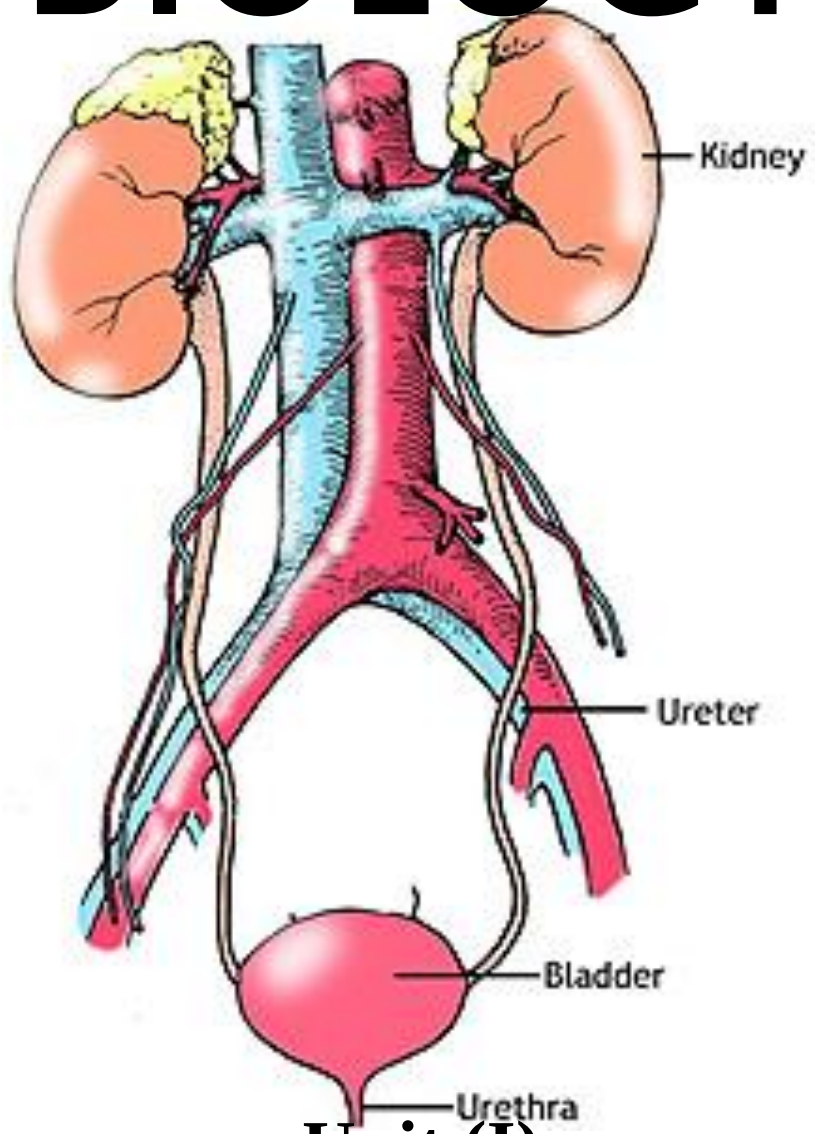
BIOLOGY



Unit (I)
Chapter (4)
Excretion in Living Organisms

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Concept and importance of excretion.

All biological processes that occur in the bodies of all living organisms are carried out through chemical reactions that leave some waste products. The living organism must get rid of these waste products as soon as they are formed, otherwise it will cause many problems and infections.

Excretion: the process by which the living organisms get rid of these waste products.

Excretion in Animals.

Excretion refers to the materials that leave the body through the plasma membranes.
The undigested food that goes out of the animal body in the form of faeces is not considered as excretion.
The Nitrogen in the air which enters the lungs in inspiration and leaves them in expiration is not considered as excretion.

The important waste products that are produced and excreted from the animal's body:

1. CO_2 and water: that are produced and excreted from organic molecules degeneration.
2. The nitrogenous waste products (Ammonia, Urea, and Uric acid) that are resulted due to protein degradation.

N.B.:

1. The organs that carry out excretion in higher animals are the skin, the lungs, the liver, and the kidneys.
2. Organs of excretion also regulate the body contents of minerals.
3. Some of the spices that have volatile content leave the body through the lungs, and the rest is excreted through the kidneys.
4. The poisonous materials are transformed into non-poisonous forms in the body or into non-soluble form by the liver or the kidneys.

The following table represents the important waste products of the Human body, and the ways of their excretion:

The excreted material	The excretion organ
Carbon dioxide	Lungs
Water	Kidneys / Skin / Lungs
Nitrogenous waste products	Kidneys / Skin (small percentage)
Salts	Kidneys / Skin
Spices	Kidneys / Lungs (volatile substances)

Excretion in Man

The skin:

The skin is considered an excretory organ in Man. It's the biggest organ in the body, as it covers the whole body and the limbs from the outside.

Skin structure:

It consists of two main layers: an outer epidermis and an inner dermis, under which there is a layer of fat.

1. The epidermis:

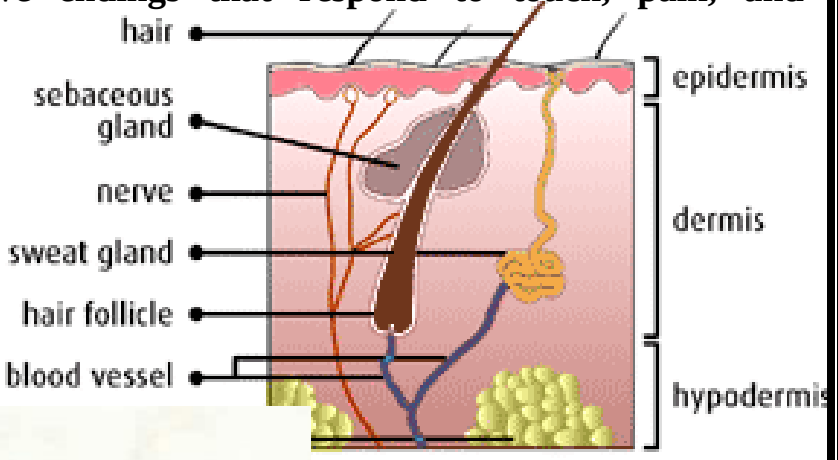
It consists of several layers of epithelial cells.

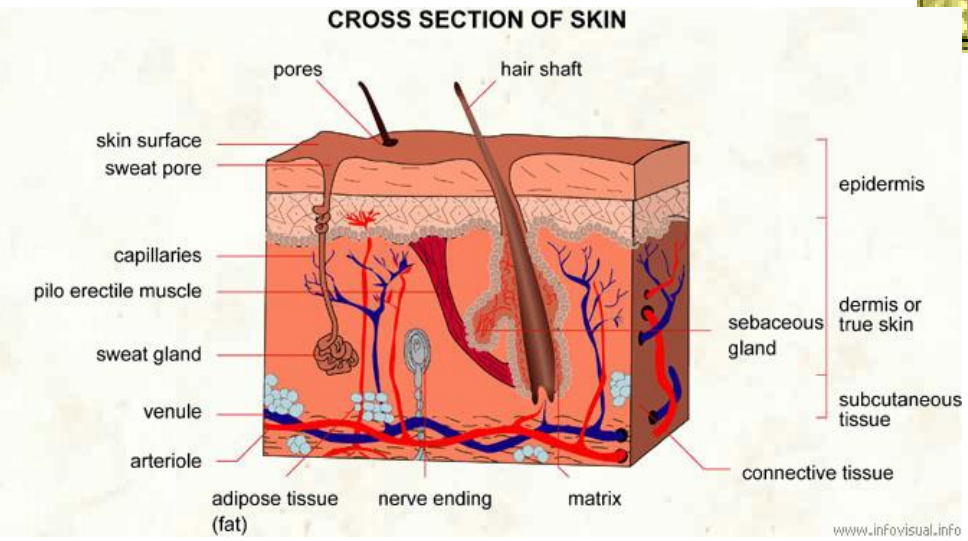
At the surface: These cells are dead, full of a horny substance called keratin, and always are subjected to friction, e.g. when wiping your face or body with a towel, or rubbing your hands. This layer is worn away and is continuously replaced from beneath.

At the base of its inner layer: There are pigment cells which secrete granules responsible for the color of the skin (melanin).

2. The dermis:

It lies next to the epidermis, consisting of connective tissues. Dermis contains blood capillaries, nerve endings, lymphatics, sweat glands, fat glands, fatty cells, and hair follicles. There are sensory nerve endings that respond to touch, pain, and temperature.





The sweat gland:

Is a coiled tube that reaches the skin surface through a pore.

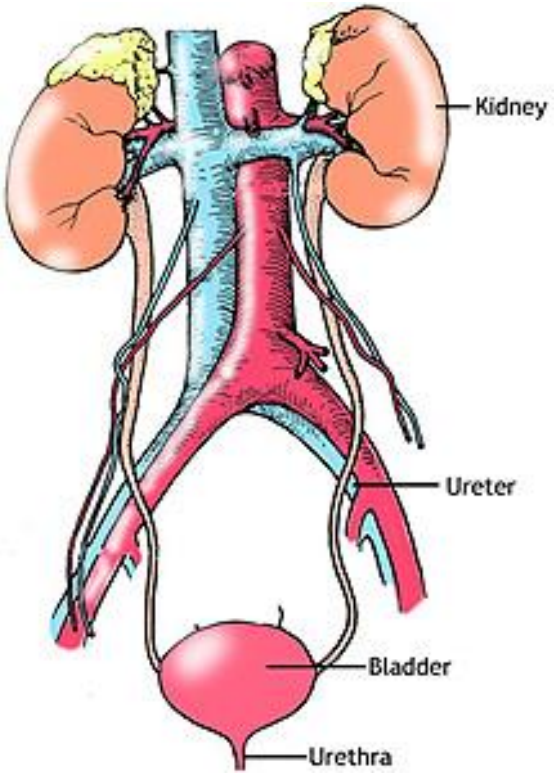
Sweat is continually being produced on the surface of the skin, so decreasing the body temperature through its evaporation. Remaining wastes cause the skin to be sticky. It is important to remove these wastes continually by washing; otherwise sweat pores become blocked resulting in a foul odour.

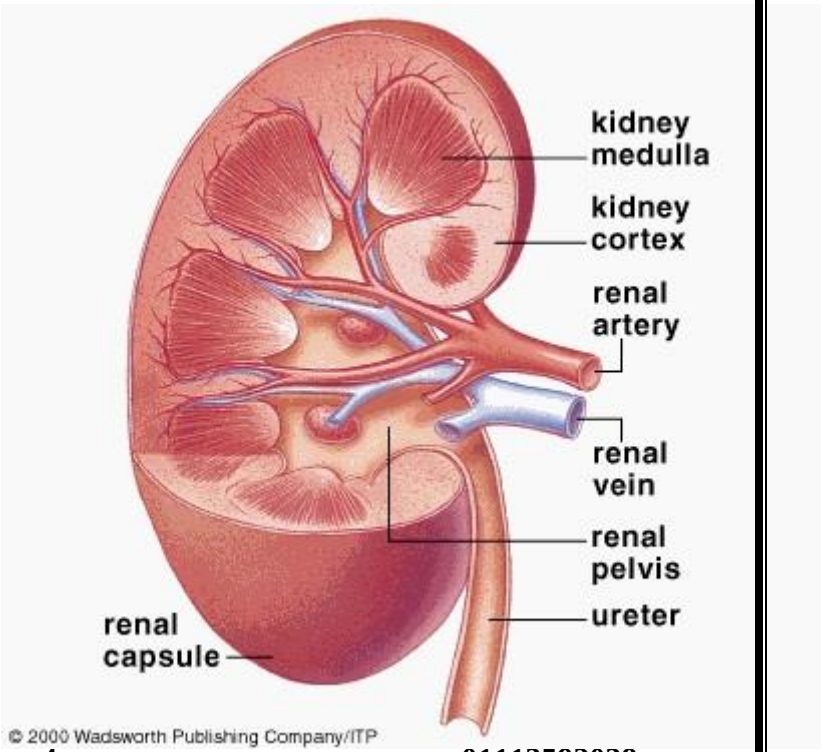
The hair:

The hair is made of a hair follicle, surrounded by many blood capillaries. At its free end, there is a sebaceous (fat) gland, which produces an oily secretion that facilitates the exit of the hair from the skin, keeping it soft and pliable. The hair follicle is supplied with an erector muscle.

The kidney:

Each vertebrate animal has two kidneys. In lower vertebrates, the kidneys are long, thin organs which extend from the two sides of the vertebral column. In higher vertebrates, such as mammals, the kidneys are more firm and are situated behind the peritoneum (membranes lining the abdominal cavity). A ureter emerges from each kidney, which passes the urine into a small muscular sac called the urinary bladder. The ureter opens at the back of the bladder in an inclined position. A sphincter muscle closes the outlet of the bladder till urine accumulates, then the bladder contracts expelling the urine through a duct called the urethra.





Kidney structure:

The two kidneys are situated in the upper part of the abdominal cavity, one at each side of the vertebral column. The length of each kidney is about 12 cm long, and about 7 cm wide. Its thickness is about 3 cm. The kidney is bean-shaped. Its outer part is convex, while the inner one is concave. On the inner side of each kidney, the renal artery comes from the Aorta, and the renal vein leads to the posterior (inferior) vena cava. Internally, the kidney is differentiated into two regions, an outer narrow cortex and an inner broad medulla. The functional unit of the kidney is the nephron, of which there are about one million in each kidney.

The structure of the nephron:

The nephron starts in the cortex with a cup-shaped, thin, double-walled Bowman's capsule. The capsule leads to the first coiled tubule in the cortex, then to the loop of Henle in the medulla which is U-shaped, then to the second coiled tubule in the cortex before joining the collecting duct. This duct opens in the concave cavity of the kidney which is called the pelvis.

Urine extraction:

The renal arteries come from the Aorta, each entering a kidney at its concave surface. The renal artery divides into a great many arterioles and capillaries at the cup-shaped nephron. Plasma (blood fluid) filters out of the blood to collect in the nephron. The filtered fluid contains: water, wastes, salts, and glucose. Blood cells and large protein molecules remain in the blood.

What happens if all the contents of this fluid are excreted outside the body?

The body will lose much of its required water and essential substances and the individual has to drink 170 liters of water daily to compensate its loss. Therefore, re-absorption of required water, glucose, and mineral substances back into the blood, must take place.

The remaining liquid contains nitrogenous wastes (urea), some inorganic salts and excess water which form the urine. Excess substances such as small amounts of glucose and Vitamins may be also present.

Re-absorption:

Re-absorption takes place in the nephron tubules. Urine then passes down the collecting duct to the pelvis of the kidney where it collects and continues down the ureter to the bladder to be stored. When the bladder contracts, urine is expelled through the urethra.

N.B.:

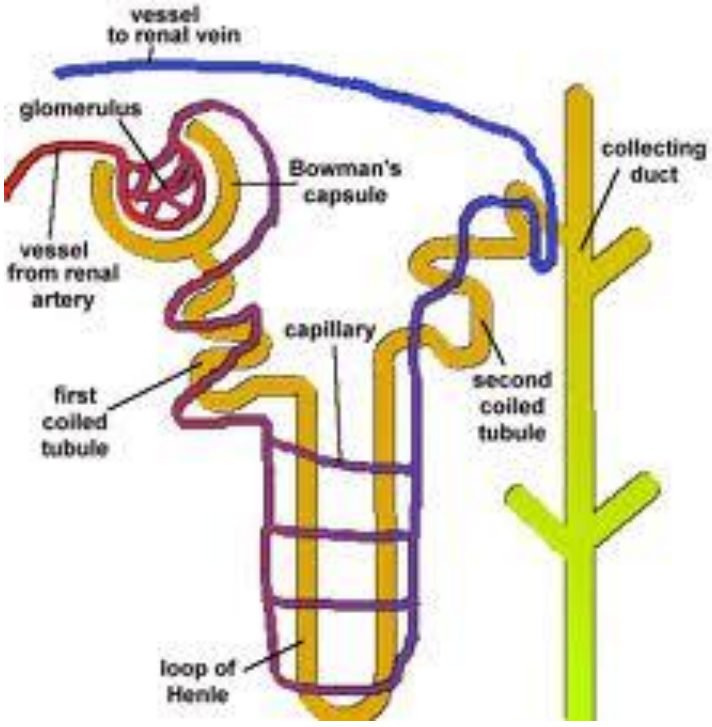
1. Kidneys, ureters, urinary bladder and urethra are collectively known as the urinary system.

2. The individual can live with one kidney. In this case, this kidney grows and becomes slightly bigger to perform the function of the two kidneys. No one can live without a kidney, nor can he live if the kidneys stop functioning. Accumulation of poisonous wastes in the blood happens leading to death.

3. The human body contains about 5.6 litres of blood. 1.2 – 1.3 litres of blood passes through the kidney per minute.

4. The total amount of blood which passes daily through the kidney is about 1600 litres (i.e. approximately ¼ of the blood volume pumped by the heart). This means that a very high percentage of blood always passes through the kidney.

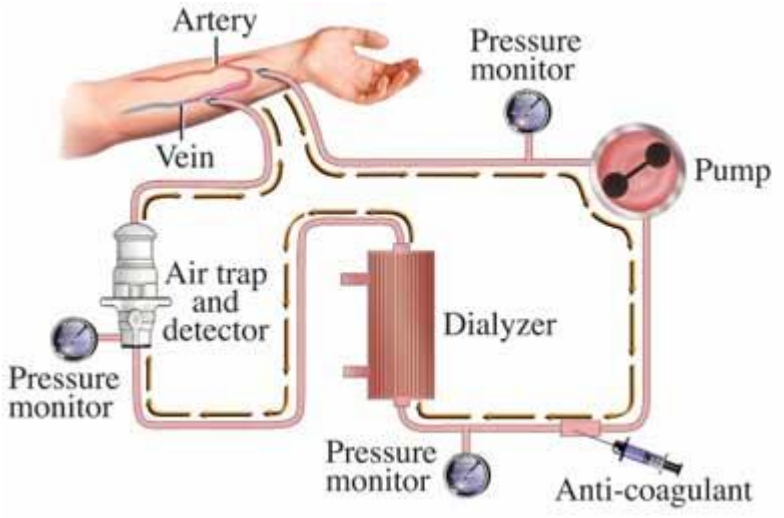
5. Of the total blood volume, three litres of plasma pass through the kidney to be examined about 560 times per day.



The artificial kidney:

Kidney failure takes place due to some diseases. The kidney stops functioning and this leads to the accumulation of harmful wastes in the blood.

In treating cases of kidney failure, a tube is inserted into an artery in the patient's arm and the blood is channeled through semi-permeable tube immersed in a bath containing all the normal blood chemicals except urea and other metabolic wastes. Since the concentration of harmful metabolic wastes is higher in the blood than in the bath, they pass through the wall of the tubes into the bath and purified blood is returned to the body. A patient receives artificial kidney treatment for several hours each day, 2 – 3 times a week.



Excretion in Plants

Excretion in plants does not cause any serious problem, since:

1. The rate of catabolism is much lower in plants than that in animals of the same weight, so accumulation of metabolic wastes in the plant cells will be very slow.

2. Green plants re-use the catabolic wastes, for example:

a. Carbon dioxide and water which result from respiration are reused in photosynthesis.

b. The nitrogenous wastes are reused in the synthesis of the required proteins.

3. Since the metabolism of plants is based mainly on carbohydrates rather than proteins, this reduces their excretory needs, as the wastes of carbohydrates metabolism are less toxic than those resulting from protein metabolism.

4. The metabolic wastes such as organic salts and acids are stored in the form of insoluble crystals in the cytoplasm, or in the vacuole. Since these crystals are insoluble they will cause no harm to the cells.

N.B.:

1. Many plants get rid of Carbon dioxide and some mineral salts through their roots.

2. Plants which live in soils rich in Calcium can get rid of the excess amounts of these elements by its accumulation in leaves which are finally shed.

3. Carbon dioxide which results from respiration and Oxygen obtained from photosynthesis are excreted through the stomata by diffusion.

4. Excess water is lost mainly through transpiration and guttation.

Guttation:

Drops of water are seen at the leaf tips of some plants as Potatoes and Tomatoes. This occurs in the early morning in spring. There is a special system for guttation which consists of one or many loose cells opening by a water stoma called a hydathode which opens constantly day and night. Guttation water contains other substances which can therefore be deposited, when water evaporates rapidly.

Transpiration:

Water needs in plants:

1. The plant needs water more than an animal of equal weight.

2. The animal can retain water in its body to be used again, while the plant loses about 90% of its water content to the outside.

3. The plant absorbs 17 times more water daily than that taken in by a man of equal mass.

4. One feddan of Maize plant needs more than two million litres of water during its life.

In facts, great quantities of water are absorbed from the soil, mainly through the roots. Water is then transferred through the conductive tissues (Xylem) to the stem and leaves. At the same time the plant loses most of this water in a continuous manner. Loss of water in the form of water vapor from the plant is called transpiration.

Stomatal Transpiration:

Water passes, in the form of vapor, through the moist cell walls of the mesophyll tissue, and evaporates into the intercellular spaces, where it diffuses out into the atmosphere through the stomata. The same process occurs in other cells with intercellular spaces between them in different plant tissues. More than 90% of the total water loss is lost though the stomata and is called stomatal transpiration.

Stomata occur in plant leaves rather than any other vegetative organ. So, most of the transpired water is lost through the leaves. In most dicotyledonous plants, the leaf blades are wide, flattened and contain a network of veins. The veins contain transporting elements (xylem) which provide the mesophyll with water. The mesophyll tissue is characterized by the presence of intercellular spaces, which allow water to evaporate continuously to these spaces through the cell walls.

Cuticular Transpiration:

Small quantities of water pass through the cuticle that covers the epidermis of the vegetative organs in the form of water vapor; it does not exceed 5% of the total amount of the lost water.

Lenticular transpiration:

Stems of woody plants lose small quantities of water vapor through the lenticels by lenticular transpiration. It does not exceed 5% of the total amount of the lost water.

An experiment to illustrate transpiration in plants:

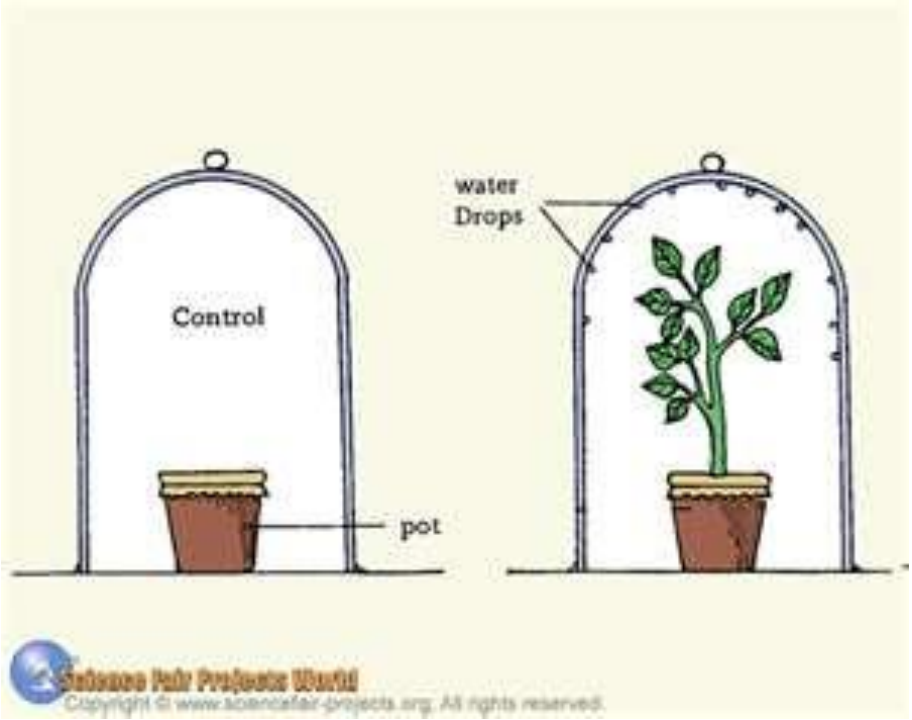
1. Take a potted leafy plant.
2. Cover the soil surface and the surface of the pot with paraffin.
3. Place the potted plant on a glass sheet under a dry bell-jar and wait for some time.

Observation:

Tiny droplets of water appear on the inside of the bell-jar that accumulate, become bigger in size and run downwards on the wall of the bell-jar.

Conclusion:

Air inside the bell-jar receives water vapor from the plant which condenses forming water that changes the white color of anhydrous copper sulfate into blue confirming that it is water. Water passes from the exposed parts of the plant to the surrounding air.



Importance of transpiration for the plant:

1. The decrease of the plant temperature:

A large amount of energy absorbed by the leaves is in the form of heat or is converted into heat inside the leaf tissues. This may cause a rise in the leaf temperature, especially in sunny, warm days. This rise in temperature harms the protoplasm and could lead to its death if transpiration did not decrease the plant's temperature through water loss.

2. The ascent of water and salts from the soil:

The root cells contain cell sap with a concentration (of soluble organic and inorganic substances) higher than that of the soil solution. As a result, the soil water enters the root cells by osmosis. The osmotic pressure is sufficient to move water from the root hairs to the inner root tissues till it reaches the xylem vessels and tracheids. Water rises upwards through the xylem vessels of the stem, then through vessels of leaves (in veins) and at the end it reaches the mesophyll cell sap, decreasing the ability of these cells to pull up more water.

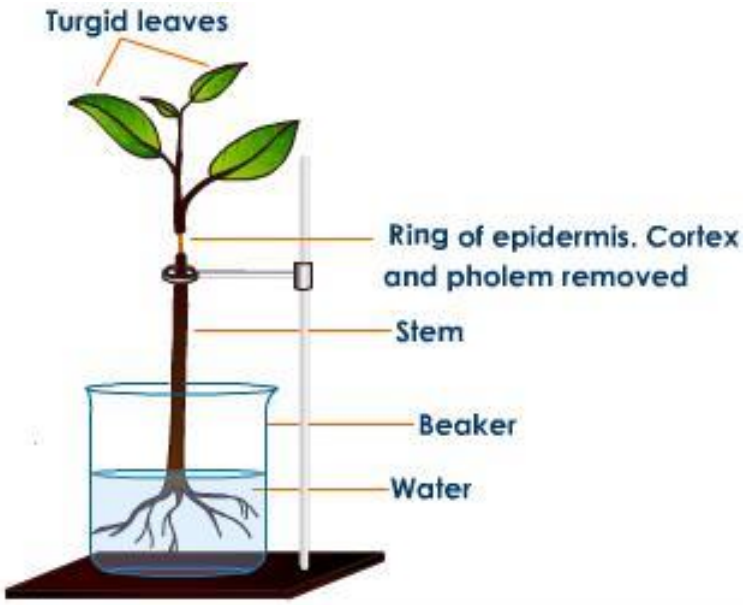
There are intercellular spaces full of air between the mesophyll cells, to which water evaporates. As a result of the continuous loss of water `from the mesophyll cells, the concentration of salts in these cells increases, and so the ability to pull water upwards increases. This explains the so-called transpiration cycle and its role in the ascent of water.

N.B.:

Osmotic pressure is only enough to move water through the plant stem for a short distance by what is known as root pressure. In some trees, water has to move through their vessels to a height reaching up to 125 meters, and therefore, a new theory was put forward to explain the force which pushes water to such heights. This theory is known as adhesion, cohesion, and transpiration pull theory.

An experiment to show that water ascends through xylem:

1. Fill a test tube with eosin solution.
2. Carefully detach a small flowering plant with its roots from its soil.
3. Immerse the plant roots in the eosin solution, and close using a cotton wool plug.
4. Keep the tube in a vertical position for few hours.



Observation:

The leaf petioles change to pink, as well as the veins of the leaves and petals.
5. Cut a thin transverse section of the plant stem and examine it under the microscope (after placing it on a slide).

Observation 2:

Xylem tissue only is stained be eosin.

Conclusion:

Pink coloration of petioles and petal veins indicates that eosin solution reaches these organs. This experiment proves that:
1. Water is absorbed by roots.
2. Water ascends through xylem tissue of the stem to the leaves.

An experiment to show the :

1. Fill a small beaker with mercury.

2. Fill a narrow tube with water and invert it in the beaker, so that its lower end becomes immersed in the mercury.

3. Cut a leafy twig of a potted plant under water and insert the lower tip of the twig in a cork plug through a hole and fix the cork plug tightly with the twig in the upper opening of the tube and close it firmly with Vaseline.

4. Mark the mercury level in the tube.

5. Leave the apparatus in open air for a while.

Observation:

Mercury rises in the tube.

Conclusion:

The rise of mercury in the tube is due to transpiration pull, where the leafy twig loses water by evaporation, so water from the tube must rise to replace it. As a result, mercury rises up in the tube. This indicates that water loss by transpiration generates a pull to raise water upwards.

Revision VII
Excretion in Livings.

1. Give the scientific term that represents each of the following:

a. The process by which the living organisms get rid of these waste products. (---------)
b. The materials that are produced and excreted from organic molecules degeneration. (----------)
c. The materials that are resulted as wastes due to protein degradation. (----------)
d. The organs that carry out excretion in higher animals. (----------)
e. The organs that regulate the body contents of minerals. (----------)
f. The organs that get rid of the volatile content of spices. (----------)
g. The organs that transform poisonous materials into non-poisonous forms in the body or into non-soluble form. (----------)
h. The biggest organ in the Human body. (----------)
i. The two main layers that form the Human skin. (----------)
j. Several layers of epithelial cells that cover the Human skin. (----------)
k. The substance that fills the epithelial cells at the surface of the skin. (----------)
l. Cells which secrete granules responsible for the color of the skin. (----------)
m. The substance that are responsible for the color of the skin. (----------)
n. Lies next to the epidermis of the Human skin, consisting of connective tissues. (----------)
o. The structures that are present in the dermis of the Human skin. (----------)
p. A coiled tube that reaches the skin surface through a pore. (----------)
q. A gland that is situated at the free end of the hair. (----------)
r. The muscle that is supplied to the hair follicle. (----------)
s. A membrane that lines the abdominal cavity.(----------)
t. Closes the outlet of the bladder till urine accumulates. (----------)
u. The duct through which urine passes out when the bladder contracts. (----------)
v. A duct that emerges from each kidney, through which urine passes into the urinary bladder. (----------)
w. A small muscular sac inside which urine accumulates till urination. (----------)
x. Long, thin organs which extend from the two sides of the vertebral column in lower vertebrates. (----------)
y. The structures that are attached to the inner side of each kidney. (----------)
z. The functional unit of the kidney. (----------)
a. The two regions of the kidney. (----------)
b. Cup-shaped, thin, double-walled structure at the beginning of each nephron. (----------)
c. The duct that opens in the concave cavity of the kidney. (----------)
d. The concave cavity of the kidney. (----------)
e. The arteries that come from the Aorta, each entering a kidney at its concave surface. (----------)

f. The required materials that are re-absorbed to blood at the nephron tubules. (----------)
g. The constituents of urine. (----------)
h. Volume of blood in the Human body in liters. (----------)
i. Volume of blood that passes through the kidney per minute in liters. (----------)
j. The total amount of blood which passes daily through the kidney. (----------)
k. No. of times that the blood plasma passes through the kidney to be examined daily. (----------)
l. The apparatus used in treating cases of kidney failure. (----------)
m. Excretory substances that are reused in photosynthesis in green plants. (----------)
n. Wastes that are reused in the synthesis of the required proteins in plants. (----------)
o. The materials that are mainly used in the metabolism of plants. (----------)
p. The materials that are mainly used in the metabolism of animals. (----------)
q. The metabolic wastes that are stored in the form of insoluble crystals in the cytoplasm, or in the vacuole of plants cells. (----------)
r. Two processes through which excess water is lost in plants. (----------)
s. Drops of water are seen at the leaf tips of some plants as Potatoes and Tomatoes. (----------)
t. A special system for guttation which consists of one or many loose cells opening by a water stoma. (----------)
u. Loss of water in the form of water vapor from the plant. (----------)
v. Loss of water in the form of water vapor from the stomata in plants. (----------)
w. Loss of water in the form of water vapor through the cuticle that covers the epidermis of the vegetative organ in plants. (----------)
x. Loss of water in the form of vapor through the lenticels of woody stems. (----------)

2. Give reasons for:

a. The undigested food that goes out of the animal body in the form of faeces is not considered as excretion.
b. The Nitrogen in the air which enters the lungs in inspiration and leaves them in expiration is not considered as excretion.
c. Cells of the epidermis of the skin are dead.
d. pigment cells are responsible for the color of the skin in Man.
e. Secretion of sweat on the Human skin decreases the body temperature.
f. At the free end of the hair follicle, there is a sebaceous (fat) gland.
g. re-absorption of required nutrients back into the blood, must take place.
h. No one can live without a kidney, nor can he live if the kidneys stop functioning.
i. The artificial kidney is used to treat kidney failure.
j. Accumulation of metabolic wastes in the plant cells is very slow.
k. Excretion in plants does not cause any serious problem.
l. Some plants can live in soils rich in Calcium.
m. Plants need water more than animals.
n. Transpiration in plants is needed to decrease its temperature.

3. Draw a labeled diagram to represent:

a. The structure of the Human skin.
b. A section in the Human kidney.
c. The structure of the nephron.
d. The urinary system in Man.
e. The structure of the artificial kidney.

4. What do you know about:

a. The structure of the Human skin.
b. The sweat gland.
c. The structure of the nephron.
d. Urine extraction.
e. Re-absorption at the nephron tubules.
f. The artificial kidney.
g. Guttation.
h. Transpiration cycle.

5. Draw the apparatus used, and describe the experiment that proves:

a. Ascent of water in plants takes place due to transpiration.
b. water ascends in plants through xylem.
c. The occurrence of transpiration in plants.

6. Compare between:

a. The epidermis of the Human skin and its dermis.
b. Keratin and melanin.
c. kidney in lower vertebrates and that in higher vertebrates.
d. The cortex and the medulla of the Human kidney.
e. The concentration of different materials in the renal artery and the renal vein.
f. Metabolism in plant cells and that in animal cells.
g. Transpiration and guttation.
h. Stomata and hydathodes.
i. Stomatal transpiration, cuticular transpiration, and lenticular transpiration.

7. Describe the working idea of the artificial kidney.

8. Describe the mechanism of urine extraction in nephrons.