Ratna Sagar

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Education, Our Mission

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Ratna Sagar
Education, Our Mission!

Revised and Updated

LIVING SCIENCE BIOLOGY

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10

EDUCATION, OUR MISSION

ICSE
Living Science
Biology

Class 10

Chapter 9 Excretion – Elimination of Body Wastes

LEARNING OBJECTIVES

Nature of Excretory Wastes

Human urinary system

- **Kidneys**
- **Ureters**
- **Urinary bladder**
- **Urethra**
- **Internal structure of the kidney**
- **Physiology of urine formation**
- **Hormonal control of urine formation**
- **Urine and its composition**
- **Osmoregulation by the kidney**

Renal failure and artificial kidney

What is Excretion and Osmoregulation?

The removal of waste products formed in the body as a result of metabolism is termed as **excretion**. Excretion can also defined as the removal of nitrogenous waste from the body. The process of maintaining the right amount of water and proper ionic balance in the body is called **osmoregulation**.

Nature of excretory wastes

The wastes formed as a result of various metabolic activities are:

1.Respiratory waste formed as a result of oxidation of glucose (food)(through cellular respiration)**:** These mainly constitute **carbon dioxide** and **water.**

2. Nitrogenous waste formed as a result of deamination of unwanted amino acids, body's own proteins and nucleic acids: The three main nitrogenous waste products excreted by animals are **ammonia**, **urea** and **uric acid**.

3. Other wastes like salts (NaCl), vitamins and water, that we take directly through food**:** Excess **salts** are mainly excreted by kidneys. The excess water is removed by kidneys as urine and some of it is excreted as sweat by the sweat glands on our skin. Bile pigments are formed due to breakdown of haemoglobin in dead RBCs in the liver. A large amount of these pigments is excreted out in faeces while some of it is excreted in urine.

Human urinary system

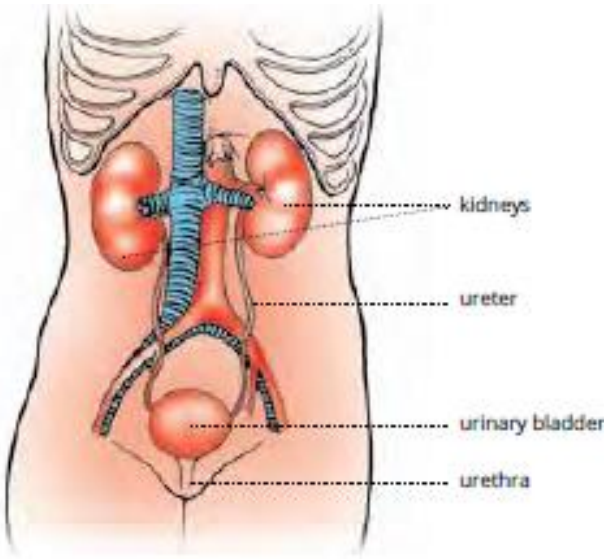
The urinary system in human beings consists of the following parts:

Kidneys

Each kidney is a bean-shaped organ, about 10 cm long, 6 cm wide and 4 cm thick. The right kidney is positioned slightly at lower level than the left kidney as the right side of the abdominal cavity is occupied by the liver.

2. Ureters

The ureters arise from within the renal sinus of the kidneys at hilum. The front end of each ureter is extended into a funnel-shaped structure, the **renal pelvis**. The ureters transport urine from the kidneys to the urinary bladder. Each ureter opens obliquely in the urinary bladder by a slit-like aperture to prevent back flow of the urine.



The human urinary system

3. Urinary bladder

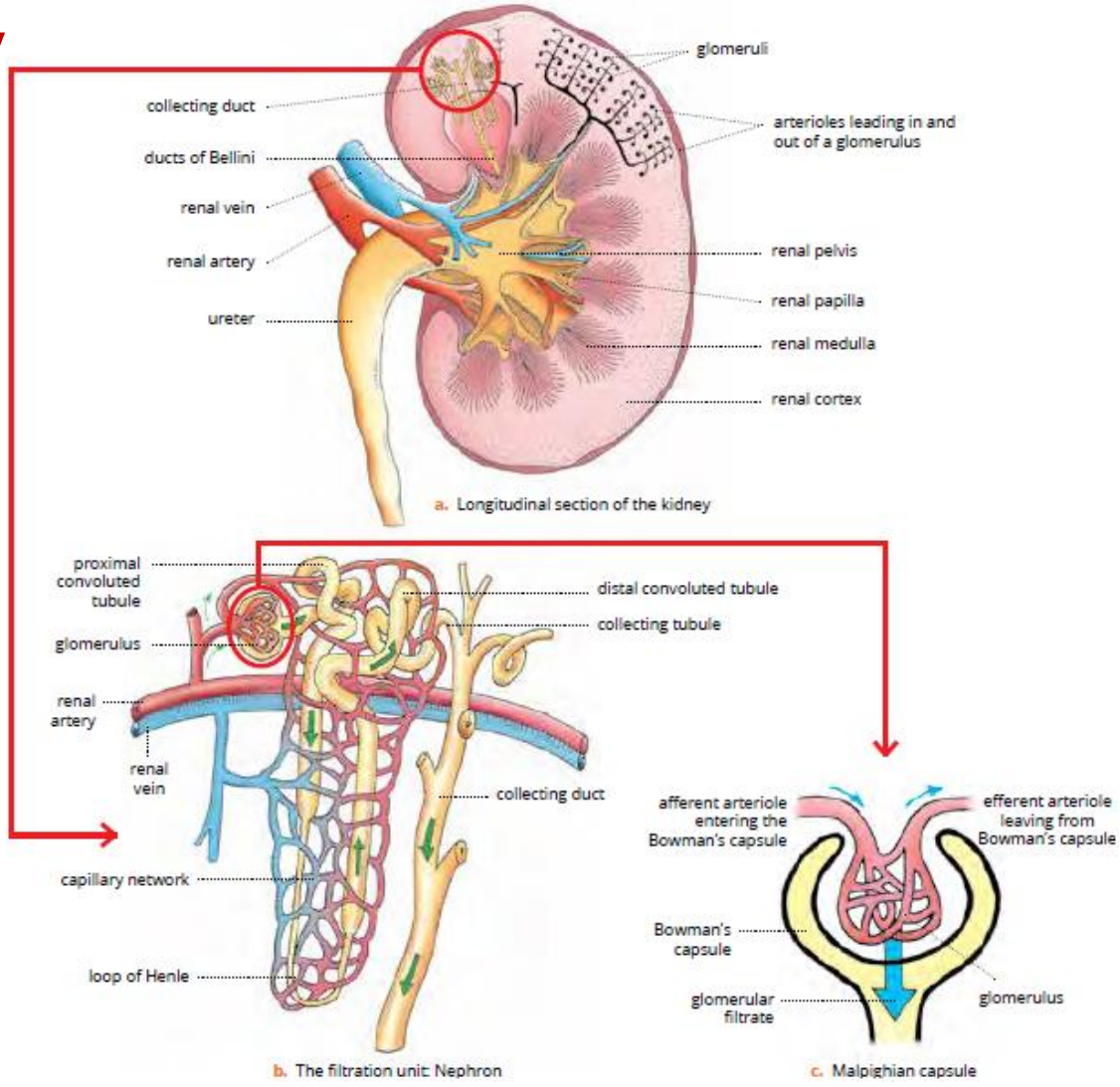
The urinary bladder is a muscular reservoir for storage of urine. It lies in the **pelvic cavity** of the abdomen. The neck of the urinary bladder is surrounded by **sphincters**. Sphincter acts like a valve which remain closed until the time of micturition (urination). Besides functioning as a temporary reservoir of urine, the bladder also evacuates the urine at suitable intervals. The act of voiding or discharging urine is called micturition.

4. Urethra

The urethra is a tube that arises from the neck of urinary bladder and extends up to the outside. In males, it serves as a common passage for urine and sperms. Urethra in females serves as a passage for urine only.

Internal structure of the kidney

Each kidney in a longitudinal section shows two distinct regions – an **outer renal cortex** and an **inner renal medulla**. The **medulla** is subdivided into 15 or 16 conical masses, the **renal pyramids**. Due to presence of these pyramids, the medulla has a stripped appearance.
Each pyramid has narrow **renal papilla** toward the pelvis and a broad base toward the cortex. Renal papillae open into a wide funnel-like structure, **renal pelvis**. The renal pelvis in turn leads into the ureter.



The structure and location of nephron in a kidney

Nephron – structural and functional unit of kidney

Each kidney consists of more than one million nephrons or uriniferous tubules. Nephron is the functional unit of a kidney. Each nephron consists of – a Malpighian capsule or renal tubule, a nephric tubule (secretory part of uriniferous tubule) and a collecting tubule.

Structure of Malpighian capsule or kidney tubule

It has two parts – a Bowman's capsule and a glomerulus .

1. Bowman's capsule: It forms the dilated blind end of the nephron. It is a double-walled, cup-shaped structure. It is lined by a thin **semipermeable squamous epithelium**. The outer concavity of Bowman's cup contains a knot-like mass of blood capillaries called **glomerulus**.

2. Glomerulus: The **afferent arteriole** enters in Bowman's capsule and divides into a bunch of about 50 capillaries. This bunch is called **glomerulus**. Their diameter gets reduced to increase the blood pressure. Bowman's capsule together with glomerulus are called renal capsule or Malpighian capsule.

Nephric or uriniferous tubule

It is a long, coiled tubule and can be divided into three major regions – the proximal convoluted tubule (PCT), the loop of Henle and the distal convoluted tubule (DCT).

1. **Proximal convoluted tubule (PCT):** It is the initial (proximal) convoluted region of the nephric tubule nearer to Bowman's capsule.
2. **Loop of Henle:** It is a U-shaped loop formed in the middle of the nephric tubule. It has a thin **descending limb** and a thick **ascending limb**.
3. **Distal convoluted tubule (DCT):** It is a convoluted structure and is present in the cortex region. It is lined by cuboidal epithelium. It opens into the collecting tubule.

Collecting ducts and the ducts of Bellini

Collecting ducts are larger ducts, each receiving collecting tubules from nephrons. These pass into the renal medulla and join with each other forming still larger ducts of Bellini. These ducts drain the urine collected from the nephrons into the renal pelvis which leads to the ureter.

Physiology of urine formation

Urine formation involves three main processes – **ultrafiltration, tubular reabsorption** and **tubular secretion**.

1. Ultrafiltration : Walls of glomerular capillaries and Bowman's capsule are very thin and semipermeable in nature. Hence, they act as **ultrafilters**. The glomerular hydrostatic pressure or the capillary pressure is the main driving force that tends to move fluid out of the glomeruli.

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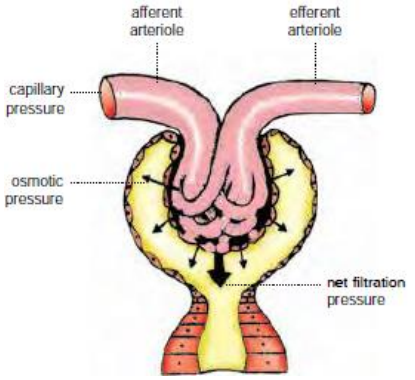


Due to this high filtration pressure in the blood of glomerulus, a part of water and dissolved constituents of blood (like nitrogenous wastes, glucose, amino acids, mineral ions, etc.), are filtered out in the Bowman's capsule. This forms the **glomerular filtrate**.Filtration under high pressure is called **ultrafiltration**

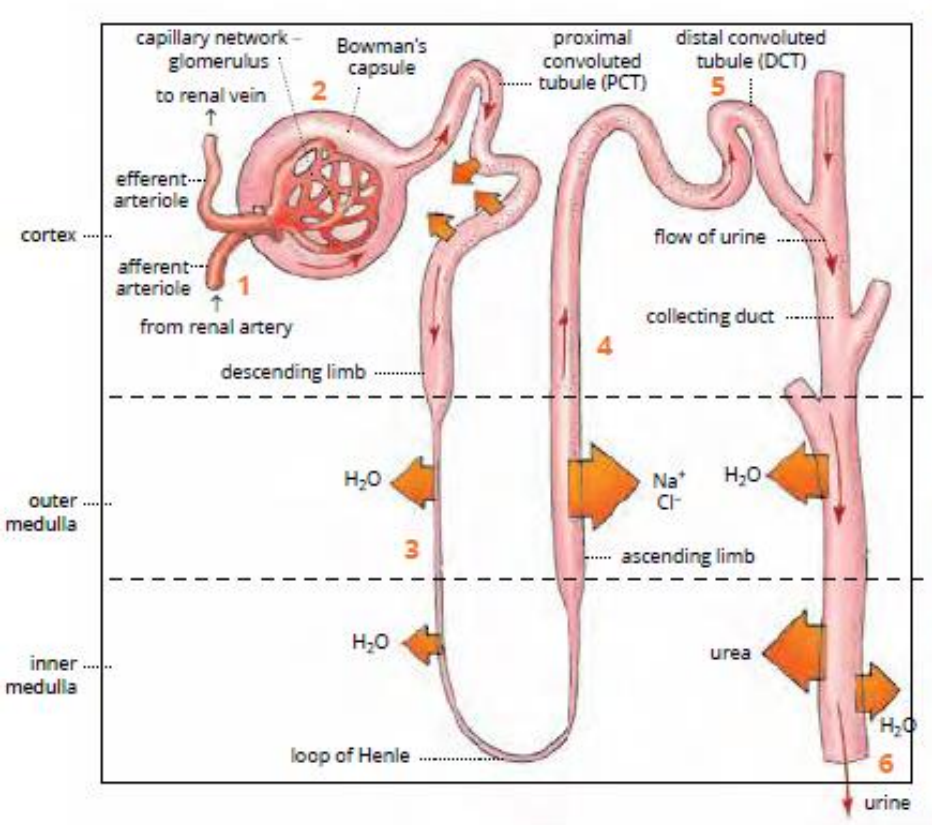
Filtration in the glomerulus ultrafiltration)

2. Tubular reabsorption or selective reabsorption: Our body cannot afford to lose several useful substances that are filtered in the glomerular filtrate. As this filtrate flows through the nephric tubule, water and several useful substances (solutes) are reabsorbed through the wall of the renal tubule (nephric tubule) and returned to the blood flowing in peritubular capillaries. This is called selective reabsorption. Water is reabsorbed by osmosis. Selective reabsorption of glucose, amino acids and salts also takes place.

3. Tubular secretion: This process is the converse of tubular reabsorption.The cells of the renal tubule also remove wastes from blood and pass into the filtrate by the process of secretion. Tubular secretion removes ammonia, urea, uric acid, creatinine and hippuric acid from the blood.

Hormonal control of urine formation

Urine formation is under the control of two hormones – antidiuretic hormone (ADH) and aldosterone.



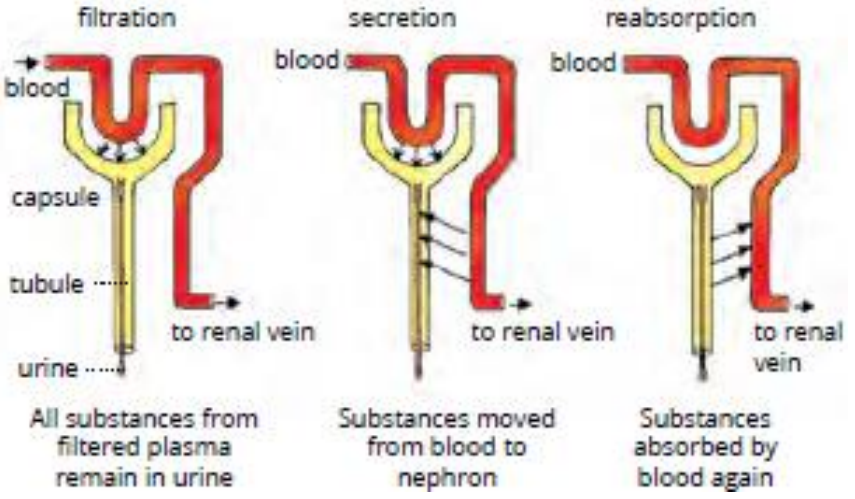
1. Blood from renal artery enters kidneys.
2. **Ultrafiltration:** Blood enters glomerular capillaries. Water and small solutes are filtered in Bowman's capsule.
3. **Tubular reabsorption:** Water and many solutes are reabsorbed through the wall of nephric tubule and return to the blood in peritubular capillaries.
4. **Tubular secretion:** Cells of renal tubule remove wastes from blood and pass them into filtrate.
5. Hormonal action adjusts the urine concentration. ADH promotes water reabsorption. Aldosterone influences reabsorption of sodium and potassium.
6. **Urination:** Water and solutes flow to renal pelvis, then eliminated out through urinary tract.

Note: The function of various parts of renal tubule in formation of urine are given in Table 9.1.

Urine and its composition

An adult man normally passes about 1–1.5 litres of urine in a day. Urine is a transparent yellowish fluid. Its yellow colour is due to a pigment **urochrome** derived from the breakdown of haemoglobin of worn out RBCs.

In normal composition, urine consists of 95 per cent water, and rest 5 per cent is the organic and inorganic substances (solid wastes). Each litre of urine contains nitrogenous organic compounds – urea 2.3 g, uric acid 0.7 g, creatinine 1.5 g and negligible amount of hippuric acid. Of these, urea is the principal nitrogenous waste in human urine.



The process of urine

Osmoregulation by the kidney

The water and solute content of body fluids is regulated by the kidney. This function of regulation of osmotic concentration of blood by the kidney is called **osmoregulation**.

In human beings, the kidney is extremely flexible in its working. Generally in summer when most of water is lost from the body by perspiration,

the urine passed out is **hypertonic**. However, in winter as there is no perspiration, the urine passed out is **hypotonic.**

When there is excess of water in body fluids

In such a condition, the urine passed out of the body is more dilute (hypotonic) than the body fluids. It is achieved by two processes:

❖ Excess of water increases blood volume which increases the hydrostatic pressure in glomerulus, hence, more nephric or glomerular filtrates are formed.

❖ The sensation of excess of water in the body fluid is received by osmoregulator cells in the hypothalamus part of the brain. These cells in turn influence the posterior lobe of the pituitary gland to inhibit or reduce the release of antidiuretic hormone (ADH).

Deficiency of ADH reduces the permeability of cells in the distal convoluted tubule and collecting duct, thereby decreasing the reabsorption of water.

If the body fluids fall below normal

During summer, due to excessive sweating more water is lost, the body fluids reduce. As a result more and more water is reabsorbed by kidney tubules back into the blood and urine turns thick and yellow. To maintain water balance of the body, the following changes take place in the body.

❖ The glomerular filtration slows down due to decreased filtration pressure in the glomerular capillaries.

❖ The osmoreceptor cells of the hypothalamus send impulses to the posterior pituitary lobe to release ADH. ADH increases the reabsorption of water in the distal convoluted tubule and the collecting duct by making them more permeable to water.

Less filtration and more reabsorption of water leads to the discharge of small amounts of hypertonic urine. This raises the volume of body fluids to normal.

Renal failure and artificial kidney

Artificial kidney is used to filter the blood of a patient whose kidneys are damaged. The patient is said to be put on **dialysis** and the process of purifying blood by an artificial kidney is called **haemodialysis**.

SUMMARY...

- The removal of waste products formed in the body due to metabolic activities is termed as excretion.
- Kidneys in human beings are said to be retroperitoneal because they lie behind the peritoneal lining of the abdominal cavity.
- Each kidney in longitudinal section shows two distinct regions – an outer renal cortex and an inner renal medulla.
- Nephron is the functional unit of kidney.
- Each nephron consists of – a Malpighian capsule, a nephric tubule and a collecting tubule.
- Urine formation involves three main processes – ultrafiltration, tubular reabsorption and tubular secretion.
- Yellow colour of the urine is due to the presence of a pigment, urochrome, derived from the breakdown of haemoglobin of worn out RBCs.
- The water and osmotic concentration of blood is maintained by the kidney. This phenomenon is known as osmoregulation.
- The process of purifying blood by the use of an artificial kidney is called dialysis.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