **excretion** is the removal of chemical waste from the body which are produced by the metabolic processes within cells.

## 4.1.1 Nitrogen as excretory product

Animals excrete a variety of nitrogenous waste products, but ammonia, urea and uric acid predominate. A major factor in determining the mode of nitrogen excretion is the availability of water in the environment

## 4.1.2 Relationship between Excretory Products and Habitats

The exact nature of excretory product is determined mainly by the availability of water to the organism which is based upon its habitat. The correlation with habitat is: (a) ammonia - aquatic (b) urea - aquatic and terrestrial (c) uric acid - terrestrial.

### Ammonia

Ammonia is highly toxic because it tends to raise the pH of body fluids and interferes with membrane transport functions. It is highly soluble in water and diffuses rapidly across cell membrane. It is therefore excreted rapidly. One gram of nitrogen, in the form of ammonia, requires five hundred ml of water to dissolve it to nontoxic level. Such plenty of water can only be afforded by many aquatic organisms, particularly those in freshwater e.g., most fishes, protozoans, sponges,cnidaria, echinoderms and crustaceans. Animals which excrete ammonia as their major nitrogenous waste product are called **ammonotelic.**

### Urea

Organisms with less freshwater available, such as some marine organisms and all terrestrial organisms remove their most of the nitrogenous waste in the form of urea. They will often invest some energy to convert the ammonia into urea, which is 100,000 times less toxic than ammonia. One gram of nitrogen, in the form of urea, requires 50 ml of *water to dilute* it to nontoxic level. Animals which excrete urea as their major nitrogenous waste product are called **ureotelic.** Examples include mammals e.g. man, many amphibians and some marine animals like shark.

**CRITICAL THINKING**

Where do you think the carbon dioxide used in the formation of urea comes from? Where does the remainder of excess carbon dioxide go to be excreted?

**SCIENCE TITBITS**

Humans excrete small quantities of uric acid but this is produced from the breakdown of nucleic acid and not from breakdown of proteins. Approximately one gram of uric acid is excreted in urine per day.

### Uric acid

Uric acid is byproduct of breakdown of purine and is less toxic than urea, and can precipitates from solution, allowing the 4 nitrogen atoms per uric acid molecule to be excreted. One gram of nitrogen, in the form of uric acid, requires just 1 ml of water for its excretion. It has evolved in two groups with major water shortage problems, terrestrial invertebrates e.g., land snail, many insects and egg-laying vertebrates e.g. reptiles (snakes, lizards) and birds. These animals are called **uricotelics**. The examples includes many terrestrial insects, reptiles and most birds.

## 4.2 URINARY SYSTEM OF MAN

The excretory system (urinary system) consists of kidneys, ureters, urinary bladder and a tubular urethra. The kidneys lie on either side of the vertebral column between the twelfth thoracic and third lumbar vertebrae.

Each **ureter** is a tubular organ about 25 cm long, which begins as the funnel-shaped renal pelvis. It extends downward parallel to the vertebral column to join the urinary bladder. It transports urine from the kidney to the urinary bladder. The **urinary bladder** is a hollow and distensible muscular organ. It is located within the pelvic cavity. It serves as urine reservoir. The **urethra** is a tube that carries urine from urinary bladder to the outside of the body.

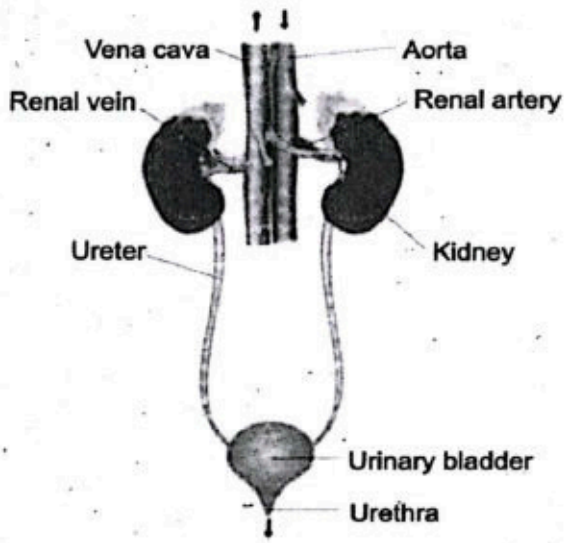


Fig. 4.1: Excretory system of man

### 4.2.1 Structure of kidney

**Location:** The **kidneys**, are a pair of bean-shaped structures. These are located just below and posterior to the liver in the peritoneal cavity. The adrenal glands are on top of each kidney. Kidneys filter blood and purify it. The filtrate coming out of the kidneys is called **urine**. The reason why the right kidney is slightly lower than the left is due to considerable space occupied by the liver on the right side.

**Structure:** Externally, the kidneys are surrounded by three layers. The outermost layer is a tough connective tissue layer called the **renal fascia**. The second layer is called the **perirenal fat capsule**, which helps anchor the kidneys in place. The third and innermost layer is the **renal capsule**.

Internally, the kidney has three regions—an **outer cortex**, a **medulla** in the middle, and the **renal pelvis** in the region called the **hilum** of the kidney. The hilum is the concave part of the bean-shape where blood vessels and nerves enter and exit the kidney; it is also the point of exit for the ureters. The renal cortex is granular due to the presence of nephrons—the functional unit of the kidney. The medulla consists of multiple pyramidal tissue masses, called the **renal pyramids**. In between the pyramids are spaces called **renal columns** through which the blood vessels pass. The tips of the pyramids, called **renal papillae**, point toward the renal pelvis. There are, on average, eight renal pyramids in each kidney. The renal pyramids along with the adjoining cortical region are called the **lobes of the kidney**. The renal pelvis leads to the **ureter** on the outside of the kidney. On the inside of the kidney, the renal pelvis branches out into two or three extensions

called the **major calyces**, which further branch into the **minor calyces**. The ureters are urine-bearing tubes that exit the kidney and empty into the **urinary bladder**.

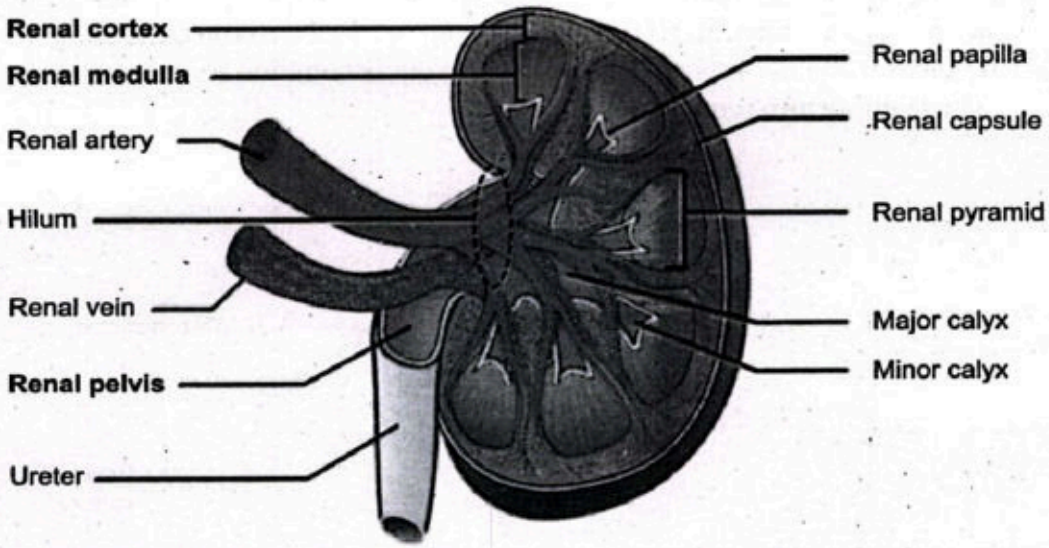


Fig. 4.2: Internal anatomy of the kidney

## 4.2.2 Relationship between structure and function of kidney

The main parts of kidney anatomy with related function are given below:

**Kidney capsule (renal capsule):** The renal capsule consists of three layers of connective tissue or fat that covers kidneys. It protects the kidneys from injury, increases their stability and connects kidneys to surrounding tissues.

**Renal artery:** The renal artery is a large blood vessel that controls blood flow into kidneys. For most people at rest, the renal kidneys pump a little over 5 cups (1.2 liters) of blood to kidneys each minute.

**Renal cortex:** It is the outer layer of kidney, where the nephrons (blood-filtering units) begin. The renal cortex also creates the hormone erythropoietin (EPO), which helps make red blood cells in the bone marrow.

**Renal medulla:** The renal medulla is the inner part of the kidney. It contains most of the nephrons with their glomeruli and renal tubules. The renal tubules carry urine to the renal pelvis.

**Renal papilla:** These pyramid-shaped structures transfer urine to the ureters.

**Renal pelvis:** This funnel-shaped structure collects urine and passes it down two ureters. Urine travels from the ureters to the bladder, where it's stored.

**Renal vein:** This vein is the main blood vessel that carries filtered blood out of the kidneys and back to your heart. Each of your kidneys has a renal vein.

## 4.2.3 Structure of a nephron

The **nephron** is the functional unit of kidney. A nephron consists of a **renal corpuscle** and a **renal tubule**. A renal corpuscle is composed of a network of capillaries called **glomerulus** which is surrounded by a thin double-walled structure called **Bowman's capsule**. The Bowman's capsule is an expansion at the closed end of a **renal tubule**. The renal tubule leads away from the Bowman's capsule and becomes highly coiled. This coiled portion of the tubule is called **proximal convoluted tubule**.

The proximal convoluted tubule dips toward the renal pelvis into the medulla forming a sharp loop called **loop of Henle**. The loop of Henle consists of a descending limb and an ascending limb. The ascending limb returns to the region of the renal corpuscle, where it becomes highly coiled again, and is called the **distal convoluted tubule** which is connected to the **collecting duct**. The collecting duct receives many nephrons. Many collecting ducts combine together to form larger collecting ducts which empty into renal pelvis.

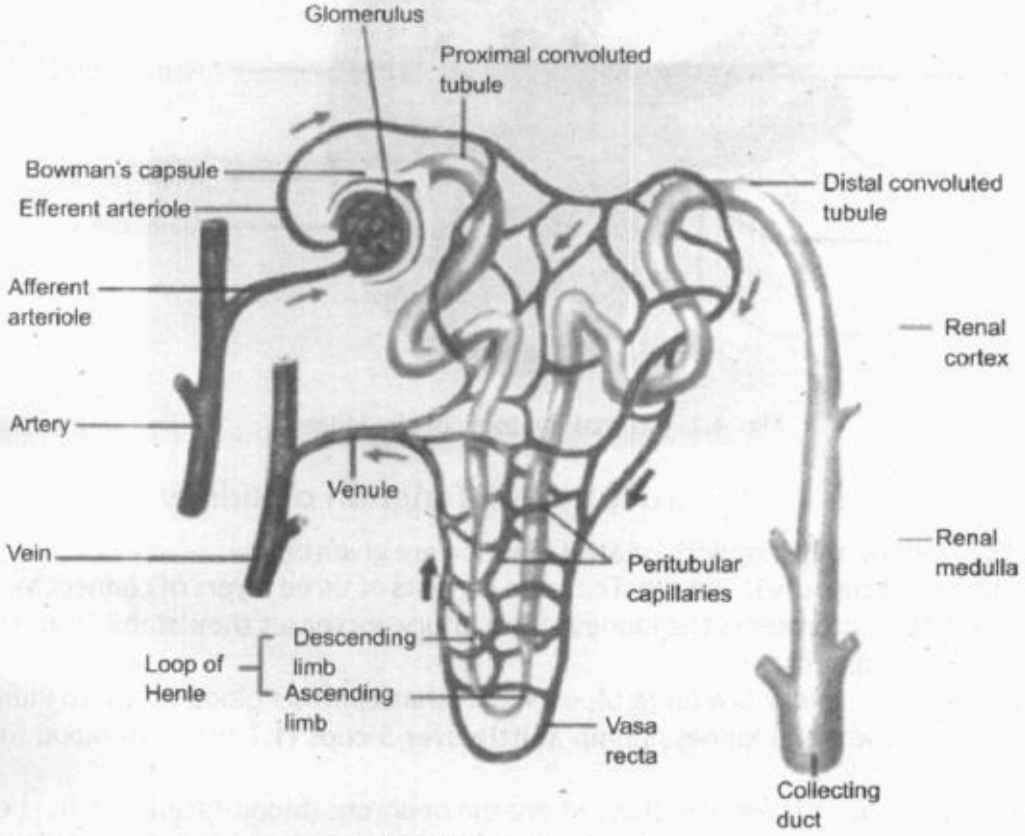


Fig. 4.3: Structure of nephron

## Blood circulation to nephron

The renal artery within the kidney gives rise to branches that project into the cortex and give rise to **afferent arterioles**. The afferent arterioles supply blood to the glomerular capillaries of the renal capsule. **Efferent arterioles** arising from the glomeruli give rise to a plexus of capillaries called the **peritubular capillaries** around the proximal and distal tubules. Specialized part of the peritubular capillaries called **vasa recta** course into the medulla along with the loops of Henle and then back toward the cortex. The peritubular capillaries drain into renal vein. The renal vein exits the kidney and connects to the inferior vena cava.

# 4.3 URINE FORMATION

The formation of urine involves glomerular filtration, tubular reabsorption and tubular secretion. **Glomerular filtration** (pressure filtration) takes place in the **renal capsule** under pressure. The pressure comes from the blood pressure and is known as **hydrostatic pressure**. Glomerular capillaries have exceptionally high blood pressure than any other part of capillary bed in the body.

The diameter of efferent arteriole is half as compared to the afferent arteriole so as the blood enters the narrow capillaries, pressure rise. Due to such a high pressure, water and small solute molecules (ions, glucose and amino acids) are filtered out of the glomerular capillaries and are collected into the Bowman's capsule. Larger molecules like proteins, as well as red blood cells and platelets are left behind in the blood. The filtered fluid in the capsule is called **glomerular filtrate.** It has a chemical composition similar to that of blood plasma.

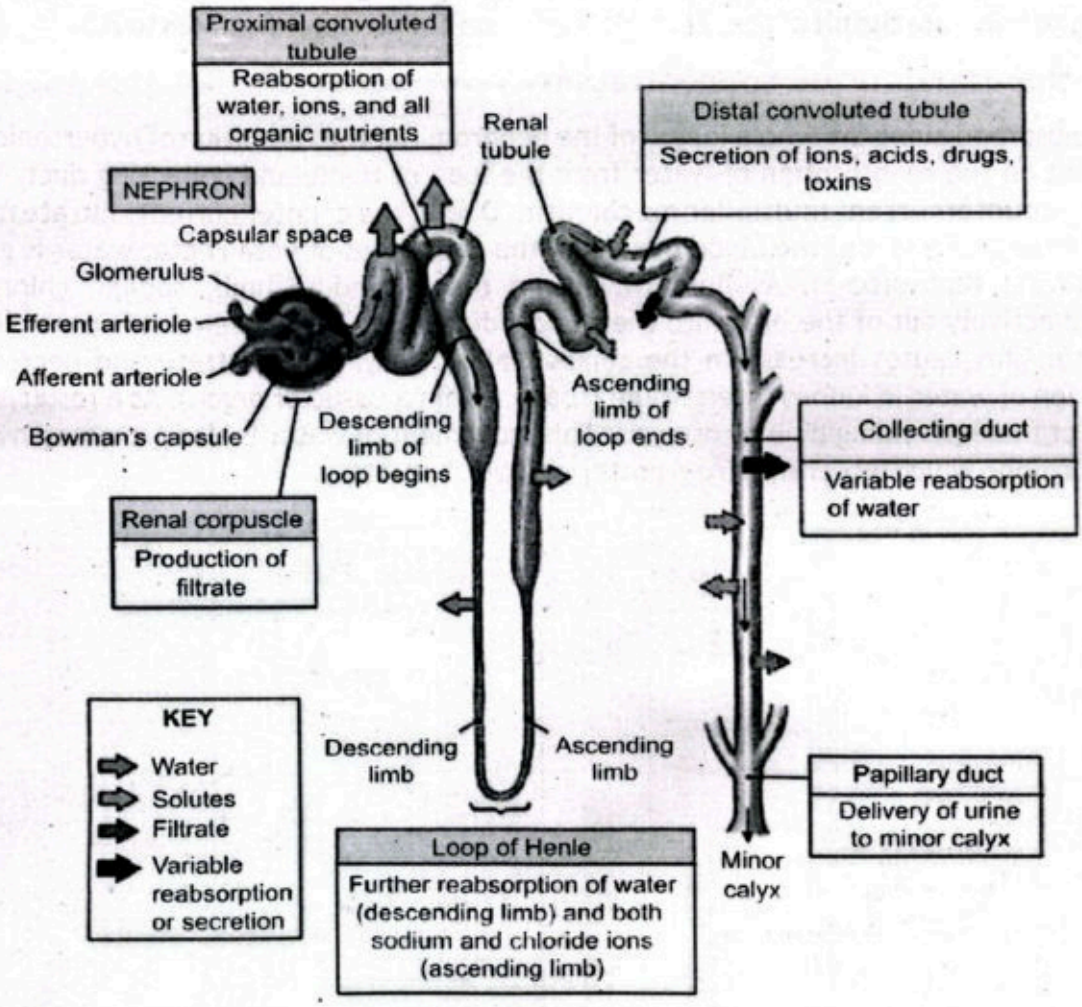


**Fig. 4.4: Urine formation**

## SCIENCE TITBITS

There are two types of nephrons, **cortical nephrons** and **juxtamedullary nephrons.** Cortical nephrons are found in the cortex. They have their renal corpuscle in the superficial renal cortex and have relatively short loops of Henle. 70 to 80% nephrons in human kidney are cortical. Under normal conditions of water availability, the cortical nephrons deal with the control of blood volume by forming diluted urine. Juxtamedullary nephrons have their renal corpuscle close to the junction of the cortex and medulla. They have long loop of Henle which extends deep into the medulla. These types of nephrons are relatively rare and only comprise 20-30% of the nephrons in the human kidney. When water is in short supply, increased water retention occurs through juxtamedullary nephrons.

**Selective reabsorption**, is the process by which certain substances that have been filtered out of the blood during ultrafiltration are reabsorbed. These substances include glucose, amino acids, vitamins, inorganic salts and some water. As only certain substances are reabsorbed, it is known as selective reabsorption.

**Tubular secretion** is the process by which certain substances e.g., ammonium and hydrogen ions are secreted mainly by the tubular epithelial cells of loop of Henle into the lumen of the tubule. However, to some extent this process also occurs in convoluted tubule. The main purpose of this secretion is to maintain the pH of the urine. Normal urine has pH range from 4.8 to 7.5.

### 4.3.1 Mechanism of urine concentration

Water is reabsorbed along the whole length of the nephron, but the formation of hypertonic urine is dependent on the reabsorption of water from the loop of Henle and collecting duct. This is achieved by **countercurrent multiplier mechanism**. Due to the counter current, filtrate moving in limbs of loop of Henle and the blood moving in the capillaries of **vasa recta**, water is greatly (approx. 99.5%) reabsorbed . As fluid travels up the ascending limb, sodium chloride is transported actively out of the limb into the surrounding area. This movement is controlled by **aldosterone**. This causes increase in the concentration of water in filtrate and decrease in concentration of water in kidney interstitium (space within a tissue or organ). As a result, water passes out of the descending limb by osmosis. This movement of water is also promoted by **anti-diuretic hormone** which is secreted from posterior lobe of pituitary.

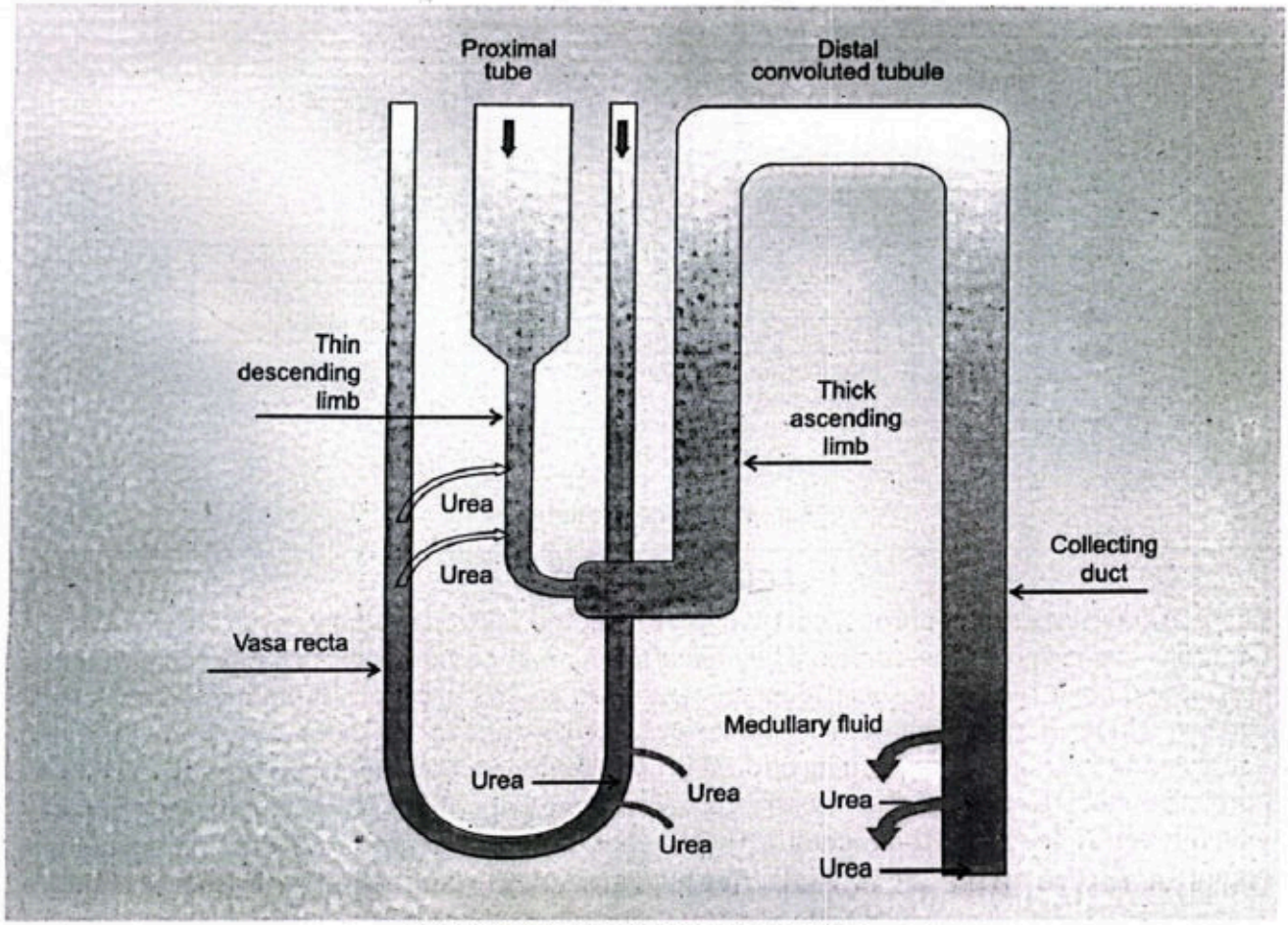


Fig. 4.5: Counter current mechanism

Table 4.1: Comparision of function of glomerular capillaries and peritubular capillaries

| Glomerular capillaries | Peritubular capillaries |
|---|---|
| These function as a filtration unit of kidney. | They filter waste from the blood so the waste can leave the body through urine. |
| The glomerular function ensures that essential plasma proteins are retained in blood and the filtrate is passed on as urine. | Peritubular capillaries also reabsorb nutrients the body needs to work properly, such as minerals. |
| Blood cells and proteins pass through the glomerulus harmlessly. | The peritubular capillaries reabsorb essential minerals and nutrients, along with excess water. |

**SCIENCE TITBITS**

In addition to their excretory and osmoregulatory role, kidneys also help to control the red blood cell formation by secreting the hormone **erythropoietin** and help to regulate blood pressure by secreting the (EPO) enzyme **renin**.

## 4.4 FUNCTIONS OF KIDNEY

Kidneys function as excretory as well as osmoregulatory organs.

**Excretory functions:** The excretory functions include the filtration of nitrogenous wastes from the blood and its removal outside the body in the form of urine.

**Osmoregulatory Function:** Being osmoregulatory organ, these are concern with the formation of diluted urine during the state of flooding and form concentrated urine during the state of dehydration.

## 4.5 DISORDERS OF URINARY TRACT

The normal aging process in human affects kidney function in various ways. Urinary tract infections (UTI) are fairly common. **Urology** is the branch of medicine which deals with diseases and abnormalities of urinary tract and their treatment.

### 4.5.1 Urinary Tract Infection

Although males can get a urinary tract infection, the condition is fifty times more common in women. In general, the higher risk in women is mostly due to the shortness of the female urethra, which is 1.5 inches compared to 8 inches in men. Bacteria from faecal matter at the anal opening can be easily transferred to the opening of the urethra. Almost all parts of the urinary tract are affected by the infection except ureters which are rarely the site of infection. The types of UTIs depending upon the site are: **urethritis** is an infection of urethra, **cystitis** involves the bladder and if the kidneys are infected the infection is called **pyelonephritis**.

Since the infection is caused by bacteria, it is curable by antibiotic therapy. For prevention, one should drink lot of water to flush out bacteria. Personal hygiene is especially important too.

| Table 4.2: Urinary Tract Infection (UTI) Caused by Bacteria | |
|---|---|
| Bacteria | Diseases |
| 1. *E. coli*<br>2. *N. gonorrhoeae*<br>3. *T. palladium* | 1. UTI<br>2. Urethritis, Gonorrhoea<br>3. Syphilis |

## 4.5.2 Kidney Stones

Urinary stones are hard, crystalline mineral materials that stick together to form small "pebbles" within the kidney or urinary tract. They can be as small as grains of sand or as large as golf balls. They may stay in kidneys or travel out of the body through the urinary tract. The condition of having stones in the kidney is termed **nephrolithiasis.**

**SCIENCE TITBITS**

There are five major types of urinary stones: **calcium oxalate, calcium phosphate, magnesium ammonium phosphate, uric acid and cystine.** Uric stones are composed of combination of uric acid and calcium oxalate. They are normally 2-3 mm in diameter with either smooth or uneven surface. Branching stone is called **staghorn stone.**

**Hypothesize kidney stone by studying the urine test of relevant patient.**
When urine is acidic (low pH) the stone is of calcium oxalate.
When the urine is alkaline (high pH) the stone is of calcium phosphate.
When urine is persistently acidic the stone is of uric acid type.

**Do you know?**

The science concerned with the structure, functions and diseases of the kidneys is called **nephrology.**

### Symptoms

Common symptoms include severe pain in lower back, blood in urine, nausea, vomiting, fever and chills, or urine that smells bad or looks cloudy.

### Causes

Kidney stones may be caused by increased calcium level in the blood which is termed as **hypercalcemia.** It, in turn, causes high calcium in the urine, the **hypercalciuria.** Increased oxalate level in the urine is called **hyperoxaluria.** Hypercalciuria and hyperoxaluria cause **calcium oxalate** type of kidney stones which are present in 70% of kidney stone patients. **Hyperuricemia** is the increased amount of uric acid in the blood and it causes **uric acid** type of kidney stones which are found in 10% of kidney stone patients. High concentration of cysteine and phosphates in urine also cause kidney stones. Continuous state of dehydration increases the chances of kidney stone formation.

### Treatment

Extracorporeal shock wave lithotripsy (ESWL) and Percutaneous Nephro Lithotripsy (PCNL) are common methods for kidney stone treatment. In ESWL, an instrument called **lithotripter** is used to generate shock waves from outside the patient's body focused on the stone, breaking it into small pieces. Most of the fragments then pass spontaneously via the urethra.

In case of larger stone PCNL is preferred in which a tube is inserted from the patient's back into the kidney to create a tract. A scope is run through the tract to directly visualize the stone inside the kidney. Ultrasound equipment can then be inserted to breakup the stone. While watching the

stone through the scope, the stone fragments can be grasped with special equipment and pulled through the tract out from the kidney. Open surgery is now almost never needed except for large bladder stone.

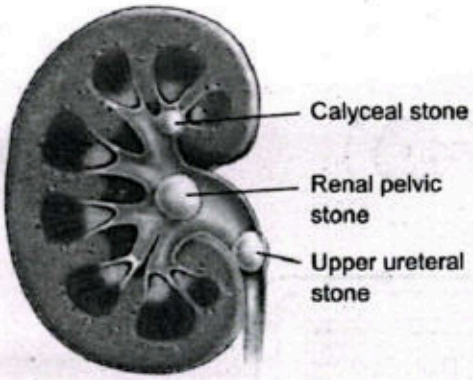


Fig. 4.6: Kidney stone

Fig. 4.7: Extracorporeal shock wave lithotripsy

### 4.5.3 Kidney Failure

A general term for a decline kidney function particularly the efficiency of the filtering process is called **kidney failure** or **renal failure**. **Chronic renal failure** is the irreversible deterioration in renal function. It is a gradual, slowly progressive and occurs over a period of years.

**Chronic renal failure may be caused by:** (a) Bacterial infection of the pelvis and surrounding tissue. (b) Nephritis (inflammation of glomeruli). (c) Damage due to high blood pressure. (d) Diabetes mellitus.

**Acute renal failure may be caused by:** (a) Haemorrhage due to trauma. (b) Vomiting, diarrhoea. (c) Diuresis (excess excretion of urine), sweating. (d) Obstruction of the ureters, bladder or urethra e.g., kidney stone. (e) Severe nephritis.

**SCIENCE TITBITS**

Chronic kidney failure can progress to **end-stage renal disease (ESRD)** and **uremia**, which is fatal unless artificial filtering (dialysis) or a kidney transplant.

### 4.5.4 Dialysis: Mechanism

A procedure to filter toxins from the blood by artificial methods when the kidneys are unable to perform this function is called **renal dialysis**. Dialysis works on the principle of kidneys although it is not as effective, efficient or thorough as the natural processes performed by the kidneys. There are two general types of renal dialysis: haemodialysis and peritoneal dialysis.

### Haemodialysis

Haemodialysis removes wastes and water by circulating blood outside the body through an external filter, called a **dialyzer**, which consists of tubes of semipermeable membrane. In this process, a **catheter** is inserted into a blood vessel, usually in the arm. *It routes the blood* circulation externally through a machine that removes wastes. The cleansed blood then returns to the body through a second catheter. The haemodialysis machine consists of a pump and a container in which a network of synthetic tubes made up of cellophane membrane, called the **dialyzer**, is situated. The blood moves into the tubes of dialyzer from the top through blood pump. After circulating through the dialyzer, blood leaves the machine from the bottom and transfuses (to pour out into another vessel, to transfer to another's vein) back to the body. On the

other hand, **dialysate** (dialysis fluid) pour into the machine from bottom, which after circulating around the membranous tube, leaves the machine from the top. The dialysate attracts certain substances-minerals, electrolytes, and waste by-products—to cross the membrane from the blood. The dialysate absorbs these substances.

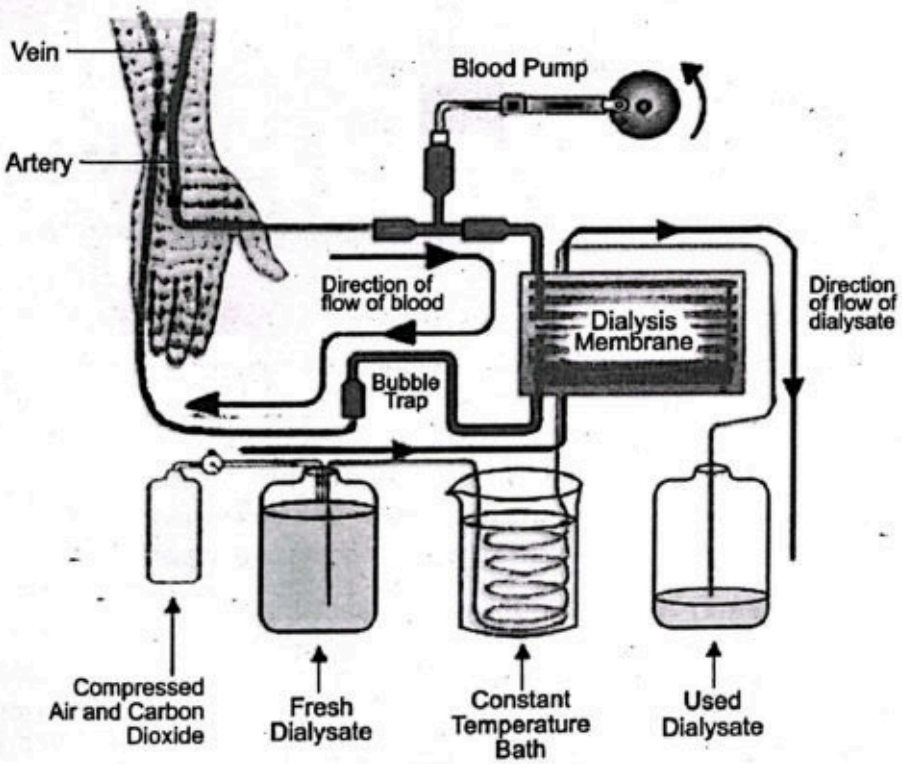


Fig. 4.8: Haemodialysis

## Peritoneal dialysis

Peritoneal dialysis involves the use of a natural membrane in the body, the peritoneum, which encloses the abdominal cavity. In this process, two catheters are surgically inserted into the abdominal cavity that serve as the portals (any entrance) through which **dialysate** enters and leaves the cavity. During circulation, when blood passes through the blood capillaries within the peritoneum, the dialysate attracts certain molecules to cross the membrane into the dialysate.

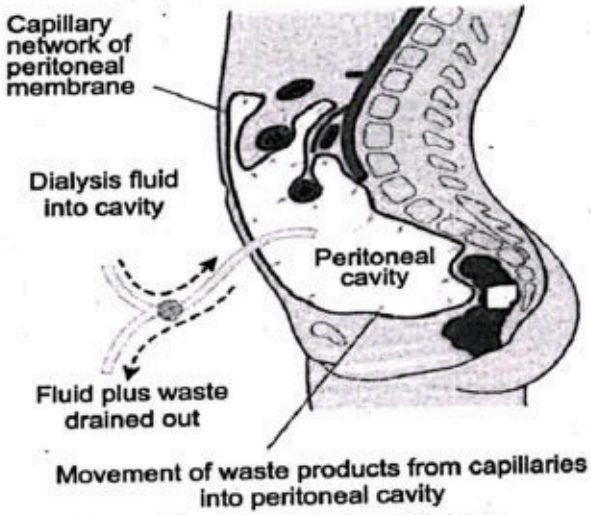


Fig. 4.9: Peritoneal dialysis

### 4.5.5 Kidney Transplant: Process and Problems

Kidney transplantation is the surgical procedure of placing a fully functioning kidney into a person with chronic kidney failure.

## Principles of kidney transplant

The kidney graft is taken from a deceased donor or from a related or unrelated person. ABO blood group compatibility between donor and recipient is essential. It is usual to select donor kidneys on the basis of human leucocytes antigen (HLA) matching as this improves graft survival. A person can live normally with just one kidney.

## Problems associated with kidney transplant

The two problems are rejection and toxic effects of cyclosporine. These problems are usually treated simultaneously by adding extra doses of **steroids**. Patients are required to take medications such as **cyclosporine** etc., to suppress their immune system in order to prevent rejection of the transplanted kidney. If at any point a recipient stops taking the medications, rejection can occur; even ten or fifteen years after the transplant.

### Science Technology and Society Connections

**Describe the importance of kidney donation for the benefit of kidney failure patients.**

Kidney donation is a relatively safe operation, and many donors will never feel the loss of their second kidney. It's the most expendable of organs. So giving up a kidney causes no disadvantage to your long-term health. In fact, studies have shown, that kidney donors actually live longer than the general population, because donors come from a pool of people in good health.

Just think people have no problem having only one kidney, so we have to ask, why did Allah give us two kidneys? Perhaps it is so you would have an extra one to donate and save a life.

## STEAM ACTIVITY 4.1

### Experiment to show blood dialysis and kidney functions

**Requirements**

Three small beakers or jars (not larger than 250 mL size), Distilled or deionized water Scissors, Ruler, Timer or clock, Paper towels, String (optional)

1. Cut the dialysis tubing into three 4-inch segments.
2. Soak the segments of dialysis tubing in a jar or beaker filled with distilled water for at least one hour.
3. Add 75-100 mL distilled or deionized water to three separate beakers or jars. Label "Normal", "P1", and "P2". These are the water baths.
4. Carefully tie a single knot at one end of all three dialysis tubing segments. Tie the knots as close to the ends as possible. You can also use string to tie the ends.
5. Fill the first dialysis tubing with 2 mL of the Normal Patient Sample. To do this:
   a. Roll the untied end of the dialysis tubing between your thumb and pointer finger to open the end.
   b. Squeeze the transfer pipet bulb and fill the tip to the 2 mL mark.
   c. Gently insert the tip of the transfer pipet deep into the dialysis tubing and slowly transfer the sample into the tubing by applying gentle pres- sure to the bulb.
   d. Remove any trapped air in the dialysis tube without displacing the sample.
   e. Carefully tie the second knot at the open end of the tubing.

f. Rinse the filled-tied dialysis tube with water, especially near the tied ends and place the bag on a paper towel in front of the beaker labeled "Normal" (do the same for P1 and P2 when you fill those).

6. In a *separate container*, rinse the transfer pipet with water by repeatedly squeezing the bulb and flushing the pipette.
7. Repeat steps 5 and 6 for Patients 1 and 2. Quickly place all dyalysis tubes in their respective water baths.
8. Monitor the three dialysis water baths every 5 minutes or so, taking notes as to any changes in the color of the water outside the dialysis bag. Allow the bags to soak for up to 30 minutes.
9. After you have recorded your results, you can cut or untie dialysis tubing, empty, and rinse well to reuse for another experimental trial.

| | Normal | Patient 1 | Patient 2 |
|---|---|---|---|
| Colour at 5 min. | | | |
| Colour at 10 min. | | | |
| Colour at 15 min. | | | |

## EXERCISE

**Section I: Multiple Choice Questions**
**Select the correct answer:**

1. Excretion of hypotonic urine in humans is associated best with the
   A. glomerular capsule
   B. proximal convoluted tubule
   C. loop of the Henle
   D. distal convoluted tubule

2. The walls of the ---------- are made more or less permeable to water, depending on the need to conserve water:
   A. ureter B. urethra C. fibrous capsule D. collecting duct

3. Which of the following will cause a decrease in ADH production?
   A. dehydration
   B. an increase in osmotic pressure of blood
   C. drinking water
   D. abnormally low blood pressure

4. The function of glomerulus and Bowman's capsule of the nephron is to
   A. reabsorb water into the blood
   B. eliminate ammonia from the body
   C. reabsorb salts and amino acids
   D. filter the blood and capture the filtrate

5. In man, glucose is present in blood plasma but not in urine. This is because glucose molecules are
   A. actively transported from the proximal convoluted tubule to blood capillaries
   B. oxidised to supply energy for ultrafiltration
   C. stored in the kidney
   D. too large to enter Bowman's capsule

6. Evidence for glomerular filtration in the kidney could be obtained by comparing the sizes of the molecules present in Bowman's capsule with those in the

A. afferent blood vessel B. collecting duct C. loop of Henle D. proximal tubule

7. The site and principal mechanism for the passage of glucose into the bloodstream in the human kidney is the

A. collecting duct, by active secretion
B. glomerulus, by selective reabsoption
C. glomerulus, by ultrafiltration
D. proximal convoluted tubule, by selective reabsorption

8. A drug reduces mitochondrial activity in kidney nephrons. Which chemical will be present in increased amounts in the urine?

A. ammonia B. glucose C. uric acid D. urea

9. The water content of human blood is regulated by ADH. In which part of the nephron does regulation occur?

A. ascending limb of loop of Henle B. descending limb of the loop of Henle
C. Bowman's capsule D. proximal convoluted tubule

10. The reason why the right kidney is slightly lower than the left is

A. the left kidney is bigger than right
B. considerable space occupied by the heart
C. considerable space occupied by the liver on the right side
D. the right kidney is bigger than the left

11. Which of the following is known as the functional unit of the kidney and is found in the cortex?

A. calyces B. renal pyramids C. nephrons D. medulla

12. This artery passes blood to the kidney

A. common iliac B. cystic C. renal D. coeliac

13. Which structure carries urine from the kidneys to the bladder?

A. nephron B. ureter C. bladder D. urethra

14. The blood vessel which carries blood to the glomerulus is the

A. renal artery B. afferent arteriole
C. renal vein D. peritubular capillaries

15. The basic unit of the renal system is the

A. cortex B. neuron C. nephron D. medulla

16. The centre of the kidney where urine collects before leaving the kidneys is the

A. glomerulus B. proximal tubule C. distal tubule D. renal pelvis

17. An organ or structure that is not a component of the urinary system is the:

A. urethra B. urinary bladder C. ureter D. adrenal gland

18. All of the following belong to the urinary system except:

A. urethra B. ureter C. bladder D. prostate

19. What portion of the nephron extends into the medulla?

A. nephron loop B. proximal convoluted tubule
C. distal convoluted tubule D. papillary duct

20. Fibrous connective tissue that surrounds each kidney is the:

A. cortex B. hilum C. medulla D. renal capsule

## Section II: Short Answer Questions

1. Name the organs of the urinary system and write their major functions.
2. Describe glomerular filtration.
3. Describe the countercurrent multiplier mechanism.
4. Name the parts of a nephron and trace the blood supply to the nephron.
5. Name general processes which are involved with urine formation?
6. Describe urinary tract infection.
7. Name three urinary tract infections and bacteria responsible.
8. What are the causes of kidney failure?
9. By what physical processes do solutes enter or leave the blood during dialysis?
10. Why do blood and dialysate flow in opposite direction?
11. Suggest two problems that might occur if the dialysate was pure water.
12. Why women are more likely to acquire UTI as compared to men?
13. Write the differences between:
    (a) osmoregulation and osmoconformers
    (b) ammonotelic and ureotelic
    (c) ureotelic and uricotelics
    (d) proximal and distal convoluted tubule
    (e) afferent and efferent arterioles
    (f) hypercalcemia and hyperuricema
    (g) extracorporeal shock wave lithotripsy and percutaneous nephronlithotripsy
    (h) chronic renal failure and acute renal failure
    (i) peritoneal dialysis and haemodialysis
    (j) renal cortex and renal medulla
    (k) vasodilation and vasoconstriction
    (l) dialyzer and dialysate

## Section III: Extensive Answer Questions

1. Discuss relationship between excretory products and habitats.
2. Describe the structure and function of human kidney.
3. Describe the structure of human nephron.
4. Discuss the 'urine formation 'and mechanism of urine concentration in man.
5. What are kidney stones? Discuss the causes and treatment of kidney stones?
6. What is renal dialysis? Describe the two types of renal dialysis.
7. What is kidney transplantation? Describe principles of kidney transplant. What are the problems associated with kidney transplant?