Basic concept of plant growth and nutrition

6.1 Growth

Growth is regarded as one of the most fundamental and conspicuous characteristics of a living being. What is growth? Growth can be defined as an irreversible permanent increase in size of an organism or its parts or even of an individual cell. Generally, growth is accompanied by metabolic processes (both anabolic and catabolic), that occur at the expense of energy. For example, expansion of a leaf is growth. How would you describe the swelling of piece of wood when placed in water?

6.1.1 Plant Growth Generally is Indeterminate

Plant growth is unique because plants retain the capacity for unlimited growth throughout their life. This ability of plants is due to the presence of meristems at certain locations in their body. The cells of such meristems have the capacity to divide and self-perpetuate. The product, however, soon loses the capacity to divide and such cells make up the plant body. This form of growth wherein new cells are always being added to the plant body by the activity of the meristem is called the open form of growth. What would happen if the meristem ceases to divide? Does this ever happen?

In First Year, you studied about the root apical meristem and the shoot apical meristem. You know that they are responsible for the primary growth of the plants and principally contribute to the elongation of plants along their axis. You also know that in dicotyledonous plants and gymnosperms, the lateral meristems, vascular cambium and cork-cambium appear later in life. These are the meristems that cause the increase in the girth of the organs in which they are active. This is known as secondary growth of the plant (see Figure 6.2).

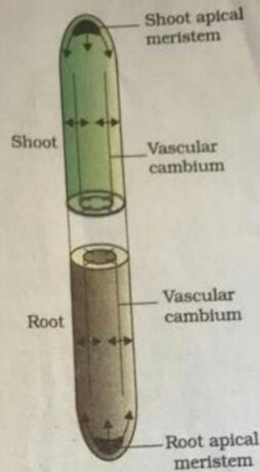

Figure 6.2 Diagrammatic representation of locations of root apical meristem, shoot apical meristem and vascular cambium. Arrows exhibit the direction of growth of cells and organ

6.1.2 Growth is Measurable

Growth, at a cellular level, is principally a consequence of increase in the amount of protoplasm. Since increase in protoplasm is difficult to measure directly, one generally measures some quantity which is more or less proportional to it. Growth is, therefore, measured by a variety of parameters some of which are: increase in fresh weight, dry weight, length, area, volume and cell number. You may find it amazing to know that a single maize root apical mersitem can give rise to more than 17,500 new cells per hour, while cells in a watermelon may increase in size by upto 3,50,000 times. In the former, growth is expressed as an increase in cell number; the latter expresses growth as an increase in the size of the cell. While the growth of a pollen tube is measured in terms of its length, an increase in surface area denotes growth in a dorsiventral leaf.

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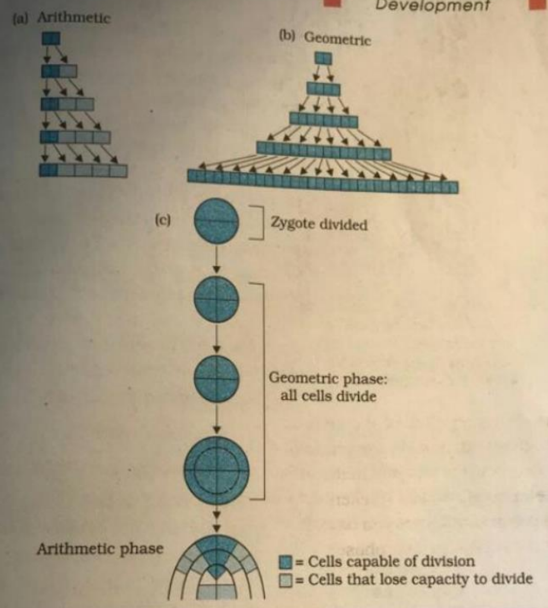

Figure 6.4 Diagrammatic representation of :
(a) Arithmetic
(b) Geometric growth and
(c) Stages during embryo development showing geometric and arithematic phases

Let us now see what happens in geometrical growth. In most systems, the initial growth is slow (lag phase). Growth increases rapidly thereafter at an exponential rate (log or exponential phase). Here, both the progeny cells following mitotic cell division retain the ability to divide and continue to do so. However, with limited nutrient supply, the growth slows down, leading to a stationary phase. If we plot the parameter of growth against time, we get a typical sigmoid or S-curve (Figure 6.6). A sigmoid curve is a characteristic of

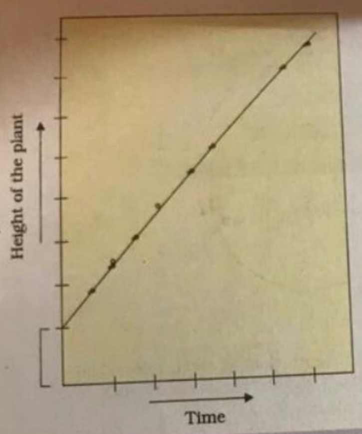

Figure 6.5 Constant linear growth, a plot of length L against time t

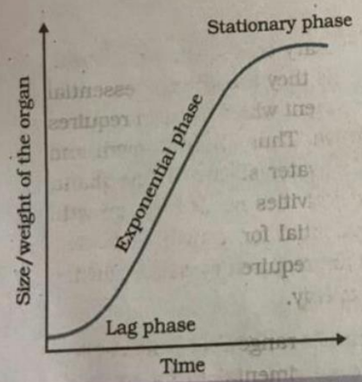

Figure 6.6 An idealised sigmoid growth curve typical of cells in culture, and many higher plants and plant organs

living organism growing in a natural environment. It is typical for all cells, tissues and organs of a plant. *Can you think of more such examples? What kind of curve can you expect in a tree showing seasonal activities?*

The exponential growth can be expressed as

$W_1 = W_0 e^{rt}$

W_1 = final size (weight, height, number etc.)

W_0 = initial size at the beginning of the period

r = growth rate

t = time of growth

e = base of natural logarithms

Here, r is the relative growth rate and is also the measure of the ability of the plant to produce new plant material, referred to as efficiency index. Hence, the final size of W_1 depends on the initial size, W_0.

Quantitative comparisons between the growth of living systems can be of two kinds

(i) Measurement and comparison of the total growth per unit time is called the Absolute Growth Rate (AGR).

(ii) The growth of the given system per unit time as percentage of initial size is called the Relative Growth Rate (RGR).

$$RGR = \frac{\text{Growth per unit time}}{\text{Initial size}} \times 100$$

Nutrition

Basic needs of all living organisms are essentially the same. All living organisms require biomolecules, such as carbohydrates, proteins, & fats & water, minerals for their growth & development.

Here we are talking about plant nutrients. Most of the minerals present in soil can enter plants through roots. In fact, more than sixty elements are found in plants.

Criteria for Essentiality

- The element must be absolutely necessary for supporting normal growth & reproduction. In the absence of the element the plants do not complete their life cycle.
- The requirement of element must be specific & not replaceable by another element. In another word deficiency of any one element by another ~~element~~ can not be met by supplying some other element.
- The element must be directly involved involve in the metabolism.

These elements are further divided into two categories.

① Macronutrients

② Micronutrients.

Macronutrients are generally present in plant tissues in large amounts. They include carbon, hydrogen, O_2, nitrogen, phosphorous, sulphur, potassium, calcium & magnesium. Of these, elements carbon, hydrogen & O_2 are mainly obtained from CO_2 & H_2O, while the others are absorbed from the soil as mineral nutrients.

Micronutrients

Micronutrients or trace elements are needed in very small amounts. These include iron, manganese, copper, molybdenum, zink, boron, chlorine & nickel.

ROLE OF MACRO-MICRO-NUTRIENTS

~~Ef~~ Essential elements perform several functions. They participate in various metabolic processes in the plant cells such as permeability of cell membrane, maintenance of osmotic concentration of cell, electron transport system, enzymatic activity.

The various forms & functions of essential nutrients elements are given below:

Nitogen

This is the essential mineral nutrient element required by plants in the greatest amount. It is absorbed mainly as NO_3^-. Nitrogen is required by all parts of a plant, particularly the meristematic tissues & the metabolic activity. Nitrogen is one of major constituents of proteins, nuleic acids, enzymes, vitamines & hormones.

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Phosphorus

(2)

Phosphorus is absorbed by plants from the soil in the form of phosphate ions. Phosphorus is a constituent of cell membranes, certain proteins, all nucleic acids.

Potassium

It is absorbed as potassium ion (K^+). It is required in more abundant quantities in the meristematic tissues, buds, leaves & root tips. Potassium helps in protein synthesis, opening & closing of stomata, activation of enzymes.

Calcium

Plant absorb calcium from the soil in the form of calcium ions. Calcium is required by meristematic & differentiating tissues. During cell division, it is used in the synthesis of cell wall. It accumulates in older leaves. It plays important role in metabolic activity. It helps in photosynthesis.

Magnesium

It is absorbed by plants in the form of Mg^{++} ions. It activates the enzymes of respiration & photosynthesis & involved in the synthesis of DNA & RNA.

Sulphur

Plants obtain sulphur in the form of sulphate SO_4^{--} ions. It is important for enzyme activity. It helps in stabilizing the protein structure.

Iron

Plants obtain iron in the form of ferric ions Fe^{3+}. Iron is required in larger amounts compared to other micronutrients. It is essential for the formation of chlorophyll.

Manganese Mn

It activates many enzymes involved in photosynthesis, respiration & metabolism. Its main function is to split water to liberate O_2 during photosynthesis.

Zinc

Plant obtain zinc as zinc ions. Zinc activates various enzymes, especially carboxylase. It is needed in the synthesis of auxin.

Copper

It is essential for the overall metabolism in plants.

Boron is require for pollen germination, cell elongation, cell differentiation etc.

Molybdenm

enzyme activity.

Chlorine

It is absorbed in the form of molybdate chloride anion (Cl^-). It is essential in water spliting reaction.

Nickel

It is imp for nitrogen metabolism. It acts as disease resistance in some plants.

Deficiency Symptoms of Essential Elements

Whenever the supply of an essential element becomes limited, plant growth is retarded. The deficiency symptoms tend to appear first in older tissues. e.g. the deficiency symptoms of nitrogen, potassium & magnesium are visible first in the senescent leaves.

The kind of deficiency symptoms shown in plants include chlorosis, necrosis, premature leaf fall of leaves & buds. Chlorosis is loss of chlorophyll leading to yellow in leaves.
(N, K, Mg, Fe, Mn, Zn Mo)

Likewise necrosis or death of tissues, particularly leaf tissue is due to deficiency of Ca, Mg, Cu, K etc.

Nitrogen fixation

Nitrogen fixation is a process by which nitrogen in the air is converted into ammonia (NH_3) or related nitrogenous compounds. Atmospheric nitrogen is molecular dinitrogen, a relatively nonreactive molecule that is metabolically useless to all but a few microorganisms. Biological nitrogen fixation converts N_2 into ammonia, which is metabolized by most organisms.

Nitrogen fixation is essential to life because fixed inorganic nitrogen compounds are required for the biosynthesis of all nitrogen-containing organic compounds, such as amino acidsand proteins, nucleoside triphosphates and nucleic acids. As part of the nitrogen cycle, it is essential for agriculture and the manufacture of fertilizer.

Nitrogen fixation is carried out naturally in the soil by a wide range of microorganisms termed diazotrophs that include bacteria such as *Azotobacter*, and archaea.

Some nitrogen-fixing bacteria have symbiotic relationships with some plant groups, especially legumes Looser non-symbiotic relationships between diazotrophs and plants are often referred to as associative, as seen in nitrogen fixation on rice roots.

Nitrogen fixation also occurs between some termites and fungi

It also occurs naturally in the air by means of NOx production by lightning.

All biological nitrogen fixation is effected by enzymes called nitrogenases.

NON BOLOGICAL NITROGEN FIXATION

Lightning heats the air around it breaking the bonds of N_2 starting the formation of nitrous acid.

Nitrogen can be fixed by lightning converting nitrogen and oxygen into NO
x (nitrogen oxides). NO
x may react with water to make nitrous acidor nitric acid, which seeps into the soil, where it makes nitrate, which is of use to growing plants. Nitrogen in the atmosphere is highly stable and nonreactive due to there being a triple bond between atoms in the N_2 molecule.

Lightning produces enough energy and heat to break this bond allowing the nitrogen atoms to react with oxygen forming NO_x. This itself cannot be used by plants, but as this molecule cools it reacts with more oxygen to form NO_2. This molecule in turn reacts with water to produce HNO_3 (nitric acid), or its ion NO_3^- (nitrate), which is usable by plants.

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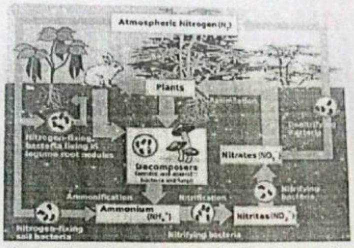
Biological nitrogen fixation



Schematic representation of the nitrogen cycle. Abiotic nitrogen fixation has been omitted.

Biological nitrogen fixation (BNF) occurs when atmospheric nitrogen is converted to ammonia by an enzyme called a nitrogenase.

Nitrogenases are rapidly degraded by oxygen. For this reason, many bacteria cease production of the enzyme in the presence of oxygen. Many nitrogen-fixing organisms exist only in anaerobic conditions, respiring to draw down oxygen levels, or binding the oxygen with a protein such as leghemoglobin

Microorganisms that fix nitrogen

Diazotrophs are widespread within domain Bacteria including cyanobacteria (e.g. the highly significant *Trichodesmium* and *Cyanothece*), as well as green sulfur bacteria, Azotobacteraceae, rhizobia and *Frankia*.

Several obligately anaerobic bacteria fix nitrogen including many (but not all) Clostridium spp. Some Archaea also fix nitrogen, including several methanogenic taxa, which are significant contributors to nitrogen fixation in oxygen-deficient soils

Cyanobacteria inhabit nearly all illuminated environments on Earth and play key roles in the carbon and nitrogen cycle of the biosphere.

In general, cyanobacteria can use various inorganic and organic sources of combined nitrogen, like nitrate, nitrite, ammonium, urea, or some amino acids.

Nitrogen fixation by cyanobacteria in coral reefs can fix twice as much nitrogen as on land—

Root nodule symbioses

The legume family

Plants that contribute to nitrogen fixation include those of the legume family – Fabaceae – with taxa such as kudzu, clovers, soybeans, alfalfa, lupines, peanuts, and rooibos. They contain symbiotic bacteria called rhizobia within nodules in their root systems, producing nitrogen compounds that help the plant to grow and compete with other plants

When the plant dies, the fixed nitrogen is released, making it available to other plants; this helps to fertilize the soil.

The efficiency of nitrogen fixation in soil is dependent on many factors, including the legume as well as air and soil conditions.

Respiratory System

Respiratory system of man includes

(1) External nostrils

A pair of external nostrils opens out above the upper lip. They lead into nasal chambers.

(2) Nasal chambers

They lie above the palate & are separated from each other by a nasal septum. Each nasal chamber can be differentiated into three parts namely:

(1) Vestibular part (which has hair & sebaceous glands to prevent the entry of dust particles.

(2) Respiratory Part (which is involved in the conditioning the temperature of inhaled air; it is supported by three thin twisted bony plates called turbinals / conchae) & -hind

(3) Olfactory Part (which is lined by an olfactory epithelium to detect sense of smell).

(3) Naso-Pharynx

Nasal chambers lead into nasophaynx through a pair of internal nostrils, located above the soft palate. Nasophaynx is the upper portion of the pharynx.

④ Larynx

Larynx is a cartilaginous box which helps in sound production, hence called the voice box. Wall of the larynx is supported by nine cartilages. Thyroid & Cricoid & epiglottis are unpaired cartilages, whereas corniculate cartilages, arytenoids & cuneiform cartilages are paired cartilages.

Epiglottis is a thin leaf like elastic cartilaginous flap attached to the thyroid cartilage to prevent the entry of food into the larynx through the glottis.

⑤ Trachae

Trachae, the wind pipe is a straight tube extending up to the ~~mid~~ mid-thoracic cavity. The wall of the trachae is supported by 'c' shaped rings of hyaline cartilage. These rings are

⑥ Bronchi & Bronchioles

On entering the mid thoracic cavity, trachae divides at the level of the fifth thoracic vertebra into right & left primary bronchi. Each primary bronchus enters the corresponding lung & divides into secondary bronchi that further divided into tertiary bronchi.

· Each respiratory bronchiole terminates in a cluster of alveolar ducts which ends into alveolar sacs. Bronchi & initial bronchioles are supported by incomplete cartilaginous rings. The branching network of trachea, bronchi & bronchioles constitute the pulmonary tree

(7) Lungs

Lungs occupy the greater part of thoracic cavity. Lungs are covered by a double layered pleura with pleural fluid between them. It reduces ~~frictions~~ friction on the lung surface. The outer pleural membrane is in close contact with the thoracic lining whereas the inner pleural membrane is in contact with lungs surface. The part starting with external nostrils up to the terminal bronchioles constitute the conducting part, whereas the alveoli & their ducts form the respiratory or exchange part of the respiratory system.

- The conducting part transports the atmospheric air to the alveoli, clear it from foreign particles, humidifies & also brings the inhaled air to the body temp.
- Exchange part is the site of actual diffusion of oxygen & CO_2 between blood & atmospheric air.

The lungs are situated in thoracic chamber which automatically an air-tight chamber.

The anatomical setup of lungs in the thorax is such that any change in the volume of thoracic cavity will be reflected in the lung cavity (Pulmonary volume). Such an arrangement is essential for breathing, as the pulmonary volume cannot be directly altered.

Respiration in humans involves the following steps:

1) Breathing or pulmonary ventilation by which atmospheric air with 21% of O_2 is drawn in & alveolar air rich in CO_2 is sent out.

2) Diffusion of gases across the alveolar membrane

3) Transport of gases by blood, between the lungs & tissues.

4) Diffusion of O_2 & CO_2 between the blood in the systemic capillaries & the tissues.

5) Utilization of O_2 by the cells for catabolic reactions & resultant production of CO_2, H_2O & ATP (cellular respiration)

...ectly altered.

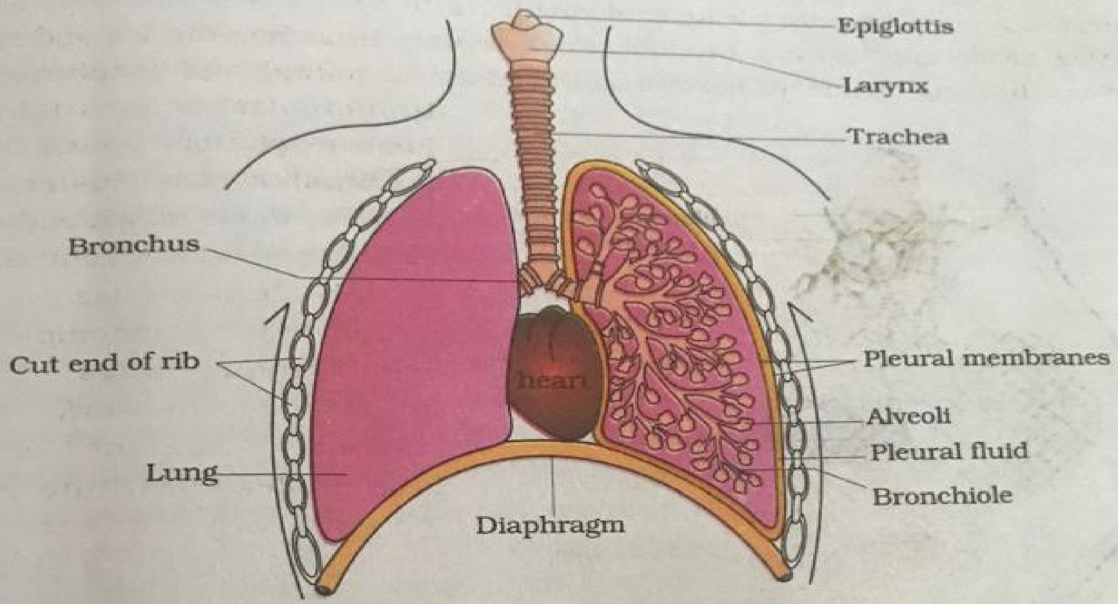


Figure 1.11 Diagrammatic view of human respiratory system (Sectional view of the left lung is also shown)

Mechanism of Breathing

Breathing is a means of maximising the process of gaseous exchange. The movement of air into & out of the lungs is carried out by creating a pressure gradient between the lungs & the atmosphere.

Breathing involves two stages such as inspiration & expiration.

Inspiration can occur if the pressure within the lungs is less than the atmospheric pressure.

Similarly expiration takes place when the intra-pulmonary pressure is higher than the atmospheric pressure.

The muscular ~~diagr~~ diaphragm helps in generating such gradients.

(1) Inspiration

Intake of atmospheric air into the lungs is called inspiration. It is an active process, as it takes place by the contraction of the muscles of the diaphragm & the external inter costal muscles, which extend in between the ribs. The contraction of the diaphragm increases the volume of the thoracic chamber. ~~in the~~

- An increase in the pulmonary volume decreases the intra pulmonary pressure to less than that of the atmosphere, which forces the air from the outside to move into the lungs i.e. inspiration.

(2) Expiration

Release of alveolar air to the exterior is called expiration. It is a passive process. Relaxation of the diaphragm & the external inter costal muscles returns the diaphragm to its normal position & reduces the thoracic volume & thereby the pulmonary volume. This leads to an increase in the intra pulmonary pressure to slightly above that of the atmospheric pressure, causing the expulsion of air from the lungs i.e. expiration.

Photosynthesis

Introduction

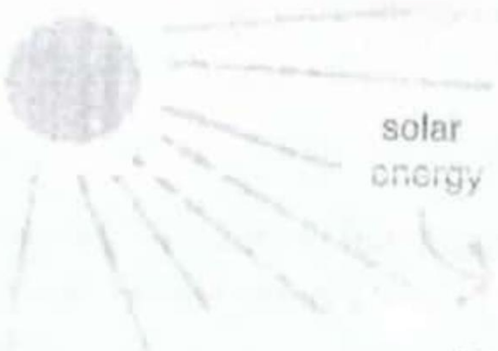
All organisms, including humans, need energy to fuel the metabolic reactions of growth, development, and reproduction. But organisms can't use light energy directly for their metabolic needs. Instead, it must first be converted into chemical energy through the process of photosynthesis.

What is photosynthesis?

Photosynthesis is the process in which light energy is converted to chemical energy in the form of sugars. In a process driven by light energy, glucose molecules (or other sugars) are constructed from water and carbon dioxide, and oxygen is released as a byproduct. The glucose molecules provide organisms with two crucial resources: energy and fixed—organic—carbon.

X
- **Energy.** The glucose molecules serve as fuel for cells: their chemical energy can be harvested through processes like cellular respiration and fermentation, which generate adenosine triphosphate—\text{ATP}ATPA, T, P, a small, energy-carrying molecule—for the cell's immediate energy needs.
- **Fixed carbon.** Carbon from carbon dioxide—inorganic carbon—can be incorporated into organic molecules; this process is called **carbon fixation**, and the carbon in organic molecules is also known as **fixed carbon**. The carbon that's fixed and incorporated into sugars during

photosynthesis can be used to build other types of organic molecules needed by cells.



$$6CO_2 + 6H_2O \xrightarrow{\text{Photosynthesis}} C_6H_{12}O_6 + 6O_2$$

carbon dioxide — water — glucose — oxygen

In photosynthesis, solar energy is harvested and converted to chemical energy in the form of glucose using water and carbon dioxide. Oxygen is released as a byproduct.

The ecological importance of photosynthesis

Photosynthetic organisms, including plants, algae, and some bacteria, play a key ecological role. They introduce chemical energy and fixed carbon into ecosystems by using light to synthesize sugars. Since these organisms produce their own food—that is, fix their own carbon—using light energy, they are called **photoautotrophs** (literally, self-feeders that use light).

Humans, and other organisms that can't convert carbon dioxide to organic compounds themselves, are called **heterotrophs**, meaning different-feeders. Heterotrophs must get fixed carbon by eating other organisms or their by-products. Animals, fungi, and many prokaryotes and protists are heterotrophs.

-
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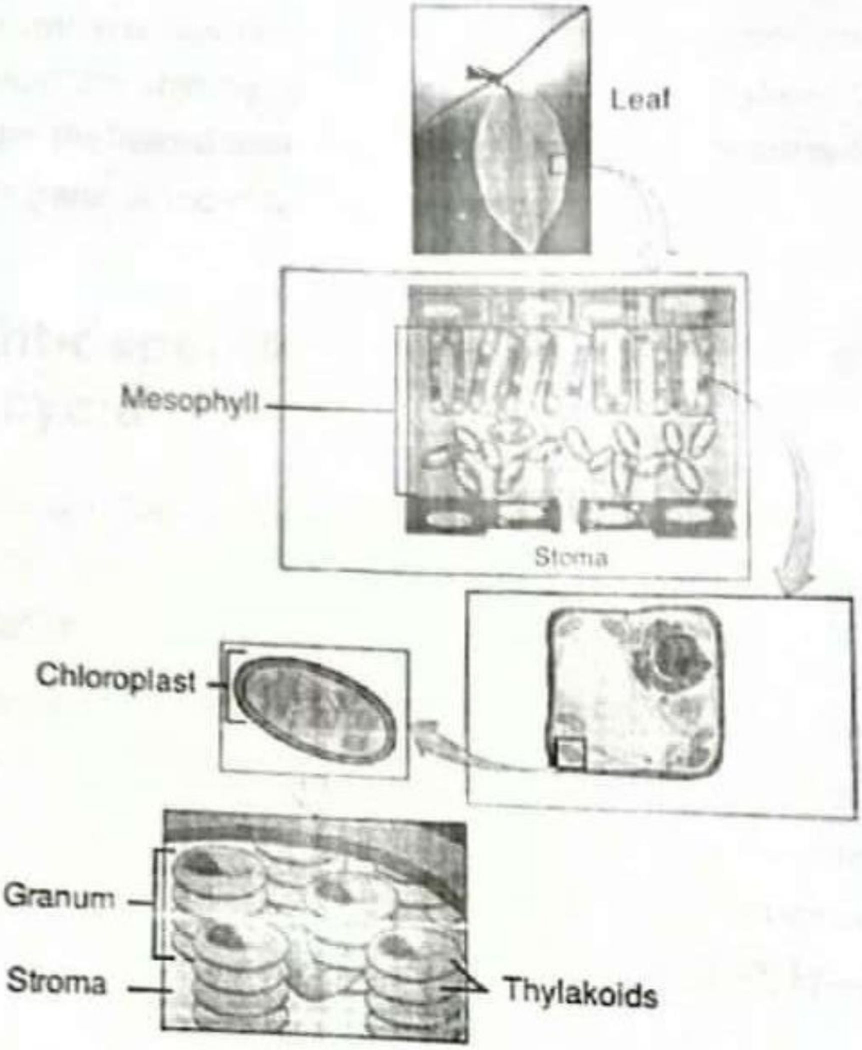
Besides introducing fixed carbon and energy into ecosystems, photosynthesis also affects the makeup of Earth's atmosphere. Most photosynthetic organisms generate oxygen gas as a byproduct, and the advent of photosynthesis—over 333 billion years ago, in bacteria resembling modern cyanobacteria—forever changed life on Earth^11start superscript, 1, end superscript. These bacteria gradually released oxygen into Earth's oxygen-poor atmosphere, and the increase in oxygen concentration is thought to have influenced the evolution of aerobic life forms—organisms that use oxygen for cellular respiration. If it hadn't been for those ancient photosynthesizers, we, like many other species, wouldn't be here today!

Photosynthetic organisms also remove large quantities of carbon dioxide from the atmosphere and use the carbon atoms to build organic molecules. Without Earth's abundance of plants and algae to continually suck up carbon dioxide, the gas would build up in the atmosphere. Although photosynthetic organisms remove some of the carbon dioxide produced by human activities, rising atmospheric levels are trapping heat and causing the climate to change. Many scientists believe that preserving forests and other expanses of vegetation is increasingly important to combat this rise in carbon dioxide levels.

Leaves are sites of photosynthesis

Plants are the most common autotrophs in terrestrial—land—ecosystems. All green plant tissues can photosynthesize, but in most plants, but the majority of photosynthesis usually takes place in the leaves. The cells in a middle layer of leaf tissue called the **mesophyll** are the primary site of photosynthesis.

Small pores called **stomata**—singular, stoma—are found on the surface of leaves in most plants, and they let carbon dioxide diffuse into the mesophyll layer and oxygen diffuse out.



A diagram showing a leaf at increasing magnifications. Magnification 1: The entire leaf Magnification 2: Mesophyll tissue within the leaf Magnification 3: A single mesophyll cell Magnification 4: A chloroplast within the mesophyll cell Magnification 5: Stacks of thylakoids—grana—and the stroma within a chloroplast

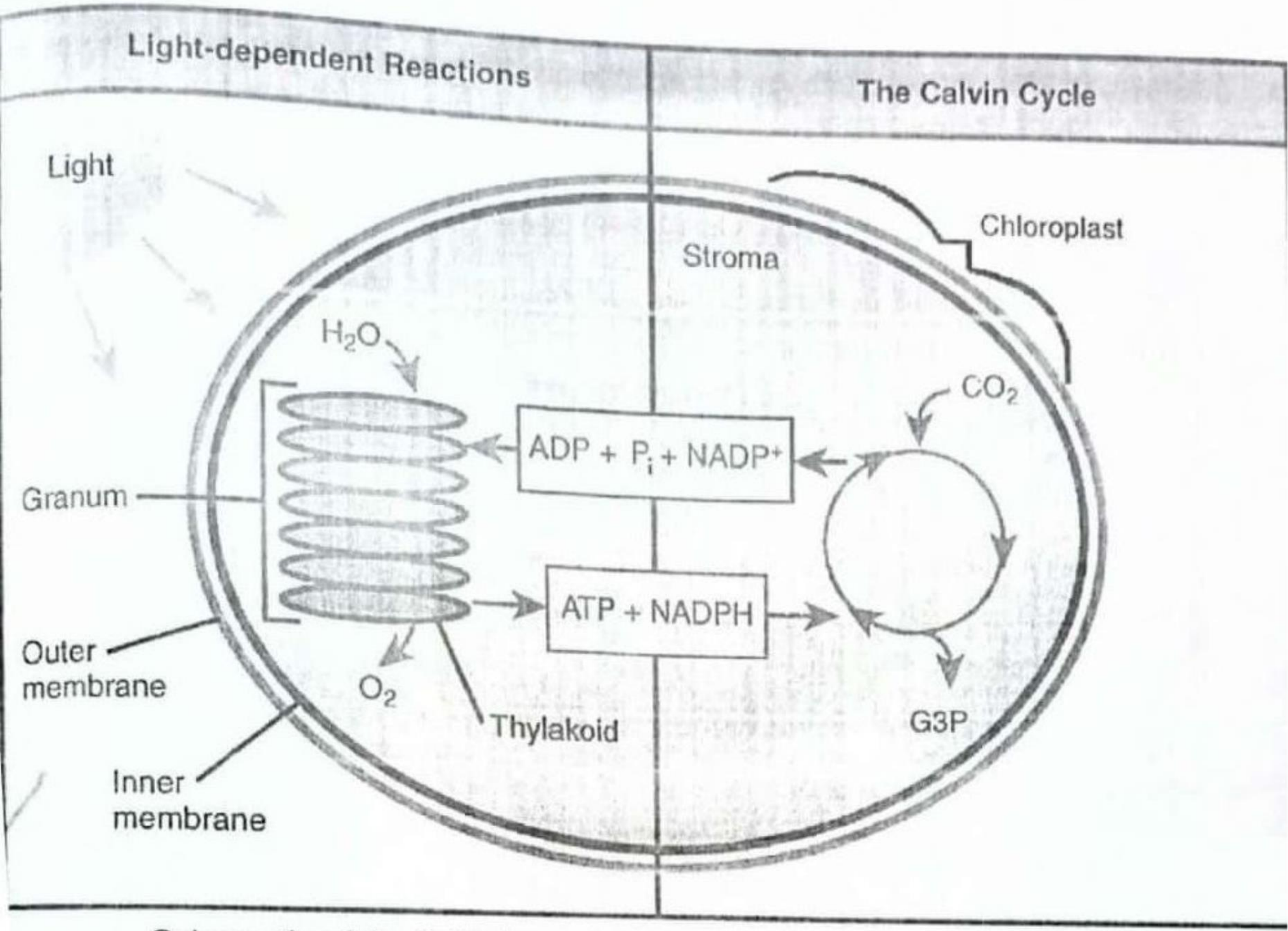
Each mesophyll cell contains organelles called chloroplasts, which are specialized to carry out the reactions of photosynthesis. Within each chloroplast, disc-like structures called **thylakoids** are arranged in piles like stacks of pancakes that are known as **grana**—singular, granum.

The membrane of each thylakoid contains green-colored pigments called **chlorophylls** that absorb light. The fluid-filled space around the grana is called the **stroma**, and the space inside the thylakoid discs is known as the **thylakoid space**. Different chemical reactions occur in the different parts of the chloroplast.

The light-dependent reactions and the Calvin cycle

Photosynthesis in the leaves of plants involves many steps, but it can be divided into two stages: the light-dependent reactions and the Calvin cycle.

- The **light-dependent reactions** take place in the thylakoid membrane and require a continuous supply of light energy. Chlorophylls absorb this light energy, which is converted into chemical energy through the formation of two compounds, \text{ATP}ATPA, T, P—an energy storage molecule—and \text{NADPH}NADPHN, A, D, P, H—a reduced (electron-bearing) electron carrier. In this process, water molecules are also converted to oxygen gas—the oxygen we breathe!
- The **Calvin cycle**, also called the **light-independent reactions**, takes place in the stroma and does not directly require light. Instead, the Calvin cycle uses \text{ATP}ATPA, T, P and \text{NADPH}NADPHN, A, D, P, H from the light-dependent reactions to fix carbon dioxide and produce three-carbon sugars—glyceraldehyde-3-phosphate, or G3P, molecules—which join up to form glucose.



Schematic of the light-dependent reactions and Calvin cycle and how they're connected.

The light-dependent reactions take place in the thylakoid membrane. They require light, and their net effect is to convert water molecules into oxygen, while producing ATP molecules—from ADP and Pi—and NADPH molecules—via reduction of NADP+.

ATP and NADPH are produced on the stroma side of the thylakoid membrane, where they can be used by the Calvin cycle.

The Calvin cycle takes place in the stroma and uses the ATP and NADPH from the light-dependent reactions to fix carbon dioxide, producing three-carbon sugars—glyceraldehyde-3-phosphate, or G3P, molecules.

The Calvin cycle converts ATP to ADP and Pi, and it converts NADPH to NADP+. The ADP, Pi, and NADP+ can be reused as substrates in the light reactions.

Overall, the light-dependent reactions capture light energy and store it temporarily in the chemical forms of \text{ATP}ATPA, T, P and \text{NADPH}NADPHN, A, D, P, H. There, \text{ATP}ATPA, T, P is broken down to release energy, and \text{NADPH}NADPHN, A, D, P, H donates its electrons to convert carbon dioxide molecules into sugars. In the end, the energy that started out as light winds up trapped in the bonds of the sugars.

Photosynthesis vs. cellular respiration

At the level of the overall reactions, photosynthesis and cellular respiration are near-opposite processes. They differ only in the form of energy absorbed or released, as shown in the diagram below.

solar energy

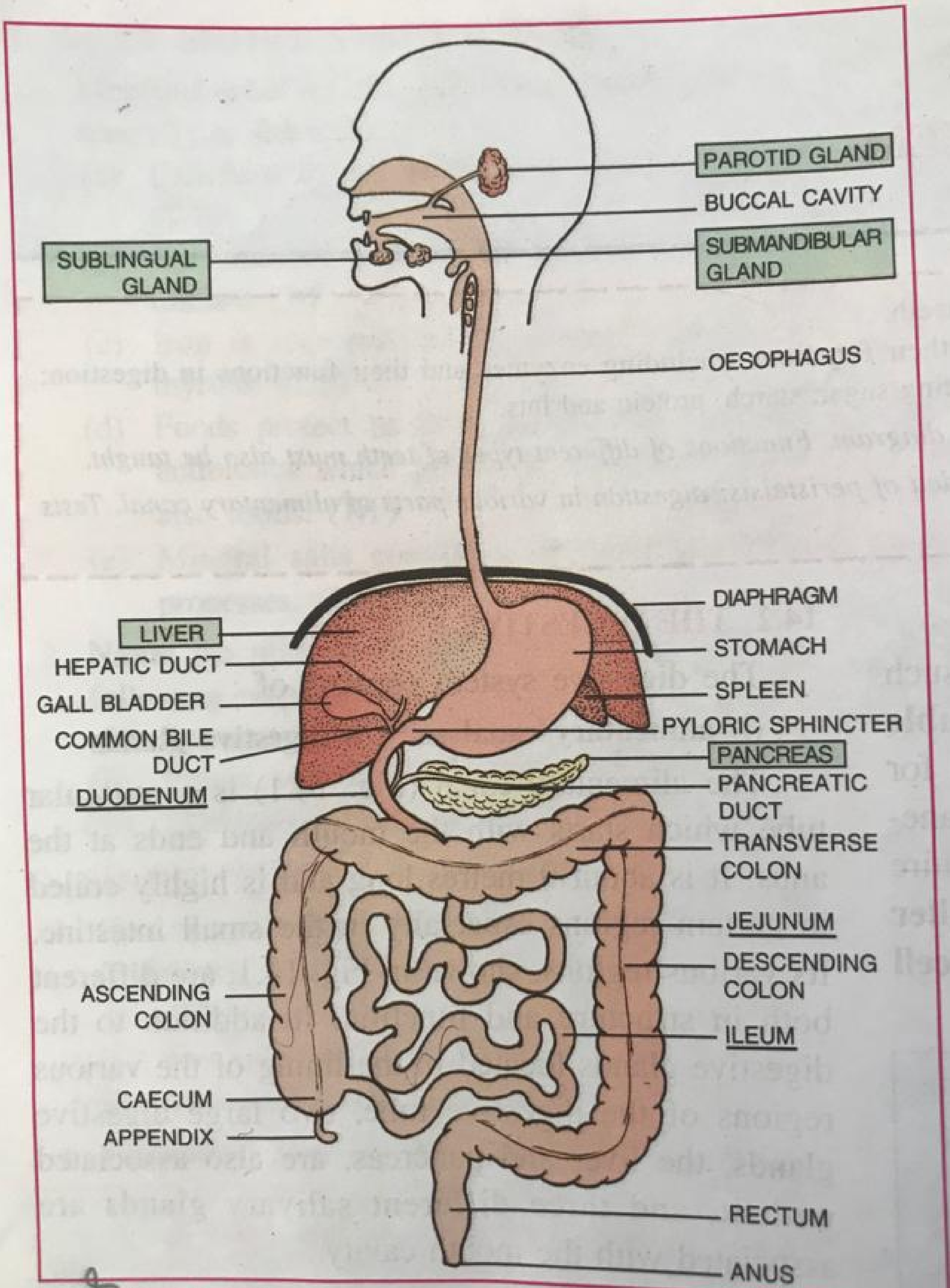
$$\underset{\text{carbon dioxide}}{6CO_2} + \underset{\text{water}}{6H_2O} \xrightleftharpoons[\text{Cellular respiration}]{\text{Photosynthesis}} \underset{\text{glucose}}{C_6H_{12}O_6} + \underset{\text{oxygen}}{6O_2}$$

chemical energy
(ATP) + heat

On a simplified level, photosynthesis and cellular respiration are opposite reactions of each other. In photosynthesis, solar energy is harvested as chemical energy in a process that converts water and carbon dioxide to glucose. Oxygen is released as a byproduct. In cellular respiration, oxygen is used to break down glucose, releasing chemical energy and heat in the process. Carbon dioxide and water are products of this reaction.

At the level of individual steps, photosynthesis isn't just cellular respiration run in reverse. Instead, as we'll see the rest of this section, photosynthesis takes place in its own unique series of steps. However, there are some notable similarities between photosynthesis and cellular respiration.

For instance, photosynthesis and cellular respiration both involve a series of **redox** reactions (reactions involving electron transfers). In cellular respiration, electrons flow from glucose to oxygen, forming water and releasing energy. In photosynthesis, they go in the opposite direction, starting in water and winding up in glucose—an energy-requiring process powered by light. Like cellular respiration, photosynthesis also uses an electron transport chain to make a \text{H}^+H+H, start superscript, plus, end superscript concentration gradient, which drives \text{ATP}ATPA, T, P synthesis by chemiosmosis.



4Ans3

Fig. 14.1 The alimentary canal and its associated glands

The Excretory system

Life of every organism depends on certain basic processes. Excretion is one among them. Different organisms follow different modes of excretion. In complex organisms including humans, there is a specialized system for excretion called human excretory system.

We all obtain our nutrients from different sources which are later digested and metabolized in our body. After metabolic reactions, the body starts to sort out useful and toxic substances in an individual. As we all know, the accumulation of the toxins may be harmful, the body removes all the metabolic wastes by the process called excretion.

Different organisms follow different modes of excretion such as kidney, lungs, skin, eyes, etc., depending on their habitat and food habit. For example, aquatic animals excrete waste in the form of ammonia while birds and insects excrete mainly uric acid. Humans produce urea as the major excretory product.

Let us have a detailed look at the excretory system in human beings, different organs of excretory system and the mechanism of excretion in humans.

Excretory System Organs

The human excretory system organs include:

- A pair of kidneys
- A pair of ureters
- A urinary bladder
- A urethra

Kidneys

Kidneys are bean-shaped structures located on either side of the backbone and protected by the last two ribs. Each human adult kidney has a length of 10-12 cm, a width of 5-7 cm and weighs around 120-170g.

Structure of Kidney

The structure of the kidney is explained below:

Capsule

The outer layer is called the capsule. Inside the kidney, there are two zones- the outer zone is cortex and the inner zone is medulla. The cortex extends in between the medullary pyramids as renal columns called columns of Bertin.

Nephrons

Nephrons are the functional units of the kidney. Each nephron has two parts- glomerulus and renal tubule.

Glomerulus consists of a bunch of capillaries formed by afferent arterioles. Blood from glomerulus is carried away by efferent arterioles.

The renal tubule starts with a cup-like structure called Bowman's capsule and this encloses the glomerulus. Malpighian body consists of glomerulus and Bowman's capsule. The highly coiled structure in the tubule next to the Bowman's capsule is the proximal convoluted tubule.

Henle's loop

The next part of the tubule is Henle's loop which has an ascending and a descending limb. The ascending loop continues as a distal convoluted tubule. The distal convoluted tubules of many nephrons open into the collecting duct.

The cortical region of the kidney comprises of malpighian corpuscle, proximal convoluted tubule and distal convoluted tubule whereas the medullary region contains a loop of Henle.

There are two types of nephrons – cortical and juxtamedullary. In case of cortical, the loop of Henle is very short and extends only a little into the medulla. In juxtamedullary, the loop of Henle is very long and runs deep into the medulla.

Ureter

A thin muscular tube called the ureter comes out of each kidney extending from the renal pelvis. It carries urine from the kidney to the urinary bladder.

Urinary Bladder

It is a sac-like structure that stores urine until micturition. Micturition is the expulsion of urine from the body. The urine is carried to the bladder through the ureters.

Urethra

This tube arises from the urinary bladder and helps to expel urine out of the body. In males, it acts as the common route for sperms and urine. Its opening is guarded by a sphincter.

Human Excretory System Diagram

The diagram below represents the different parts of the human excretory system.

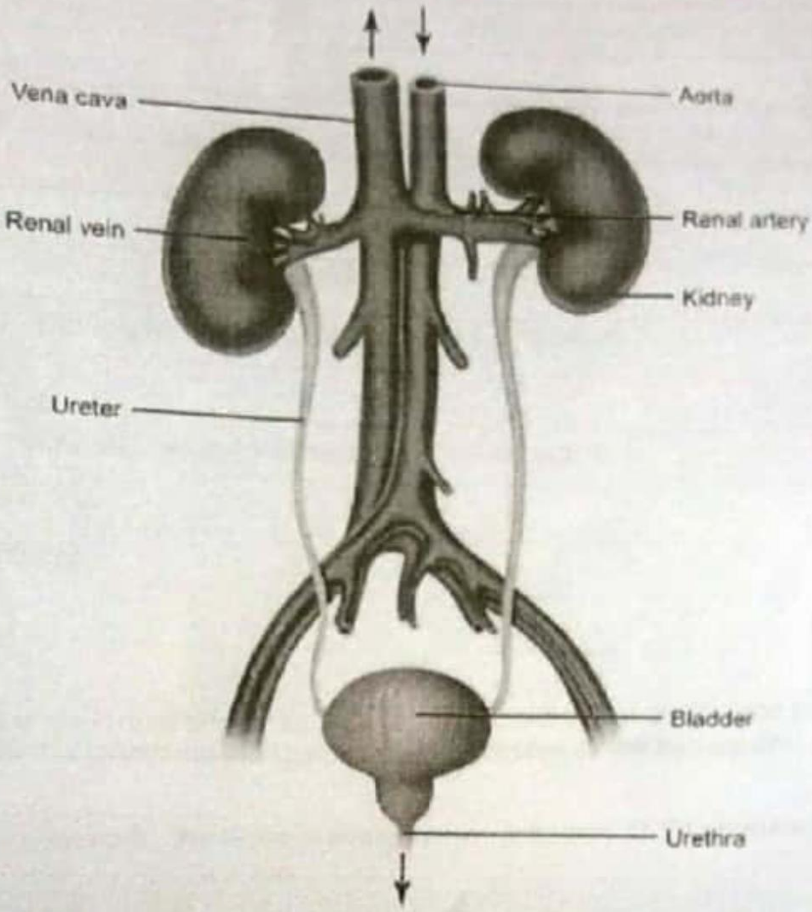


Figure 8.2 Human excretory system

Human Excretory System Diagram

Excretion in Humans

Excretion is the process where all the metabolic wastes are removed from the body. Excretion in humans is carried through different parts in a series of processes.

Most of the unicellular organisms eliminate waste from their body through diffusion. A human body is an exceptional machine where a lot of processes (respiration, circulation, digestion, etc.) take place simultaneously. As a result, a lot of waste products produced in our body are in different forms that include carbon dioxide, water, and nitrogenous products like urea, ammonia, and uric acid.

In addition to these, the chemicals and other toxic compounds from medications and hormonal products are also produced. A simple diffusion or evaporation will not be sufficient to eliminate the waste from our body. Therefore it is eliminated through different parts in a series of processes.

Blood contains both useful and harmful substances. Hence, we have kidneys which separate useful substances by reabsorption and toxic substances by producing urine.

Kidney has a structural filtration unit called nephron where the blood is filtered. Each kidney contains a million nephrons.

Capillaries of kidneys filter the blood and the essential substances like glucose, amino acids, salts, and the required amount of water are reabsorbed. Meanwhile, the pure blood circulates back to other parts.

Excess water and nitrogenous waste in humans are converted to urine. Urine thus produced is passed to the urinary bladder via the ureters. The urinary bladder is under the control of the Central Nervous System. The brain signals the urinary bladder to contract and through the urinary opening called urethra, we excrete the urine.

Mechanism of Excretion in Humans

The process of excretion in humans takes place in the following steps:

Urine Formation

The urine is formed in the nephrons and involves the following steps:

- Glomerular Filtration
- Tubular Reabsorption
- Secretion

Glomerular Filtration

It is the primary step in urine formation. In this process, the excess fluid and waste products from the kidney are filtered out of the blood into the urine collection tubules of the kidney and eliminated out of the body.

The amount of filtrate produced by the kidneys every minute is known as Glomerular Filtration Rate.

Tubular Reabsorption

It is the absorption of ions and molecules such as sodium ions, glucose, amino acids, water etc. Water involves passive absorption, while glucose and sodium ions are absorbed by an active process.

Secretion

Potassium ions, hydrogen ions, and ammonia are secreted out to maintain the equilibrium between the body fluids.

The functions of the various tubules involved in the process are:

- **Glomerulus** filters the blood
- **Proximal Convoluted Tubules** reabsorb ions, water, and nutrients, removes toxins, and maintains the pH of the filtrate.
- **Descending Loop of Henle** allows water to pass from the filtrate into the interstitial fluid through aquaporins.
- **Ascending Loop of Henle** reabsorbs sodium and chloride ions from the filtrate into the interstitial fluid.
- **Distal Tubule** reabsorbs and secretes selective ions and maintains the pH of the blood.
- **Collecting Duct**, solutes, and water is reabsorbed from the filtrate by the collecting duct.

Micturition

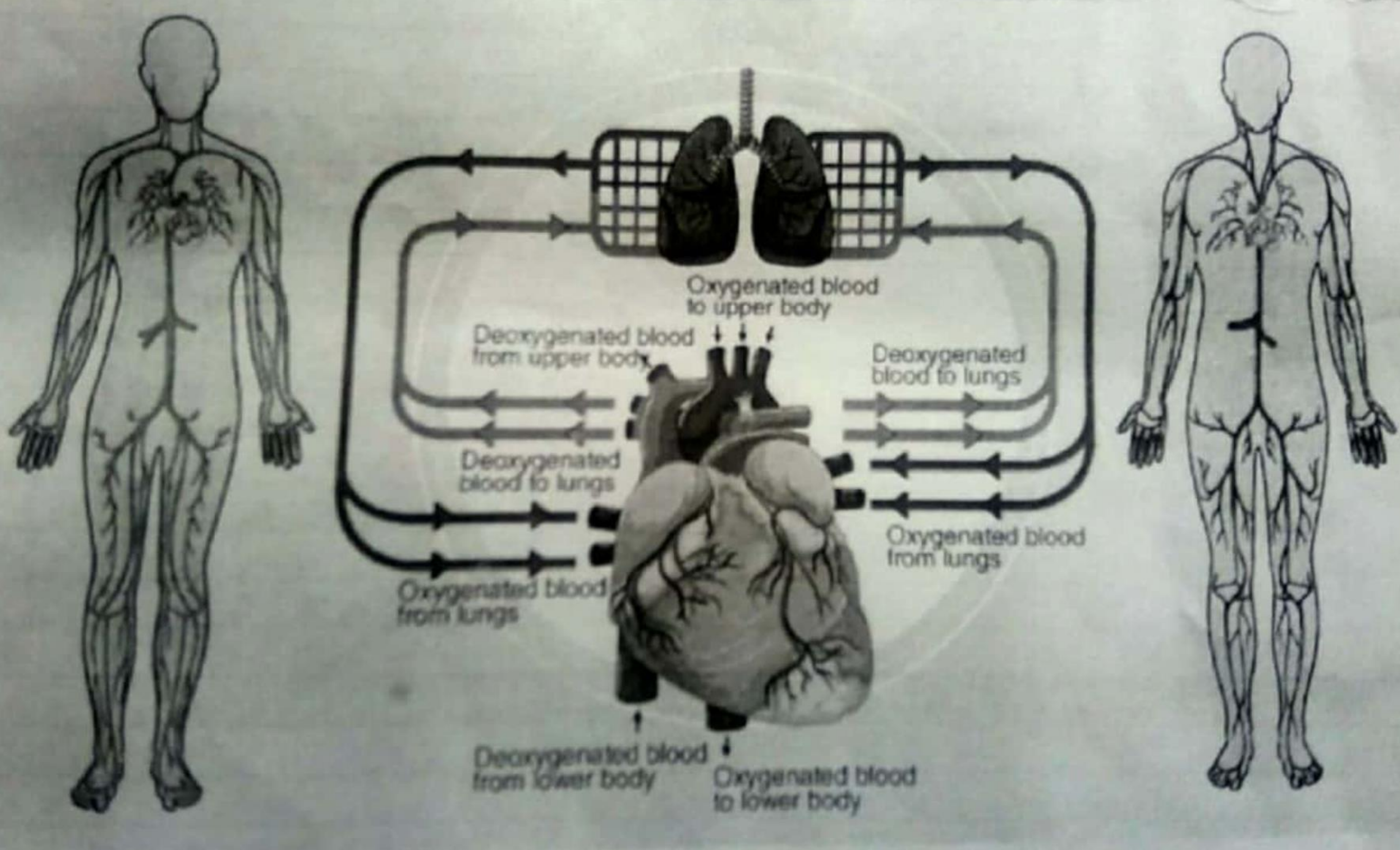
The urinary bladder is stretched and gets filled with urine formed in the nephrons. The receptors present on the walls of the urinary bladder send signals to the Central Nervous System, thereby, allowing the relaxation of sphincter muscles to release urine. This is known as micturition

Human Circulatory System - Transportation

Our body is a complex machine, requiring many processes to function efficiently. To keep these important processes running without any hitches, we need vital elements and components which are to be delivered to the various parts of our body.

This role of transportation is undertaken by the human circulatory system, moving essential nutrients and minerals throughout the body and metabolic waste products away from the body. Let us explore about the human circulatory system and its components in greater detail.

HUMAN CIRCULATORY SYSTEM - TRANSPORTATION



Circulatory system diagram highlighting the various pathways of blood (Blue=Dexoygenated blood & Red=Oxygented blood)

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Human Circulatory System

The human circulatory system is a complex network consisting of arteries, veins, capillaries and the heart. Its primary role is to provide essential nutrients, minerals and other important components such as hormones to various parts of the body. Alternatively, the circulatory system is also responsible for collecting metabolic waste and toxins from the cells and tissues to be purified or expelled from the body.

Features of the Human Circulatory System

The important features of human circulatory are as follows:

- Human Circulatory System consists of blood that transports, nutrients, gases, wastes and hormones.
- The heart consists of two pumps-
    - one to pump deoxygenated blood to the lungs
    - the other to pump oxygenated blood to different organs and tissues.

Human Circulatory System consists of a system of blood vessels to circulate blood throughout the body.

It consists of organs like lungs and intestines that add materials to the blood and lungs and kidneys that remove wastes from the blood.

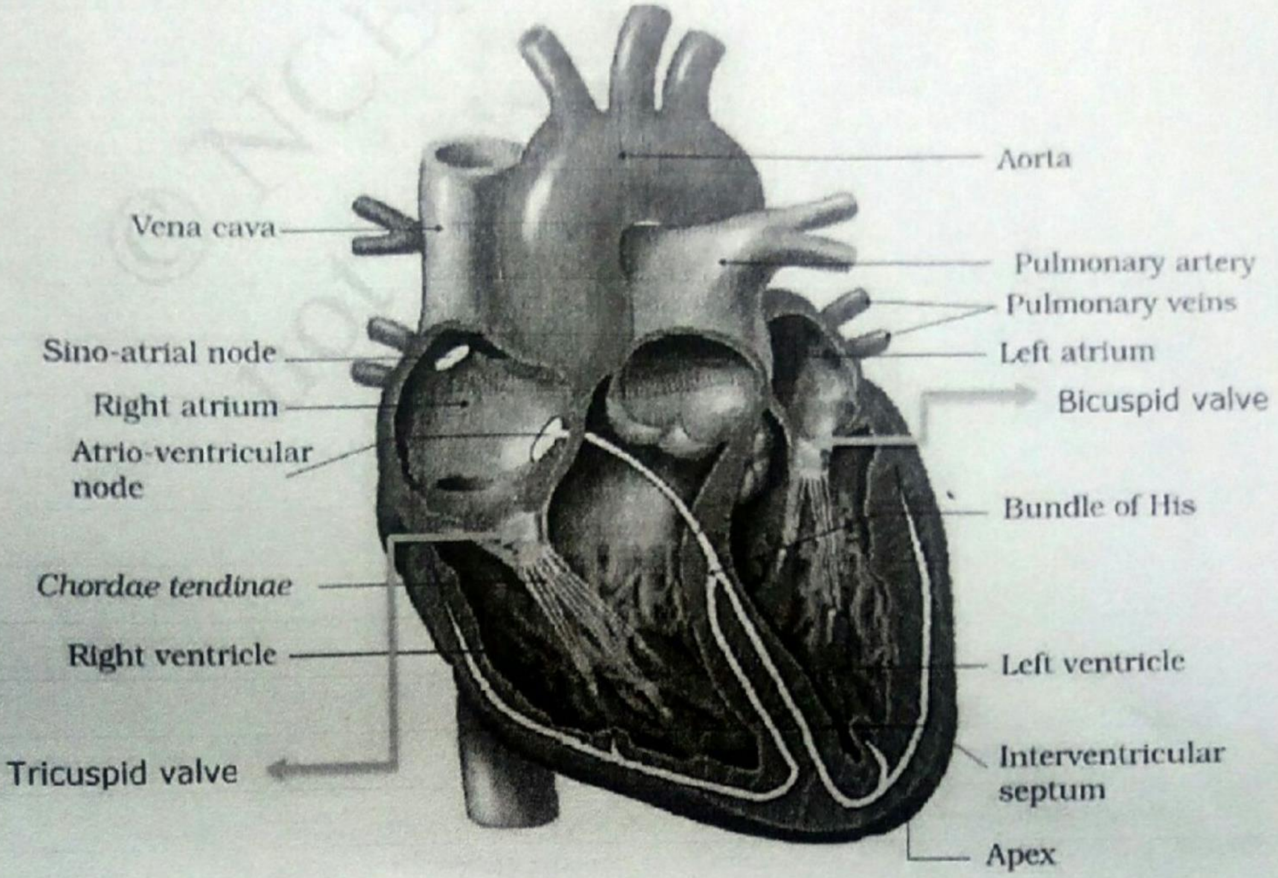
Circulatory System Organs

The human circulatory system comprises of 4 main organs that have specific roles and functions. The important circulatory system organs include:

- Heart
- Blood
- Blood Vessels
- Lymph

Heart

The heart is a muscular organ located in the chest cavity, between the lungs, It is positioned slightly towards the left in the thoracic region and is enveloped by the pericardium. The human heart is divided into four chambers – two upper chambers called atria (*singular: atrium*) and two lower chambers called ventricles.



Section of a human heart

Heart, a major part of the human circulatory system

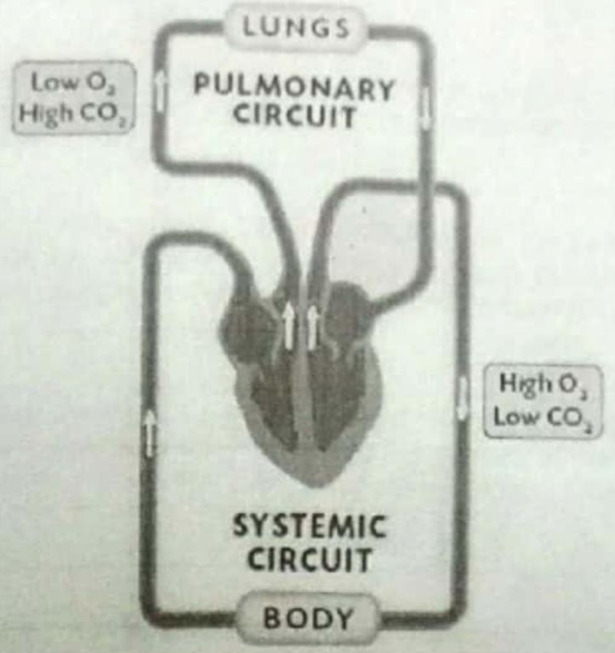
Though there are other animals that possess a heart, however, the way their circulatory system functions are quite different from humans. And in some cases, the human circulatory system is more advanced than that of other animals like insects or molluscs, where the open circulatory system is observed.

Double Circulation

The way blood flows in the human body is unique, and it is quite efficient too. The blood circulates through the heart twice, hence, it is called double circulation. Other animals like fish have single circulation, where blood completes a circuit through the entire animal only once.

The main advantage of double circulation is that every tissue in the body has a steady supply of oxygenated blood and it does not get mixed with the deoxygenated blood.

Dr. Nazneen Begu



Circulation of blood in humans – Double circulation

Blood

Blood is the body's fluid connective tissue and it plays an important role in circulating nutrients, hormones, minerals and other necessary products to different parts of the body. Blood flows through a specified set of pathways called blood vessels. The organ which is involved in pumping blood to different body parts is the heart. Blood cells, blood plasma, proteins, and other mineral components (such as sodium, potassium, calcium etc) together constitute human blood. The composition of blood are:

- Plasma is the fluid part of the blood and is composed of 90% of water.
- Red blood cells, white blood cells and platelets constitute the solid part of blood.

Types of Blood Cells

The human body consists of three types of blood cells, they are as follows:

Red blood cells (RBC) / Erythrocytes

Red blood cells are mainly involved in transporting oxygen, nutrients, and other substances to various parts of the body. These blood cells also remove waste from the body.

White blood cells (WBC) / Leukocytes

White blood cells are cells that specialize in defence. They provide immunity by fending off pathogens and harmful microorganisms.

Platelets / Thrombocytes

Platelets are cells that help to form clots and stop bleeding. They act on the site of an injury or a wound.

Blood Vessels

Blood vessels are a network of pathways through which blood travels throughout the body. Arteries and veins are the two primary types of blood vessels in the circulatory system of the body.

Arteries

Arteries are blood vessels that transport oxygenated blood from the heart to various parts of the body. They are thick, elastic and are divided into a small network of blood vessels called capillaries. The only exception to this is the pulmonary arteries, which carries deoxygenated blood to the lungs.

Veins

Veins are blood vessels that carry de-oxygenated blood towards the heart from various parts of the body. They are thin, elastic and are present closer to the surface of the skin. However, pulmonary and umbilical veins are the only veins that carry oxygenated blood in the entire body.

Lymph

The human circulatory system consists of another body fluid called lymph. It is also known as tissue fluid. It is a colourless fluid consisting of salts, proteins, water, etc. which transport and circulates digested food and absorbed fat to intercellular spaces in the tissues. Unlike the circulatory system, lymph is not pumped, instead, it passively flows through a network of vessels.

Circulatory System Function

The most important function of circulatory system is transporting oxygen throughout the body. The other important functions of the human circulatory system include:

1. It helps in sustaining all the organ systems.
2. It protects every cell from pathogens.
3. It transports blood, nutrients, oxygen, carbon dioxide and hormones throughout the body.
4. It helps in the cell to cell interaction.
5. The substances present in the blood repair the damaged tissue.

1. How does the human circulatory system work?

The human circulatory system is a network of arteries, veins, capillaries designed to provide essential minerals, nutrients, and other important components to various parts of the body. It also collects metabolic waste to be filtered or expelled from the body.

2. What are the 3 types of circulation?

- Pulmonary Circulation
- Systemic Circulation
- Coronary Circulation

3. Is the human circulatory system open or closed?

The human circulatory system is a closed system that pumps blood through a network of arteries and veins. This type of circulation is seen in all vertebrates and some invertebrates.

4. What is the advantage of a closed circulatory system?

In a closed circulatory system, more pressure is available in the system and the blood can reach body extremities much quicker. This translates to a much faster metabolism rate and quicker movements in organisms with closed circulatory systems.

5. What is double circulation?

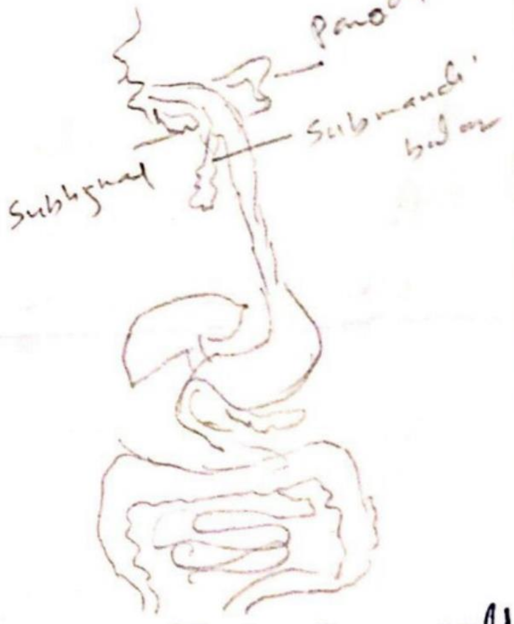
Double circulation is a system of circulation where the blood flows through the heart twice. This type of circulation is very effective as the body has a constant supply of oxygenated blood.

Digestive System

Human digestive system consists of the alimentary canal & associated glands.

- Alimentary canal begins with mouth & ends to anus.

1. Parts of alimentary canal between the mouth to anus are
   a) Buccal cavity (Mouth)
   b) Pharynx
   c) Oesophagus
   d) Stomach
   e) Small intestine
   f) Large intestine



2. Digestive Glands

The digestive glands ~~are~~ present in the wall of the alimentary canal are gastric glands, ~~Bunners~~ Brunner's glands. The salivary glands, liver & pancreas are the digestive glands associated with gut.

- Human digestive system is very complex in nature.
- Different parts are involved & perform different functions by using various digestive juices & enzymes.
- The alimentary canal is basically starts from mouth to the anus.
- We eat various types of food which has to pass through the same digestive tract. It also has to be converted to substances small enough to be utilised by our body.

Processes

(i) Food is cut & crush by our teeth in the mouth & mixed with saliva to make it wet & slippery lump called bolus (This process is called as mastication).
Now this bolus is suitable to pass through Oesophagus.
Saliva is secreted by three pairs of salivary glands.
a) first pair is located at the side of the jaw called submandibular.
b) Second pair is located below the tongue called as sublingual & the third pair is at the side
c) The third pair is at the side of the ear called parodit glands.

. Saliva mainly contains an enzyme amylase which helps in breakdown of complex carbohydrates to simple one.

→

- This process of breaksdowning down of complex sub. into simple one with the help of enzyme is called as digestion.

The tongue helps in mixing & pushing of food into next part. The lower jaw also helps in the whole process.

- The soft food mixed with saliva passes through Oesophagus by wave like movements called peristaltic movement to stomach.

- At the stomach food gets ~~crush~~ cruned with gastric juice & HCl. Now the food is semisolid condition.

- The digestion of food goes on as most proteins are break down into smaller molecules with the help of enzyme pepsin acting on them.

- Food in the form of a soft slimy substances where some proteins & carbohydrates have already been broken down is called chyme

- Now food material passes from the stomach to the small intestine.

- The small intestine is the longest part of the alimentary canal. Its proximal part is called as duodenum. It is the site of further digestion of carbohydrates, proteins & fats.

It recieve the secretion of liver & pancreas for this purpose.

- These juices render the internal condition of the intestine gradually to a basic or alkaline one.
- Fat is digested by converting them into small globule like forms by the help of the bile juice secreted from liver. This process is called as emulsification.
- Pancreatic juice secreted from pancreas contains enzymes like trypsin for carrying on the process of digestion of proteins & lipase for the process of digestion of fats.

Food → Mouth → Buccal cavity → Pharynx → oesophagus → Stomach → Duodenum (Liver, pancreas) → Small Intestine → Large Intestine → Rectum → Anus

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Microbial System

History of Micrology:

Scientific development of microbiology was ushered by Louis Pasteur, perfection on microbiological studies by Robert Koch, the introduction of antiseptic surgery by Lord Lister and the contributions of Paul Ehlirch in chemotherapy.

1. **Loius Pasteur(1822-1895):**

   He was a trained chemist of France His studies on fermentation led him to take interest in microbiology. He established that fermentation was caused by microbiological agents. He further noted that different types of fermentations were associated with different kinds of microorganisms. He is also known as father of micrology.

Important Contributions of Louis Pasteur in Microbiology

1. Development of methods and techniques of bacteriology.
2. proved conclusively that all forms of life even microbes arose only from their like not *de novo*.
3. Pasteur also had to face challenge from Pouchet who was a proponent of the spontaneous microbe. Pasteur disappear of the view by demonstrating the ubiquity of microorganisms in the air by his experiments performed in the Swan-necked flasks.
4. Introduction of sterilization techniques and development of steam sterilizer ,autoclave and hot air oven
5. Studies on Anthrax children Cholera and hydrophobia during studies on Rabies ,though Pasteur could not isolate any microorganism from man and dog but suggested that the causative agent of rabies was too small to be seen by microscope.

2.**Joseph Lister (1827-1912)**

He was a professor of surgery in Glasgow Royal infirmary. he applied precious work and introduce antiseptic techniques in surgery (1867) effecting a pronounced drop in mortality and morbidity due to surgical sepsis. It was a milestone in the evolution of surgical practice from the era of 'laudable pus' to modern aseptic technique is antiseptic surgery involve the use of carbolic acid .He is known as the father of antiseptic surgery.

3.**Robert Koch(1843-1910):**Robert Koch was a German general practitioner.He is also known as the father of bacteriology his contribution are as follows:

1)Perfected bacteriological techniques and introduced method for isolation of pure strains of bacteria

2)Produced methods of obtaining bacteria in pure cultures using solid media

3)Introduced staining techniques

4)Discovered the antrax bacillus (1876)tubercle bacillus (1882) and colour of vibrio (1883).

5) Robert Bosch postulates

According to Koch's postulate a microorganism can be accepted as a positive agent of an infectious disease only if the following conditions are fulfilled

i)The organism should be consistently associated with the lesions of the disease.

ii) It should be possible to isolate the organism in pure culture from the lesions of the disease.

iii) The isolated organism (in pure culture) when inoculated in suitable laboratory animals should produce a similar disease.

iv) It should be possible to isolate the organism in pure culture from the lesions produced in the experimental animals.

Important Discoveries by other Scientists

Lepra Bacillus : *Hansen(1874)*

Gonococcus : *Neisser(1881)*

Diphtheria Bacillus :*Klebs(1883),Loeffer(1884)*

Pneumococcus :*Frankel(1886)*

Meningococcus :*Weichselbum(1887)*
Diphtheria Toxin :*Roux and Yersin (1888)*
Tetanus Bacillus :*Kitasato(1889)*
Plague Bacillus :*Yersin (1890)*

Type of microbes:

There are different types of microbes:

- bacteria.
- fungi.
- algae.
- protozoa.
- viruses.

Bacteria: Bacteria are microscopic living organisms, usually one-celled, that can be found everywhere. They can be dangerous, such as when they cause infection, or beneficial, as in the process of fermentation (such as in wine) and that of decomposition.
Bacteria cells have four basic shapes:

- spheres
- rods
- spirals
- commas.

Fungi: A fungus (plural: fungi) is a kind of living organism: yeasts, moulds and mushrooms are types of fungi. The fungi are a separate kingdom of living things, different from animals and plants.

Fungi have cells with nuclei. Their cell walls contain chitin, unlike the cell walls of plants, which contain cellulose. These and other differences show that the fungi form a single group of related organisms, called the Eumycota or Eumycetes. They share a common ancestor and are monophyletic group.
Their basic mode of life is *saprophytic*: a fungus breaks down dead organic matter around it, and uses it as food.

Algae:

Algae are plants or plantlike organisms that contain chlorophyll and other pigments (coloring matter) that trap light from the Sun. This light energy is then converted into food molecules in a process called photosynthesis. Most algae store energy as some form of carbohydrate (complex sugars).

Algae can be either single-celled or large, multicellular organisms. They can occur in freshwater or salt water (most seaweeds are algae) or on the surfaces of moist soil or rocks. The multicellular algae lack the true stems, leaves, or roots of the more complex, higher plants, although some—like the giant kelp—have tissues that may be organized into structures that serve particular functions. The cell walls of algae are generally made of cellulose and can also contain pectin, which gives algae its slimy feel.

Algae may be unicellular, colonial, or multicellular. Some algae, like the diatoms, are microscopically small. Other algae, like kelp, are as big as trees. Some algae, the **phytoplankton** , drift in the water. Other algae, the epiphitic or benthic algae, grow attached to rocks, docks, plants, and other solid objects.

Protozoa:

Protozoa is an informal term for single-celled eukaryotes, either free-living or parasitic, which feed on organic matter such as other microorganisms or organic tissues and debris. In some systems of biological classification, Protozoa is a high-level taxonomic group.

Virus: A **virus** is a microscopic parasite which can infect living organisms and cause disease. Virus is smaller than a bacterium that cannot grow or reproduce apart from a living cell. A virus invades living cells and uses their chemical machinery to keep itself alive and to replicate itself. It may reproduce with fidelity or with errors (mutations); this ability to mutate is responsible for the ability of some viruses to change slightly in each infected person, making treatment difficult. Viruses cause many common human infections and are also responsible for a number of rare diseases. Examples of viral illnesses range from the common cold, which can be caused by one of the rhinoviruses, to AIDS, which is caused by HIV. Viruses may contain either DNA or RNA as their genetic material. Herpes simplex virus and the hepatitis B virus are DNA viruses. RNA viruses have an enzyme called reverse transcriptase that permits the usual sequence of DNA-to-RNA to be reversed so that the virus can make a DNA version of itself.

ECONOMICAL IMPORTANCE OF MICROBES

Economic Importance of Bacteria:

Bacteria in Medicine:

- Antibiotics
- Serums
- Vaccines
- Toxoids

Bacteria in Agriculture:

- Nitrogen-fixing bacteria
- Nitrifying bacteria
- Denitrifying bacteria
- Scavenging Role
- Production of fuel
- Disposal of sewage

Bacteria in the Industry:

- Curing of tea
- Tanning of leather
- Retting of fibres

- Dairy industry

Economical Importance of Fungi:

Fungi are useful to man in several ways. Some of them are edible and serve as food.

- Mushrooms.
- Yeast
- Used in Cheese industry.
- To produce Enzymes.

  Some other Importance of Fungi
- Used in Medicines.
- Plays an important role in the Nutrient cycle.
- They are a major source of citric acid (vitamin C).
- They produce antibiotics such as *penicillin*, which has saved countless lives.
- They can be genetically engineered to produce insulin and other human hormones.

Economical Importance of Algae:

Food

Algae contains several healthy elements including carbohydrates, fats, proteins, and vitamins A, B, C, and E. Not only is algae considered by many consumers worldwide to be a low cost source of protein, but it also contains a number of important minerals such as iron, potassium, magnesium, calcium, manganese, and zinc

Fodder

Algae, especially seaweed, is used as a feed for a variety of farm animals. For example, Rhodymenia palmate, or so-called "Sheep’s weed," is used in order to feed livestock such as cattle and chickens.

Pisciculture

The industry involved in the breeding and farming of fish, also known as fish farming or pisciculture, also utilizes algae as part of its production process.

Fertilizer

The two most common varieties of algae used in the manufacture of fertilizer are large red and brown. In particular, these two types of algae are utilized in areas located near the ocean.

Reclaiming Alkaline

Fields that once produced large agricultural yields can no longer be used due to high concentrations of alkalinity in the soil. In order for crops to eventually be grown in these lands, , the ph level must be lowered and the ability of the soil to hold onto water must be increased. This process can be achieved using blue-green algae.

Binding Agent

Algae can also be used to help bind soil together. The use of algae to aid in the healthy formation of soil is important in the protection against natural processes such as erosion.

Economical Importance of Protozoa:

Helpful in sanitation: Numerous biologic protozoa help indirectly in purification of water by feeding on putrefying bacteria in various water bodies. These Protozoa play an important role in the sanitary betterment, improvement of water and keeping water safe for drinking purposes.

Planktonic Protozoa as food: Protozoa floating on the plankton of sea provide directly or indirectly the source of food supplies to man, fish and other animals. They form one of the first links in the numerous and complicated food chains that exist in the oceans of the world.

Symbiotic Protozoa: Some Protozoans are found in symbiotic relationship with other organisms. This association is beneficial to both the partners. The two partners become so dependent on each other and their separation results in the death of both.

Ecological Importance of Virus :

Viruses in medicine

Viruses are being used as vectors or carriers that take the required material for treatment of a disease to various target cells. They have been studied extensively in management of inherited diseases and genetic engineering as well as cancers.

Viruses in bacteriophage therapy

These are highly specific viruses that can target, infect, and (if correctly selected) destroy pathogenic bacteria. Bacteriophages are believed to be the most numerous type of viruses accounting for the majority of the viruses present on Earth. These are basic tools in molecular biology. They have been researched for their use in therapy.

Viruses in nanotechnology

Nanotechnology deals with microscopic particles. These have various uses in biology and medicine and nanotechnology has been used in genetic engineering. Viruses can be used as carriers for genetically modified sequences of genomes to the host cells.

Viruses in weapons and biological warfare

Viruses may be tiny but have the capacity to cause death and devastation to large populations in epidemics and pandemics. This has led to the concern that viruses could be used for biological warfare.

Viruses in agriculture

Modification and genetic engineering methods can be used to make modified genomes that can be carried into plants and animals by viruses acting as vectors or vehicles. This method can lead to more productive transgenic animals and plants.

Viruses in cancer prevention and control

Similar modifications (as plants and animals in agriculture) of humans have not been attempted for technical and ethical reasons. But the modification of genes of cells of individuals has been under investigation for many years. This is known as gene therapy.

Viruses and vaccines

Viruses have been used since the time of Edward Jenner in vaccines. Jenner used cow pox viruses to inoculate people against small pox infection.

Vaccines against polio, measles, chicken pox etc. use live and weakened viruses causing the disease or dead virus particles. These, when introduced into an healthy individual, help the immune system to recognise and mount an immunity against the virus. The body remembers the organism and attacks it in case of a later infection thus preventing the disease.

Vaccines for cancer prevention

Vaccines for hepatitis B and those for human papillomavirus protect against liver and cervical cancer respectively. Both use selected proteins of the virus (subunit vaccines).

CONTROL OF TYPES OF MICROBE

Control Of Bacteria: Physical **control** includes such **methods** of **control** as high or low temperature, desiccation, osmotic pressure, radiation, and filtration.

2. Chemical **control** refers to the use of disinfectants, antiseptics, antibiotics, and chemotherapeutic antimicrobial chemicals.

Practice good hygiene, such as frequent hand washing. Fortify your immune system with healthy foods such as fruits and vegetables. Avoid close contact with people who are sick with a contagious infection from bacteria. And only take antibiotics when needed to avoid developing resistance to antibiotics in the future.

Control of Fungi: Fungicides are biocidal chemical compounds or biological organisms used to kill parasitic fungi or their spores.[1] A fungistatic inhibits their growth. Fungi can cause serious damage in agriculture, resulting in critical losses of yield, quality, and profit. Fungicides are used both in agriculture and to fight fungal infections in animals. Chemicals used to control oomycetes, which are not fungi, are also referred to as fungicides, as oomycetes use the same mechanisms as fungi to infect plants.

Control of Algae:

To treat and control the growth of algae, current options that are commonly used include the following four main methods:

1. Chemicals
2. Aeration
3. Mixing
4. Ultrasound

1. Chemicals

Chemical intervention involves treating the water with a variety of additives, such as alum, lanthanum, or any other products that precipitate.

2. Aeration

Aeration is used to increase the level of oxygen in the water. Aeration is an environmentally friendly technique to maintain and rejuvenate water bodies.

3. Mixing

The main function of mixers in a reservoir is destratification, which is a process in which the water is mixed to eliminate stratified layers (Epilimnion, Metalimnion, Hypolimnion) and make it less favourable for algae growth in certain layers.

4. Ultrasound

Ultrasound are sound waves with frequencies higher than the upper audible limit of human hearing (22 kHz). At specific frequencies, these sound waves can be used to control algae growth

Algacide	Aeration	Mixing	Ultrasound
• Effective • Fast results	• Increased oxygen levels at the bottom improve the ecological balance of a lake • Environmentally friendly	• Prevents stratification • Environmentally friendly	• Environmentally friendly and cost-effective • Can be used for large water surfaces
• Can be harmful for the environment • Needs frequent dosing for long term effect	• No direct effect on algae • Expensive	• High in maintenance • Reduced efficiency depending on the water quality	• Can control up to 90% of the algae • Takes some weeks before you can see the results

Control of Protozoa:

1. improvements in housing, sanitation and hygiene
2. control of vectors
3. development of vaccines

4. development of drugs

5. Vaccination

Control of Virus:

There are three types of antiviral agents:

(1) virucidal agents, which directly inactivate **viruses**,

(2) antiviral agents, which inhibit **viral** replication, and

(3) immunomodulators, which boost the host immune response.