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BIOLOGY

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LIVING WORLD DISCIPLINE

- **Cytology** : Study of cell structure is called cytology.
- **Embryology :** It is the study of fertilization and development of a zygote into an embryo, larva or a miniature adult.
- **Exobiology :** Study of possibility of life in the outer space.
- **Microbiobiology :** It is the study of structure, life cycle and activities of micro-organisms invisible to maked eye.
- **Pathology :** Study of diseases, effects, casual agents, transmission and other activities of pathogens is called pathology.
- **Eugenics** : Study of factors connected with impairment or improvement of a race.
- **Euthenics :** Study of environmental conditions that contribute to the improvement of intellect and other traits of human beings.
- **Euphenics** : Treatment of defective heredity through genetic engineering.
- **Cryobiology :** It is the study of effects of low temperature on organisms, including their preservation.
- **Acarology :** Study of ticks and mites.
- **Actinology :** (i) Study of radiation effects (ii) Study of radially symmetrical animals.
- **Aerobiology :** Study of air borne organisms as well as structure (e,g spores) and their distribution.
- **Agriology :** Comparative study of primitive tribal customs
- **Agrobiology :** Quantitative science of plant life and plant nutrition.
- **Agrology :** Soil science dealing with production of crops.
- **Agronomy :** Science of soil management of domesticated animals.
- **Agrostology :** Study of grasses.
- **Andrology** : Study of male reproductive organs.
- **Angiology** : Study of blood vascular system, including arteries and veins.
- **Animal Husbandry :** Raising and management of domesticated animals.
- **Anthology (Bessey) :** Study of flowers and flowering plants.
- **Anthropology :** Study of origin development and culture of present and past races of humans.
- **Aphidology :** Study of aphids.
- **Apiculture :** Rearing of bees.
- **Araneology :** Study of spiders.
- **Arboriculture** : Cultivation of trees and shrubs.
- **Arthrology** : Study of joints.
- **Bacteriology (Ehrenberg) :** Study of bacteria.
- **Bioclimatology :** Study of climatic effects on biological processes and organisms.
- **Biometerology :** Study of effects of atmospheric changes on living begins.
- **Biometrics :** (Biometry = Biostatistics). Statistical study of biological problems.
- **Bionics :** Ecology.
- **Biotechnology :** Technology connected with employing living beings or their products in industrial processes.
- **Brylogy** : Study of bryophytes.
- **Cardiology** : Study of heart.
- **Carcinology** : (i) Study of crustacea (ii) Study of cancers or tumours.
- **Chemotaxonomy** : Taxonomy based on chemicals present in organism.
- **Chirology** : Communication system for deaf and mute by sign language.
- **Chondrology** : Study of cartilages.
- **Chorology** : Biogeography.
- **Cnidology** : Study of coelentrates.
- **Conchology** : Study of shells.
- **Coprology** (Scatology) : Study of excrements.
- **Craniology** : Study of skulls.
- **Ctetology** : Branch of biology connected with acquired characters.
- **Cytotaxonomy** : Classification of organisms based on cellular structure and further, especially on the member of Chromesones.
- **Dactyology** : Communication system as for deaf using signs made of fingers.

LEGENDS OF DISCIPLINE

1.	*Father of Concept of Evolution*	*Ampedocles(495-425 B.C.)*
2.	*Father of Medicine*	*Hippocrates(460-375 B.C)*
3.	*Father of Biology, Embryology and Zoology.*	*Aristatle (384-287 B.C)*
4.	*Father of Botany and Ecology*	*Theophrastus (370-287 B.C)*
5.	*Father of Anatomy*	*Andreas Veaslius(1514-1564)*
6.	*Father of Comparative Anatomy*	*George Cuvier(1771-1712)*
7.	*Father of Microscopic Anatomy*	*Morcello Malpighi (1628-1694)*
8.	*Father of Plant Anatomy*	*N.Grew (1641-1712)*
9.	*Father/Founder of Histology*	*Francois Bichat (1771-1802)*
10.	*Father of Microscopy (Protozoology, Microbiology, Bacteriology)*	*Anton Van Leeuwenhoek (1632-1723)*
11.	*Father of Cytology*	*Robert Hooke (1635-1703)*
12.	*Father of Modern Cytology*	*Swansan*
13.	*Father of Taxonomy and Nomenclature*	*Caroleus (Carl von) Linnacus(1707-1778)*
14.	*Founder of Embryology*	*C.F.Wolff (1738-1794)*
15.	*Father of Modern Embryology*	*Von Baer (1792-1876)*
16.	*Father of Immunology*	*Edward Jenner (1749-1823)*
17.	*Father of Epidemiology*	*John Snow*
18.	*Father of Biochemistry*	*Liebig*
19.	*Father of Plant Physiology*	*Stephen Hales (1677-1761)*
20.	*Father of Experimental Physiology*	*Galen*
21.	*Father of Mycology*	*Micheli*
22.	*Father of Bryology*	*Hedwig*
23.	*Father of Plant Pathology*	*De Bary*
24.	*Father of Antiseptic Surgery*	*Joseph Lister*
25.	*Father of Bacteriology*	*Koch*
26.	*Father of Microbiology*	*Pasteur*
27.	*Father of Palynology*	*Erdtman*
28.	*Father of Endocrinology*	*Thomas Addison*
29.	*Father of Stress Physiology*	*Hans Selye*
30.	*Father of Conditioned Reflexes*	*Pavlov*
31.	*Father of ECG*	*Einthoven*
32.	*Father of Gerontology*	*Korenchevsk*
33.	*Father of Modern Paleontology*	*Cuvier*
34.	*Father of Ethology*	*Konard Lorentz*
35.	*Father of Antibiotics*	*Alexander Fleming (1881-1995)*
36.	*Father of Blood Circulation*	*William Havey (1578-1657)*
37.	*Father of Blood Groups*	*Landsteiner*
38.	*Father of Chemotherapy*	*Paul Ehlrich*
39.	*Father of Genetics*	*Gregor Johann Mendel*
40.	*Father of Modern Genetics*	*Bateson*
41.	*Father of Polygenic Inheritence*	*Kolreuter*
42.	*Father of Eugenics*	*Francis Galton*
43.	*Father of Biochemical/Human Genetics*	*Archibald Garrod*
44.	*Father of experimental Genetics*	*T.H. Morgan*
45.	*Father of Genetic Engineering*	*Paul Berg*
46.	*Father of DNA Printing*	*Alee Jeffreys*

- **Dendrochronology** : Counting and analyzing annual-growth rings of trees.
- **Dendrology** : Study of trees.
- **Dentistry** : Care of teeth including cure, removal, filling and replacement.
- **Dermatology** : Study of skin and other body coverings.
- **Desmology** : Anatomy / study of ligaments.
- **Dysteleology** : Study of appearene of vestigical organs due to evolution (Haeckel's doctrine of purposelessness).

- **Ecobiology** : (i) Study of adaptations in relation to habitat. (ii) Study of problems connected with existence of life in space and other planets.
- **Economic Botany/Economic Zoology** : Branch dealing with commercially exploited / exploitable plants / animals.
- **Ecophysiology** : Physiological adaptations in response to environment.
- **Edaphology/Paedology/Pedology** : Soil science.
- **Endocrinology** : Study of endocrine glands, hormones and their effects.
- **Entomology** : Study of insects.
- **Enzymology** : Study of enzymes and their functions.
- **Epidemiology** : Study of distribution, causes and control measures of infectious discases.
- **Ethnobotany** : Relationships between primitive humans and plants.
- **Ethnology** : Science dealing with different races of mankind.
- **Ethology** : Study of animal behaviour.
- **Etiology (=Aetiology)** : Study of life cycle of pathogen, especially on the host.
- **Fishery** : Catching, breeding, rearing and marketing of fish and other aquatic animals.
- **Floriculture** : Cultivation of plants for their flowers.
- **Gastroenterology** : Study of stomach, intestine and their diseases.
- **Genecology(Genaeology)** : Study of development of individual / race / pedigree.
- **Geology** : Science of earth.
- **Gerontology** : Study of ageing and senescence.
- **Gnotobiotics** : Germ free culture / life.
- **Gynaecology** : Study of female reproductive organs.
- **Haematology** : Study of blood.
- **Helminthology** : Study of parasitic worms.
- **Hepatology** : Study of liver.
- **Herpetology** : Study of reptiles and amphibians / creeping animals.
- **Histochemistry** : Chemistry of living tissues.
- **Horticulture** : Development and management of orchards and gardens.
- **Hypnology** : Science dealing with sleep including the one from hypnosis.
- **Hypnotherapy** : Treatment through hypnotism.
- **Ichthyology** : Study of fishes.
- **Immunology** : Study of immunity or resistance to disease.
- **Kalology** : Study of human beauty.
- **Karyology** : Study of cell nucleus and chromosomes.
- **Karyotaxonomy** : Taxonomy based on peculiarities of nucleus chromosome number and type.
- **Laryngology** : Study of larynx.
- **Lepidopterology** : Study of moths and butterflies.
- **Lichenology** : Study of lichens.
- **Limnology** : (i) Study of fresh water ecology (ii) Study of snails.
- **Malacology** : Study of mollusks.
- **Mammology** : Study of mammals.
- **Mastology** : Study of breasts including teats.
- **Melanology** : Study of development and loss of body pigments.
- **Monerology** : Study of monera.
- **Molecular genetics** : Molecular basis of genetics / science of inheritance and variations.
- **Mycology** : Study of fungi.
- **Myology (Sarcology)** : Study of muscles.
- **Myremecology** : Study of ants.
- **Nematology** : Study of round worms (nematodes).
- **Neonatology** : Scientific study of new born.
- **Neontology** : Science of present day or recent living beings.
- **Nephrology** : Study of kidneys.
- **Neurology** : Study of nervous system.
- **Nidology** : Study of nests of birds.
- **Occupational Therapy** : Treating mental and physical defects with occupation.
- **Olultureeric** : Cultivation of vegetables.
- **Onchology**: Study of cancers.
- **Oology** : Study of eggs, particularly those of birds.
- **Ophiology** : Study of ophidia or snakes.
- **Opthalmology** : Study of eyes.
- **Organocology** : Study of organogenesis and embryology.
- **Ornithology** : Study of birds
- **Osteology** : Study of bones
- **Oto-laryngology** : Study of ear and larynx.
- **Otorhinolaryngology** : Study of ENT or ear, nose and throat head and neck disorders.

- **Paediatrics** : Branch of Medicine dealing with children.
- **Parasitology** : Study of parasites
- **Parazoology** : Study of sponges.
- **Pedology/Paedology** : Edaphology Soil Science.
- **Pharmacy** : Compounding and dispensing of drugs.
- **Pharmacology** : Study of synthesis and effects of medicine an organisms.
- **Phenology** : Recording and study of periodic biotic events like flowering leaf fall, breeding and migration.
- **Phrenology** : Study of mental faculties of brain including feelings.
- **Photobiology** : Effect of light on various biological processes.
- **Phycology** (=Algalogy) : Study of algae.
- **Phylogency** : Evolutionary history.
- **Physiography** : Science of physical geography or surface of earth.
- **Physiotheraphy** : Treatment of body defects through massage and exercise.
- **Phytogeny** : Evolution and development of plants.
- **Phytology** : Botany, study of plants.
- **Pomology** : Science dealing with fruits and fruit yielding plants.
- **Poultry Science** : Management and rearing of chicken, geese and ducks.
- **Protistology** : Study of protists.
- **Protozoology** : Study of protozoans and related organisms.
- **Psychiatry** : Treatment of mental diseases.
- **Psychology** : Study of human mind and behaviour.
- **Pteridology** : Study of ferns and other pteridophytes.
- **Radiobiology** : Branch of biology dealing with effects of radiation on living beings.
- **Radiology** : Science dealing with X-rays and other imaging techniques for medical diognosis.
- **Radiotheraphy** : Treatment of diseases with X-rays and radio active substances.
- **Rhinology** : Study of nose and olfactory organs.
- **Saurology** : Study of lizards.
- **Sericullture** : Rearing silkworms of extraction of silk.
- **Serology** : Study of serum; interaction of antigens and antibodies in the blood.
- **Se**rpentology (= Ophiology) : Study of snakes.
- **Silviculture**. (= Sylviculture) : Cultivation of forest trees.
- **Sitology** : Science of food, diet and nutrition
- **Sonography** : Ultrasound imaging.
- **Sonology** : Study of hearing
- **Spelaeology** : Study of caves and cave life..
- **Syndesmology** : Branch of anatomy dealing with ligaments and articulations.
- **Taxidermatology** : Processing of skins and stuffing.
- **Tectology** : Study of structural organization of animals.
- **Teratology** : Study of abnormalities during embryogenesis.
- **Termitology** : Study of termites.
- **Therapeutics** : Treatment of disease.
- **Torpedology** : Study of skates and rays.
- **Toxicology** : Study of harmful effects of drugs and other substances.
- **Traumatology** : Study of wounds.
- **Tricology** : Study of hairs.
- **Trophology** : Science of nutrition.
- **Urology** : Science dealing with disorders of urinary tract(urinogenital tract in males).
- **Venereology** : Study and treatment of venereal diseases.
- **Virology** : Study of viruses.
- **Xylotomy** : Study of anatomy of wood / xylem.
- **Zoogeny** : Origin and development of animals.
- **Zymology** : Study of fermentation processes. ■■

CELL & GENETICS

INTRODUCTION

The cell is the structural and functional unit of all living organisms, and is sometimes called the "building block of life." Some organisms, such as bacteria are unicellular, consisting of a single cell. Other organisms such as humans are multicellular. Humans have an estimated 100 trillion or 10^{14} cells. The largest known cell is an Ostrich egg.

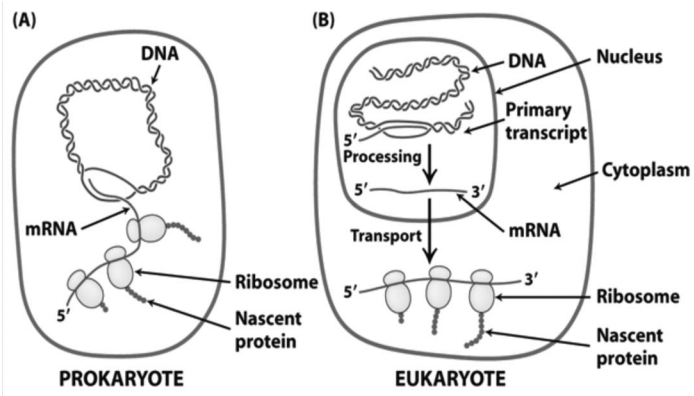
- **Anton van Leeuwenhoek** was the first person to build a microscope and draw protozoa, such as *Vorticella* from rain water, and bacteria from his own mouth.
- In 1665 **Robert Hooke** discovered cells in cork, then in living plant tissue using an early microscope.
- First of all in 1839 **Schleiden** and **Schwann**, states that all organisms are composed of one or more cells. All cells come from preexisting cells. Vital functions of an organism occur within cells, and all cells contain the hereditary information necessary for regulating cell functions and for transmitting information to the next generation of cells.
- In 1931 **Ernst Ruska** built first transmission electron microscope (TEM) at the University of Berlin and by 1935, he built an EM with twice the resolution of a light microscope, revealing previously-unresolvable organelles.
- In 1953 **Watson** and **Crick** made their first announcement on the double-helix structure for DNA.

Each cell is at least somewhat self-contained and self-maintaining: It can take in nutrients, convert these nutrients into energy, carry out specialized functions, and reproduce as necessary. Each cell stores its own set of instructions for carrying out each of these activities.

ANATOMY OF CELLS

There are two types of cells, eukaryotic and prokaryotic. Prokaryotic cells are usually singletons, while eukaryotic cells are usually found in multicellular organisms.

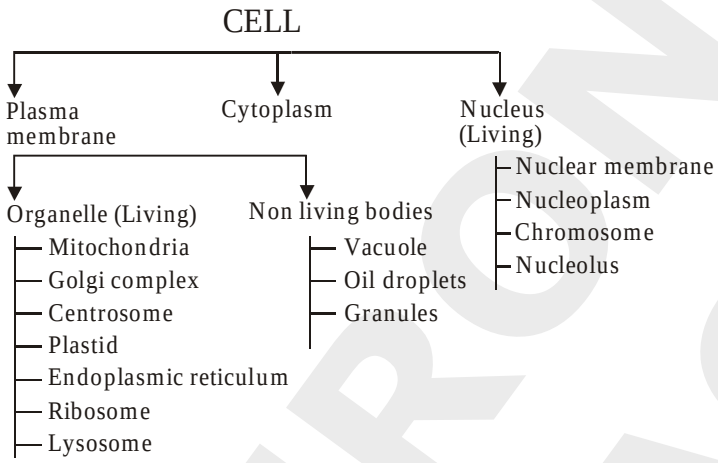
1. **Prokaryotic Cells:** Prokaryotes are distinguished from eukaryotes on the basis of nuclear organization, specifically their lack of a nuclear membrane. Prokaryotes also lack most of the intracellular organelles and structures that are characteristic of eukaryotic cells (an important exception is the ribosomes, which are present in both prokaryotic and eukaryotic cells). Most of the functions of organelles, such as mitochondria, chloroplasts, and the Golgi apparatus, are taken over by the prokaryotic plasma membrane.
   - The plasma membrane separates the interior of the cell from its environment and serves as a filter and communications beacon.
   - Most prokaryotes have a cell wall which acts as an additional barrier against exterior forces. It also prevents the cell from exploding (cytolysis) from osmotic pressure against a hypotonic environment. A cell wall is also present in some eukaryotes like fungi, but has a different chemical composition.
   - A prokaryotic chromosome is usually a circular molecule without a real nucleus and the DNA is condensed in a nucleoid.
2. **Eukaryotic Cells:** Eukaryotic cells are about 10 times the size of a typical prokaryote and can be as much as 1000 times greater in volume. The major difference between prokaryotes and eukaryotes is that eukaryotic cells contain membrane-bound compartments in which specific metabolic activities take place. Most important among these is the presence of a cell nucleus, a membrane-delineated compartment that houses the eukaryotic cell's DNA. It is this nucleus that gives the eukaryote its name, which means "true nucleus".
   - The plasma membrane resembles that of prokaryotes in function, with minor differences in the setup. Cell walls may or may not be present.
   - The eukaryotic DNA is organized in one or more linear molecules, called chromosomes, which are associated with histone proteins. All chromosomal DNA are stored in the *cell nucleus*, separated from the cytoplasm by a membrane. Some eukaryotic organelles also contain some DNA.
   - Eukaryotes can move using *cilia* or flagella. Their flagella are more complex than those of prokaryotes.



Prokaroytic and Eukaryotic Cells

	Prokaryotes	Eukaryotes
Typical organisms	*bacteria, archaea*	*protists, fungi, plants, animals*
Typical size	*~ 1-10 µm*	*~ 10-100 µm (sperm cells, apart from the tail, are smaller)*
Type of nucleus	*nucleoid region; no real nucleus*	*real nucleus with double membrane*
DNA	*circular (usually)*	*linear molecules (chromosomes) with histone proteins*
RNA-/protein-synthesis	*coupled in cytoplasm*	*RNA-synthesis inside the nucleus protein synthesis in cytoplasm*
Ribosomes	*50S+30S*	*60S+40S*
Cytoplasmatic structure	*very few structures*	*highly structured by endomembranes and a cytoskeleton*
Cell movement	*flagella made of flagellin*	*flagella and cilia made of tubulin*
Mitochondria	*none*	*one to several dozen (though some lack mitochondria)*
Chloroplasts	*none*	*in algae and plants*
Organization	*usually single cells*	*single cells, colonies, higher multicellular organisms with specialized cells*
Cell division	*Binary fission (simple division)*	*Mitosis (fission or budding) Meiosis*

SUBCELLULAR COMPONENTS



All cells, whether prokaryotic or eukaryotic, have a membrane, which envelopes the cell, separates its interior from its environment, regulates what moves in and out (selectively permeable), and maintains the electric potential of the cell. Inside the membrane, a salty cytoplasm takes up most of the cell volume. All cells possess DNA, the hereditary material of genes, and RNA, containing the information necessary to build various proteins such as enzymes, the cell's primary machinery. There are also other kinds of biomolecules in cells. The primary components of the cell and their functions are as follows:

- **Cell Membrane** (A cell's defining boundary): The cytoplasm of a cell is surrounded by a plasma membrane. The plasma membrane in plants and prokaryotes is usually covered by a cell wall. This membrane serves to separate and protect a cell from its surrounding environment and is made mostly from a double layer of lipids and hydrophilic phosphorus molecules. Hence, the layer is called a phospholipid bilayer. This membrane has a variety of protein molecules that act as channels and pumps that move different molecules into and out of the cell. The membrane is said to be 'semi-permeable'. Cell surface membranes also contain receptor proteins that allow cells to detect external signalling molecules such as hormones.

- **Cytoskeleton** (A cell's scaffold): The cytoskeleton acts to organize and maintain the cell's shape; anchors organelles in place; helps during endocytosis, the uptake of external materials by a cell, and cytokinesis, the separation of daughter cells after cell division; and moves parts of the cell in processes of growth and mobility. Eukaryotic cytoskeleton is composed of microfilaments, intermediate filaments and microtubules. There is a great number of proteins associated with them, each controlling a cell's structure by directing, bundling, and aligning filaments.

- **Genetic Material:** Within a cell two different kinds of genetic material exist: deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). Most organisms use DNA for their long-term information storage, but some viruses (e.g., retroviruses) have RNA as their genetic material. The biological information contained in an organism is encoded in its DNA or RNA sequence. RNA is also used for information transport (e.g., mRNA) and enzymatic functions (e.g., ribosomal RNA) in organisms that use DNA for the genetic code itself.

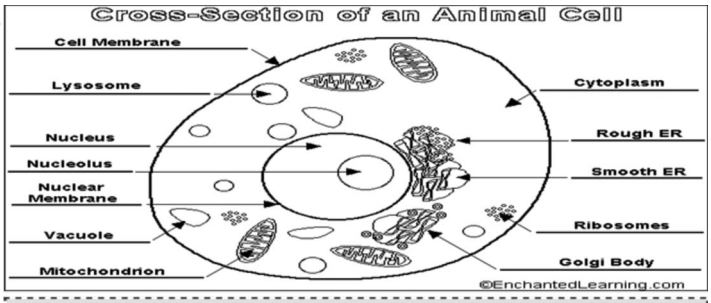
Prokaryotic genetic material is organized in a simple circular DNA molecule (the bacterial chromosome) in the nucleoid region of the cytoplasm. Eukaryotic genetic material is divided into different, linear molecules called chromosomes inside a discrete nucleus, usually with additional genetic material in some organelles like mitochondria and chloroplasts.

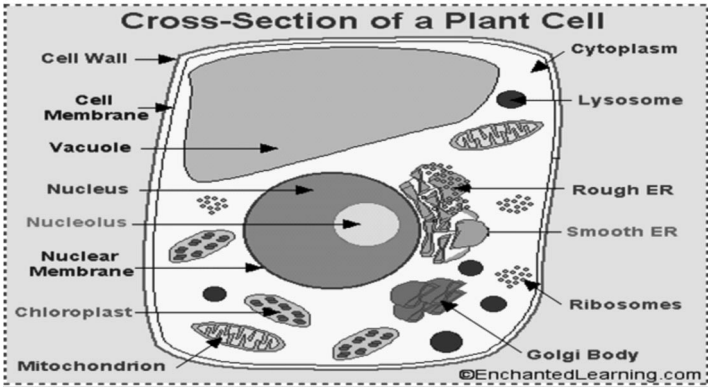
A human cell has genetic material in the nucleus (the nuclear genome) and in the mitochondria (the mitochondrial genome). In humans the nuclear genome is divided into 46 linear DNA molecules called chromosomes. The mitochondrial genome is a circular DNA molecule separate from the nuclear DNA. Although the mitochondrial genome is very small, it codes for some important proteins.

Animal and Plant Cells

	Typical Animal Cell	*Typical Plant Cell*
Organelles	• *Nucleus* • *Nucleolus (within nucleus)* • *Rough endoplasmic reticulum (ER)* • *Smooth ER* • *Ribosomes* • *Cytoskeleton* • *Golgi apparatus* • *Cytoplasm* • *Mitochondria* • *Vesicles* • *Lysosomes* • *Centrosome* • *Centrioles*	• *Nucleus* • *Nucleolus (within nucleus)* • *Rough ER* • *Smooth ER* • *Ribosomes* • *Cytoskeleton* • *Golgi apparatus (dictyosounls)* • *Cytoplasm* • *Mitochondria* • *Vesicles* • *Chloroplast and other plastids* • *Central vacuole(large)* • *Tonoplast (central vacuole membrane)* • *Peroxisome* • *Vacuoles* • *Glyoxysome*
Additional structures	• *Cilium* • *Flagellum* • *Plasma membrane*	• *Plasma membrane* • *Cell wall* • *Plasmodesmata* • *Flagellum (only in gametes)*

- **Organelles:** As the human body contains many different organs, such as the heart, lung, and kidney with different functions cells also have a set of little organs, called organelles, that are specialized for carrying out one or more vital functions. Membrane-bound organelles are found only in eukaryotes.
- **Cell Nucleus** (a cell's information center)**:** The cell nucleus, found in a eukaryotic cell, is the house of chromosomes, and is the place where almost all DNA replication and RNA synthesis occur. The nucleus is spheroid in shape and separated from the cytoplasm by a double membrane called the nuclear envelope. During processing, DNA is transcribed, or copied into a special RNA, called mRNA. This mRNA is then transported out of the nucleus, where it is translated into a specific protein molecule. In prokaryotes, DNA processing takes place in the cytoplasm.
- **Mitochondria and Chloroplasts** (the power generators)**:** Mitochondria are self-replicating organelles that occur in various numbers, shapes, and sizes in the cytoplasm of all eukaryotic cells. As mitochondria contain their own genome that is separate and distinct from the nuclear genome of a cell, they play a critical role in generating energy in the eukaryotic cell. Chloroplasts, broadly called plastids, are often involved in storage.
- **Endoplasmic Reticulum and Golgi Apparatus** (macromolecule managers)**:** The endoplasmic reticulum (ER) is the transport network for molecules targeted for certain modifications and specific destinations, as compared to molecules that will float freely in the cytoplasm. The ER has two forms: the rough ER, which has ribosomes on its surface, and the smooth ER, which lacks them. The ER contains many Ribosomes, the protein production machine. The ribosome is a large complex composed of many molecules, only exist floating freely in the cytosol, whereas in eukaryotes they can be either free or bound to membranes.
- **Lysosomes and Peroxisomes:** The eukaryotic cell could not house such destructive enzymes if they were not contained in a membrane-bound system.
- **Centrosome** (the cytoskeleton organiser): The centrosome produces the microtubules of a cell, a key component of the cytoskeleton. It directs the transport through the ER and the Golgi apparatus. Centrosomes are composed of two centrioles, which separate during cell division and help in the formation of the mitotic spindle. A single centrosome is present in the animal cells. They are also found in some fungi and algae cells.
- **Vacuoles:** They store food and waste. Some vacuoles store extra water. They are often described as liquid filled space and are surrounded by a membrane. Some cells, most notably *Amoeba* have contractile vacuoles, which are able to pump water out of the cell if there is too much water.





HUMAN CELL TYPES

- **Blastomere:** In humans, blastomere formation begins immediately following fertilization and continues through the first week of embryonic development. About 30 hours after fertilization, the egg divides into two cells. These mitotic divisions continue and result in a grouping of cells called blastomeres. During this process, the total size of the embryo (also called a "zygote") does not increase, so each division results in smaller and smaller cells. When the zygote contains 12 to 32 blastomeres it is referred to as a "morula."

- **Egg:** An ovum (plural ova) is a haploid female reproductive cell or gamete. The word is derived from Latin, meaning egg or egg cell. Both animals and embryophytes have ova. The term ovule is used for the young ovum of an animal. In some plants, such as algae, it is also called oosphere. In higher animals, ova are produced by female gonads (sexual glands) called ovaries and all of them are present at birth in mammals, and mature via oogenesis.

- **Embryonic Stem Cells:** ES cells are stem cells derived from the inner cell mass of an early stage embryo known as a blastocyst. Human embryos reach the blastocyst stage 4-5 days after fertilisation, at which time they consist of about 30 cells. Embryonic stem cells are pluripotent, meaning they can develop into each of the more than 220 cell types of the adult body when given the sufficient and necessary stimulation for a specific cell type. Because of their plasticity and potentially unlimited capacity for self-renewal, ES cell therapies have been proposed for regenerative medicine and tissue replacement after injury or disease.

- **Erythrocytes:** Red blood cells known as RBCs or erythrocytes are the most common type of blood cells and the vertebrate body's principal means of delivering oxygen from the lungs or gills to body tissues via the blood. Erythrocytes consist mainly of Haemoglobin, a complex molecule containing heme groups whose iron atoms temporarily link to oxygen molecules in the lungs or gills and release them throughout the body. Oxygen can easily diffuse through the red blood cell's cell membrane. Hemoglobin also carries some of the waste product carbon dioxide back from the tissues. A related compound, myoglobin, acts to store oxygen in muscle cells. The colour of erythrocytes is due to the heme group of Haemoglobin.

- **Fibroblast:** A fibroblast is a type of cell that synthesizes and maintains the extracellular matrix of many animal tissues. Fibroblasts provide a structural framework for many tissues, and play a critical role in wound healing. They are the most common cells of connective tissue in animals. Fibroblasts secrete the precursors of all the components of the extracellular matrix, primarily the ground substance and a variety of fibres.

- **Hepatocytes:** It makes up 70-80% of the cytoplasmic mass of the liver. These cells are involved in protein synthesis, protein storage and transformation of carbohydrates, synthesis of cholesterol, bile salts and phospholipids, and detoxification, modification and excretion of exogenous and endogenous substances. The hepatocyte also initiates the formation and secretion of bile. The hepatocyte is a cell in the body that manufactures albumin, fibrinogen, and the prothrombin group of clotting factors. It is the main site for the synthesis of lipoproteins, ceruloplasmin, transferrin, complement and glycoproteins. The liver forms fatty acids from carbohydrates and synthesizes triglycerides from fatty acids and glycerol. Hepatocytes also synthesize apoproteins with which they then assemble and export lipoproteins (VLDL, HDL). Hepatocytes have the ability to metabolize, detoxify, and inactivate exogenous compounds such as drugs and insecticides, and endogenous compounds such as steroids.

- **Myoblast:** A myoblast is a type of stem cell that exists in muscles. Skeletal muscle cells are called muscle fibres and are made when myoblasts fuse together; muscle fibres therefore have multiple nuclei.

Myoblasts that do not form muscle fibres differentiate into satellite cells. These satellite cells remain adjacent to a muscle fiber, separated only by its cell membrane and by the endomycium (the connective tissue of collagen surrounding the muscle fibre).

- **Neurons:** They are electrically excitable cells in the nervous system that function to process and transmit information. In vertebrate animals, neurons are the core components of the brain, spinal cord and peripheral nerves. Neurons are typically composed of a soma, or cell body, a dendritic tree and an axon. Neurons communicate via chemical and electrical synapses, in a process known as synaptic transmission. Human brain has about 100 billion (10^{11}) neurons.

- **Oocyte:** An oocyte or ovocyte is a female gametocyte or germ cell involved in reproduction. The formation of an oocyte, called oogenesis, is a form of gametogenesis whose male counterpart is spermatocytogenesis. Oogenesis results in the formation of both primary oocytes before birth, and of secondary oocytes after it as part of ovulation. The oocyte divides in meiosis II into one ootid and the second polar body. The ootid then differentiates into an ovum. The secondary oocyte is the largest cell in the body, and in humans is just visible to the naked eye. Oocytes are rich in cytoplasm which contains yolk granules to nourish thecell early in development. The only normal type of secondary oocyte has sex chromosomes 23,X (where sperm can be 23,X or 23,Y).

- **Osteoblast:** An osteoblast is a mononucleate cell that is responsible for bone formation. Osteoblasts produce osteoid, which is composed mainly of Type I collagen. Osteoblasts are also responsible for mineralization of the osteoid matrix. Bone is a dynamic tissue that is constantly being reshaped by osteoblasts, which build bone, and osteoclasts, which resorb bone. Osteoblasts that become trapped in the bone matrix become

osteocytes. They cease to generate osteoid and mineralized matrix, and instead act in a paracrine manner on active osteoblasts. They are believed to act in a mechanosensory manner.

- **Osteoclast:** An osteoclast is a type of bone cell that removes bone tissue by removing the bone's mineralized matrix. This process is known as bone resorption. Osteoclasts and osteoblasts are instrumental in controlling the amount of bone tissue. Osteoblasts form bone; osteoclasts resorb bone. Osteoclasts are formed by the fusion of cells of the monocyte-macrophage cell line. Osteoclasts are characterized by high expression of tartrate resistant acid phosphatase (TRAP) and cathepsin K.

CELL DIVISION

The growth and the development of every organism depend exclusively on the multiplication and enlargement of its cells. The development of a multicellular organism from the unicellular zygote is achieved by the cell division, growth and differentiation.

The division of the nucleated cells is achieved by two integral activities such as division of the nucleus (called Karyokinesis) and the division of the cytoplasm (that is called cytokinesis). Usually the Karyokinesis is followed by the cytokinesis, but sometimes it does not follow and results in multinucleated cells.

In animals and plants following three types of cell division have been observed:

1. Amitosis,
2. Mitosis
3. Meiosis

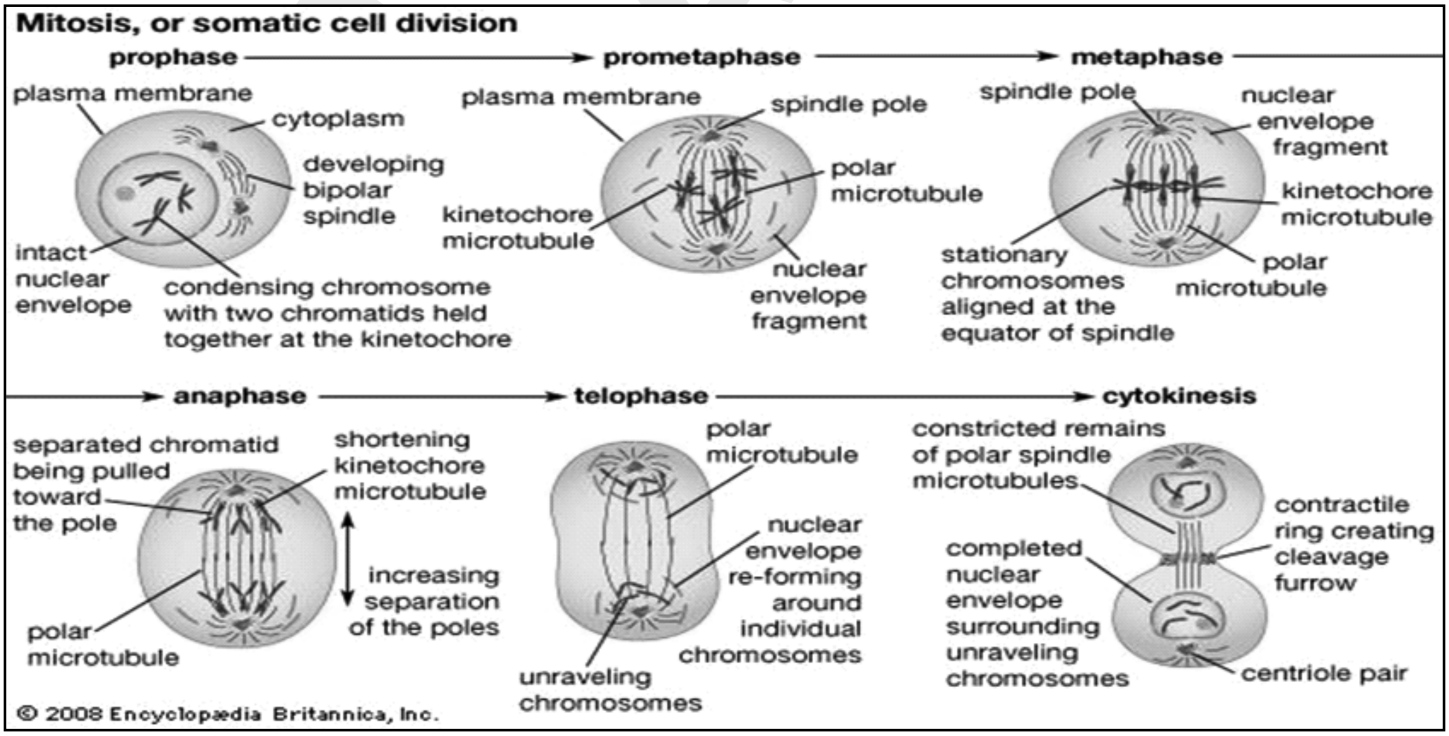
1. **Amitosis:** It is the means of asexual reproduction in unicellular organisms like bacteria and protozoans. It also occurs in embryonic membranes of vertebrates. In Amitosis, the splitting of nucleus is followed by cytoplasmic contriction. In Amitosis, two daughter cells are formed without the occurrence of any nuclear event. It is also known as direct nuclear division.

2. **Mitosis:** It takes place as a result of mitotic division One cell divides into 2 daughter cells which are quantitatively and qualitatively identical to the mother cell. No change in the Chromosome number. In between two successive mitotic divisions there is a rest period called the interphase. Mitosis has 4 phases- Prophase, Metaphase, Anaphase & Telophase.

- **Prophase :** Disappearance of nuclear membrane and nucleolus along with the doubling of chromosomes.
- **Metaphase :** Formation of spindle, chromosomes join themselves to the equatorial plane of the spindle.
- **Anaphase :** Centromeres divide longitudinally. Sister chromatids move towards opposite poles.
- **Telophase :** Grouping of chromatids at each pole along with the formation of new nuclear membrane and nucleolus.

3. **Meiosis:** Also called Reproductive cell division because it is associated with all sexual reproduction. As a result of division. in the daughter cells chromosomes number become half to that of the mother cell. Each division results into 4 daughter cells in contrast to 2 daughter cells in each mitotic divisions.

Division includes 2 phases i.e. Reduction division and Equational division (Meiosis) consist of same 4 phases, i.e., Prophase, Metaphase, Anaphase & Telophase. But Prohase I (Division I) has 5 substages. Leptotene, Zygotene, Pachytene, Diplotene & Diakinesis. The characteristics of each of the substage are:



- **Leptotene** : Close association of homologous chromosomes.
- **Zygotene**: Pairing of homologous chromosomes, the phenomena is called Synapsis. As a result, Bivalent Chromosomes are formed.
- **Pachytene** : Chiasma formation and crossing over.
- **Diplotene** : Terminations of chiasma starts.
- **Diakinesis** : Disappearance of nuclear membrane and nucleolus.

In Metaphase I spindle formation and rearrangement of chromosomes. In Anaphase I separation of homologous chromosomes. In Telophase grouping of chromosomes and formation of nuclear membrane and nucleolus. This division is followed by Division II.

CELL CULTURE

It is the process by which either prokaryotic or eukaryotic cells are grown under controlled conditions. In practice the term cell culture has come to refer to the culturing of cells derived from multicellular eukaryotes, especially animal cells. The historical development and methods of cell culture are closely interrelated to those of tissue culture and organ culture.

Applications: It is fundamental to the manufacture of viral vaccines and many products of biotechnology. Biologicals produced by recombinant DNA (rDNA) technology in animal cell cultures include enzymes, hormones, immunobiologicals (monoclonal antibodies, interleukins, lymphokines), and anticancer agents. Vaccines for polio, measles, mumps, rubella, and chickenpox are currently made in cell cultures.

HEREDITY

The members of a species give birth to their own kind. The offsprings show some basic similarities and some dissimilarities with their parents and with each other. The sexually reproducing organisms produce sex cells or gametes. Two gametes usually distinguishable as male and female fuse to form a zygote which gradually develops into a young one. The gametes constitute the link between one generation and the next and pass on the paternal and maternal characteristics to the offspring. This relationship that continues to exist between successive generations is referred to as *heredity*. Although the offsprings inherits the characteristics of the parents and resembles them very closely, the resemblance is not complete in all respects. The differences are referred to as variations, which are necessary for organic evolution. The significance of variations shows up only if they continue to be inherited by the progeny for several generations. Thus both heredity and variations are fundamental factors in the process of organic evolution. The study of the mode of transmission of characters from one generation to the next, is known as Genetics.

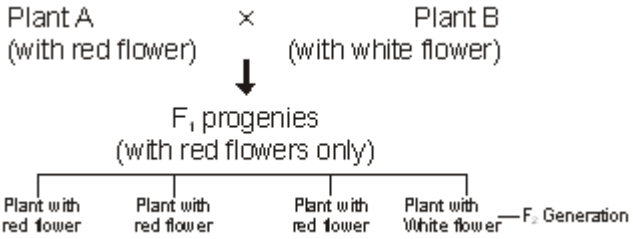
Mendel's Laws of Inheritance

The *Austrian* monk Gregor Mendel is considered as the pioneer of *modern genetics* and appropriately called *father of genetics*. His experiments with *Pisum sativum* were spread over 9 years between 1856 and 1864. The approach of Mendel was simple, logical, scientific, mathematical and analytical. Mendel decided to experiment with *Pisum sativum* because it is an annual and its different varieties possess contrasting character and hybridization is easy in it. Its flower is complete and the structure of flower ensures self fertilization. Anthers can be easily removed before dehiscing and flowers can be artificially cross fertilised with desired pollen.

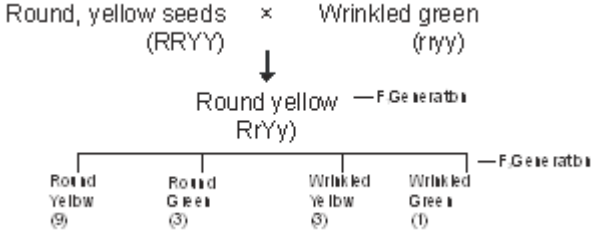
Actually Mendel himself did not postulate any genetical principles or laws. He simply gave conclusive theoretical and statistical explanation for his hybridization experiments in his research paper. However, it was Correns who postulated three laws on the basis of the result of Mendel's work:

1. **Law of Dominance:** "When two plants with contrasting characters are crossed together only one of these characters is expressed in the first generation" eg. when a true breeding tall plant is crossed with a true breeding dwarf one, all the plants of F_1 generation have the same height as the tall parent. Reciprocal cross gives the same result.

2. **Law of Segregation:** It is also known as "law of purity of gametes". The law states that the hybrids or heterozygous of F_1 generation have two contrasting characters or allelomorphs of dominant and recessive nature. They do not mix with each other and are segregated at the time of gametogenesis, so that each gamete receives only one character either dominant or recessive.



3. **Law of Independent Assortment:** When the parents differ from each other in two or more than two pairs of contrasting characters or factors then the inheritance of one pair of factors is independent of the other factors".



If we crossed a round and yellow seeded plant with a wrinkled and green seeded one, in F_1 hybrids all progenies have yellow round seeds when the F_1 hybrids are allowed to cross among themselves they produced 4 types of seeds in the ratio of 9 : 3 : 3 : 1. Where 'R' (round) is dominant over r (wrinkled) alleles and Y (hellow) is dominant over 'y' (green) alleles in dihybrid cross.

- **Gene:** An inherited factor that determines a biological character of an organism is called a genes this is a functional unit of hereditary materials.
- **Allelomorphs or Alleles, Homozygous and Heterozygous:** Alleles the abbreviated form of the terms 'allelomorphs' indicates alternative same gene for example, 'R' and 'r' are two allelomorphs of the same gene for flower colour. In pure red or pure white flower same allele is duplicated (RRandrr) while in hybrid red flower both the alleles will be present (Rr). An individual having only one allele or two identical alleles is known as homozygous (RR or rr). Similarly an individual having two different alleles will be called heterozygous or Hybrid (Dd).
- **Monohybrid, Dihybrid and Trihybrid Cross:** When a single character each controlled by a single pair of genes or alleles are considered while crossing it is known as monohybrid cross and the F_1 ratio of 3:1 is known as the monohybrid ratio. Similary crosses can be considered when two or three pairs of genes or alleles are involved. Such crosses will be called dihybrid and trihybrid crosses and the respective ratio (9:3:3:1 and 27:9:9:9:3:3:1 respectively) as *dihybrid and trihybrid ratios.*
- **Genotype and Phenotype:** The genotype of an individual represents sum total of heredity whereas phenotype represents features which are produced by interaction between genotype and environment. A genotype can thus exhibit different phenotypes under different conditions. Therefore, similar genotypes may not have the same phenotype. Conversely similar, phenotypes do not necessarily mean same genotype. In order to study the interaction of environment and heredity for the study of effect of different environments on a genotype would be to have individuals which have same genotype. This can be done by using clones, pure lines or inbred lines.

Sex-linked Inheritance

In dioecious individuals there can be two kinds of characters namely:

1. Characters which do not show any difference in reciprocal crosses.
2. Characters which show a difference in reciprocal crosses.

The former type of characters are located on autosomes and the latter are either located on specialised chromosomes known as sex-chromosomes or if located on autosomes are influenced by or depend on sex of the individual, who carries it. Traits which are carried on sex chromosomes are known as sex-linked traits. Other characters whose expression in a particular genotype depends on whether the individual is male or female are known as sex linked traits; another class of traits called sex-limited traits are distinguished by the fact that one form of this trait be expressed in one sex only and not in the other.

Sex Lnkage In Human Beings: In human beings, there are 46 chromosomes (23 pairs) present in each somatic cell. In female individual there are 22 pairs of autosomes and one pair of X-chromosomes (22 pairs + XX) and in male individuals there are 22 pairs of autosomes and one 'X' and one 'Y' chromosome (22 pairs + XY). Since female will produce only one type of gametes, gametes from male individual will determine the sex of the progeny. In man about fifty X-linked diseases have been reported. The most important and common X linked disease of man are:

1. Colour blindness
2. Haemophilia
3. Anhidrotic ectoderma (non-functional sweat glands)
4. Night blindness
5. Myopia (short sightedness)
6. Juvenile glaucoma (hardening of eye ball).

- **Turner's Syndrome:** In man there are 46 chromosomes of which 22 pairs are autosomes one pair is sex Chromosome (XY in male, XX in female). Turner's syndrome is characterised by monosomy of XO type i.e. one X chromosome of sex chromosome (XX) is missing, the Turner's syndrome individuals are phenotypically a female and can be characterised by short stature, webbed neck, underdeveloped breasts and small uterus.
- **Klinefelter's Syndrome:** Klinefelter's syndromes are characterised by trisomy (XXY) with total number of chromosomes 47. These are male individuals who are phenotypically fairly normal but have a very low sperm count and are therefore sterile. They have female like breast development, small testes and sparse body hairs.
- **Colour Blindness:** It is sex-linked inheritance found more often among men than women. It is regulated by a recessive gene. Individuals suffering from this tail to differentiate between colours, mainly between red and green colours.
- **Down's Syndrome (Mongolism):** It develops due to the trisomy of the 21st chromosome i.e. representation of the chromosome thrice instead of twice. It occurs once in every 500 to 600 child births. The individuals is mentally retarded and there is no cure for the abnormality.
- **Haemophilia:** This is a rare hereditary blood disorder marked by a tendency towards excessive bleeding. It is a sexlinked abnormality and is entirely restricted to males.
- **Albinism:** This affects skin preventing development of skin pigments. It happens due to an autosomal recessive gene Individuals suffering from this abnormality are found to lack pigmentation of skin, iris, retina, choroid and hairs. It has been proved that albinism results from

failure on the part of the amino acid. Tysosine, to become metabolised to melanin - a black pigment.

RECOMBINANT DNA AND GENE CLONING

The breakage of DNA molecule at desired places to isolate a specific DNA segment and then insert it in another DNA molecule at a desired position to obtain recombinant DNA. The technique often called genetic engineering is useful as genes can be isolated, cloned and characterised so that the technique has led to significant progress in all areas of molecular biology. Using the recombinant DNA technology we can isolate and clone single copy of gene or a DNA segement into indefinite number of copies, all identical. This has become possible because bacteriophages and plasmids reproduce in their usual style even after insertion of foreign DNA so that the inserted DNA will also replicate faithfully with the parent DNA. This technique is called 'gene cloning'.

GENE THERAPY

If a child is diagnosed to carry a defective gene leading to disability one may like to get this gene replaced by a normal functional gene. This is gene therapy in theory. Gene therapy can be used at two different levels.

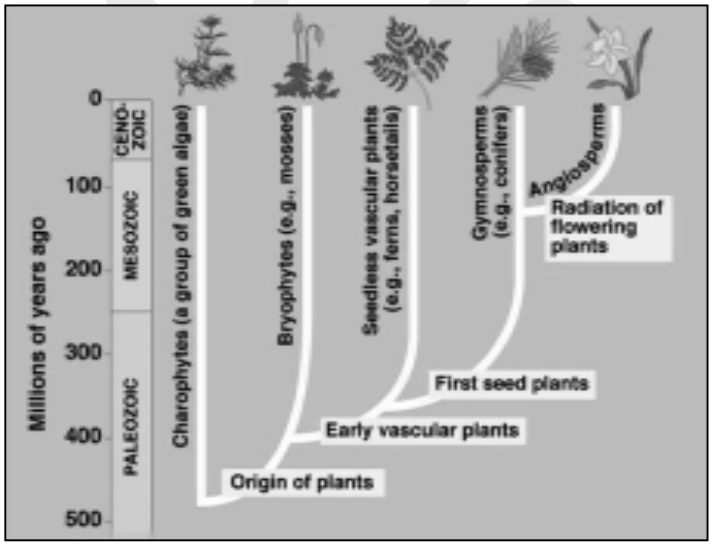
1. *Patient Therapy*: In which cells with healthy gene may be introduced in the affected tissue so that the healthy gene overcomes the defect without affecting the inheritance of the patient.
2. *Embryo Therapy*: In which genetic constitution of embryo at the post zygotic level is altered so that the inheritance will be altered. ■■■

WORLD OF PLANTS

CHRONICLE
IAS ACADEMY
A CIVIL SERVICES CHRONICLE INITIATIVE

According to longevity plants are annual, biennial and perennial. According to stature, height, growth & duration of stems, plants are herbs, shrubs, trees, creepers, twiners, climbers and lianas.

- **Annual** plants complete their life cycle within one year, e.g., Buttercup, Pea.
- **Biennial** plants complete their life cycle in two years – growing vegetatively and storing food in the first year; flowering and fruiting in the second year, eg., Henbane, Radish (in temperate areas).
- **Perennial** plants survive for several years, e.g., Canna, Zizyphus, Mango, Agave, Bambusa, Eucalyptus, etc. Some perennial plants ars also monocarpic, e.g., Agave, Bambusa tulda, Melocanna bambusoides. They die after bearing fruits.
- **Monocarpic** plants flower and fruit only once in life. All annuals and biennials are monocarpic. Some perennial plants are also monocarpic, e.g., Agave, Bambusa tulda, Melocanna bambussodies. They die after bearing fruits.
- **Polycarpic** are those perennial plants which bear fruits every year after attaining maturity, e.g., Mango, Artabotrys, Peepal.
- **Herbs** are small plants with soft and pliable stems. Herbs can be annual (e.g., Buttercup), biennial (e.g., Henbane) and perennial (e.g., Canna).
- **Shrubs** are perennial plants with medium height woody stems but without any distinction of trunk. Shrubs often have several branches of equal height and are called bushes, e.g., Capparis, Rose.
- **Trees** are tall perennial plants with a thick woody main stem or trunk. Trees are of three types:



1. **Caudex (Columnar):** Unbranched trunk, e.g., Coconut Palm, Date Palm.
2. **Excurrent:** Monopodial with one main stem or trunk from base to apex. Lateral branches giving a cone like appearance, e.g., Eucalyptus.
3. **Deliquescent:** The main stem or trunk is distinguishable only for some distance after it is replaced by a number of large branches which form a dome-shaped crown, e.g., Mango, Dalbergia.

- **Trailers** plants which spread on the ground without rooting at intervals, e.g., Tribullas terrestris, Euphorbia Prostrata.
- **Creepers** plants spread on the ground, rooting at intervals, e.g., Strawberry.
- **Twiners** are weak-stemmed plants where the stem coils or twines around an upright support, e.g., Ipomoea cairica (Railway Creeper), Quisquails (Rangoon Creeper).
- **Climbers** plants climb up an upright support by special clinging or clasping structures like tendrils, roots and hooks.
- **Lianas (Lianes)** are woody twiners and climbers are called lianas. They are found in tropical evergreen forests, e.g., Phenera (=Bauhinia) vahlii, Hiptage.
- **Epiphytes** are plants which live on other plants for space only. They are, therefore, also called Space parasites. Angiospermic epiphytes commonly live on trees, e.g., vanda, Dendrobium. They often posses hanging roots with hygroscopic outer spongy tissue called velamen.

The smallest angiosperm is **Wolffia** (a rootless aquatic). It has a diameter of 0.1 mm. The tallest plant is an angiosperm named **Eucalyptus regnans**. It reaches a height of 114 m or 375 ft. **Sequoia sempervirens** (a gymnosperm) is the second tallest tree with a height of 111m. Gymnosperm usually possess more taller trees as compared to angiosperms.

PERMANENT TISSUES

- **Commercial Fibres:** According to their origin commercial Fibres are divided into three types.
  1. **Surface Fibres :** Fibres obtained from surface of seeds, e.g., Cotton, CALOTROPIS, coconut (coir).
  2. **Best Fibres :** Nonxylem fibres present in the stems in pericycle or phloem, e.g., Cannabis (Hemp), Linum (Flax, Mostly pericycle/perivascular), Corchuts (Jute), Crotalaria (Sun Hemp), Hibiscus (Patua).

3. **Leaf Fibres :** Fibres extracted from leaves, e.g., Agava (Sisal Hemp), Musa (Manila Hemp).

- **Xylem:** Xylem or wood is a complex permanent tissue, which conducts sap or water. It also provides mechanical strengths.
- **Phloem:** Phloem or bast is complex permanent vascular tissue, which conducts organic food in the plant body.

1. **Phloem Parenchyma :** it takes part in storage as well as slow lateral conduction of food.
2. **Phloem Fibres :** Some commercial fibres are bast or phloem fibres, e.g., Hemp, Flax, Jute.

- **Lactiferous or Laticiferous Tissue :** It is connected with secretion of latex or an emulsion of oils, alkaloids, resins, proteins and sugars. Latex may be watery (e.g., Banana), milky (e.g., Banyan, Calotropis, Euphorbia, Heva)or coloured (e.g., Opium popy, Cannabis).

(i) Chicle / Chickle / Chewing Gum, Achras sapota.

(ii) Gutta Percha. Palaquim gutta.

(iii) Opium papaver somniferum.

(iv) Papain, Carica papaya.

(v) Rubber. Hevea brasiliensis

- **Xylem in Hydrophytes :** Absent or poorly developed, may be replaced by a cavity.
- **Cork Oak :** Cork is peeled after every four years when the plant (Quercus suber) becomes 20 years old.
- **Lightest Wood :** Ochroma pyramidale (= 0. lagopus).
- **Heaviest Wood :** Guaiacum officinale. Heaviest wood of India belongs to Acacia sundra.
- **Most Durable Wood :** Tectona grandis (Teak).
- **Strongest Soft Wood :** Cedrus deodar (Depdar, a gymnosperm).
- **Wooden Sports Articles** : (i). Cricket Bat – Salix (Willow). (ii). Vilion – Picea (Spruce). (iii). Billiard Ballphytelephas (lvory Palm). (iv). Hockey Blade – Morus (Mulberry). (v). Hockey Handle – Salix.

TRANSPIRATION

Loss of water in the vapour state from the aerial parts of plants is known as transpiration. 98-99% of water absorbed by a plant is lost through transpiration. Most of the transpiration occurs through leaves and is called foliar transpiration. Stomata are minute pore complexes, which occur on the soft aerial parts of the plants, especially the leaves. They hardly occupy 1-2% of leaf surface but due to perimeter diffusion the exchange capacity of stomata is very high – almost equal to the whole surface area of the leaf. Each stomata is surrounded by two small specialized and differentially thickened guard cells. Guard cells contain chloroplasts while the same are generally absent from other epidermal cells.

- **Amount of Transpiration:** 98 – 99% of absorbed water is lost through transpiration. Only 0.2% is employed in photosynthesis. Rest is used for growth.
- **Psychrometer:** Instrument for measuring atmospheric humidity as well as amount of water transpired.
- Percentage of various modes of Transpiration :

(i) **Stomatal Transpiration:** 50 – 97% of total.

(ii) **Cuticular/Epidermal Transpiration:** Ordinarily 3 – 10% but in herbaceous mesephytic plants it may be upto 50%.

(iii) **Lenticular Transpiration:** 0.1%.

(iv) **Bark Transpiration:** 0.5%.

- **Relative Humidity and Stomata:** Stomata remain open at R.H. above 70% and close below R.H. of 50%.
- **Transpiration on Hills:** High due to lower atmospheric pressure but low due to lesser hours of light and lower temperature. Transpiration is, therefore, near normal but the plants show xeromorphy due to lesser water availability.
- **Turgor Changes in Guard Cells:** Schwendener (1881) was the first to point out that stomatal opening and closing is due to turgor changes in guard cells.
- **CO_2 and Stomata:** Low CO_2 concentration induces stomata to open. High CO_2 concentration causes stomatal closure.
- **Photoactive Stomata:** Stomata open in response to light. The action spectrum consists of red and blue light (blue light is more effective in stomatal opening). Since, most of the transpiration is stomatal, the action spectrum of transpiration is red and blue light.
- **Wilting:** It is loss of turgidity and drooping of leaves and other soft aerial parts of the plant due to rate of water absorption being less than the rate of water loss in transpiration. Rapid absorption of water during day time for meeting requirement of transpiration produces water deficit around the rootlets.
- **Factors Influencing Transpiration:**

(i) **Light:** increases transpiration through opening of stomata and increased protoplasmic permeability. Solar radiations also increase temperature which simulates more loss of water.

(ii) **Temperature:** Increase in temperature increases transpiration.

(iii) **Humidity:** Increase in humidity decreases transpiration and vice versa.

(iv) **Wind (Air movement):** Air movement increases rate of transpiration by bringing dry air and removing moist air around the transpiring material. high velocity wind, however, closes stomata.

(v) **Atmospheric Pressure:** Low atmospheric pressure increases transpiration.

(vi) **Availability of Water:** Transpiration is directly influenced by availability of water. Reduced availability of soil water causes Wilting or loss of turgidity causing their drooping and rolling.

(vii) **Leaf or Transpiring Area:** Reduction in leaf area reduces transpiration as in succulents, cacti and euphorbia.

(viii) **Root/ Shoot Ratio:** Higher root/shoot ratio has higher transpiration.

(ix) **Stomata:** Sunken stomata reduce transpiration.. Stomatal opening and number have direct effect on transpiration.

(x) **Hair:** They reduce transpiration.

(xi) **Cuticle:** Transpiration is lower with the increase in thickness of cuticle.

- **Guttation:** Loss of water in the liquid state from uninjured parts of plants is known as guttation. It usually occurs from tips and margins of leaves during night or early morning when there is high atmospheric humidity as during wet seasons. Guttation occurs in some plants only (345 genera) e.g., Cucurbits, Potato, Tomato, Garden Nasturtium, Colocasia and other aroids, many grasses.
- **Photometer**: It is an instrument for measuring the rate of transpiration by shoots through measuring the rate of their water absorption.
- **Pyrometer:** An instrument that gives a rough idea about the degree of stomatal opening.

PLANT NUTRITION

Autotropic Plants: These plants are green and are able to manufacture their own organic food from inorganic raw materials with the help of chlorophyll and sunlight, majority of plants are autotropic.

Heterotrophic Plants: They are those plants which completely or partially obtain their food requirement from outside (other organisms or remains of organisms). Heterotrophic plants are of three types – saprophytes, parasites and carnivorous.

1. **Saprophytes:** They are heterotrophic plants which obtain their nourishment from dead decaying organic matter. Angiospermic saprophytes are called human plants. They are nongreen and bear only scale leaves. True humans plant is orchid Others employ fungi for obtaining nourishment from organic matter and hence mycotrophic, e.g., Neottia (Bird Nest Orchid). Monotropa (Indian Pipe) obtains nourishment from roots of forest plants through fungal hyphae.
2. **Parasites:** Parasites are organisms, which obtain their nourishment partially or wholly from other living organisms called hosts.

- Cuscutta (Dodder) is a total stem parasites with pale yellow stems and very small nongreen scale leaves. The parasites sends haustoria's into the host and make connections with its xylem and phloem.
- Arceuthobium is a total stem parasite which is the smallest among angiospermic parasites. Only the flowers are visible externally.
- Orobanche (Broom Rape) is a total root parasite. Ocemui grows on mustard, Cabbage, Brinjal, Potato and Tomato. Other total parasites are Striga (on Sorghum and Sugarcane), Cistanche (on Calotropis), Balanophora (on a number of forest trees) and Raffesia.
- Raffesia is a total root parasite which grows on a number of forest trees. The vegetative parts are thread like and embedded in the host. Only the flowers come out. Flower of Raffesia are the largest in plant kingdom with a diameter of about 1m and weight of 11 kg.
- Santalum or Sandal wood tree (santalum album) is a partial root parasite. The plant is a small tree, which yields fragrant heartwood.

3. **Carnivorous or Insectivorous Plants:** Carnivorous or insectivorous plants are predator plants which are otherwise autotrophic. They often grow in nitrogen deficient soils. The deficiency is overcome by trapping and digesting small animals. Some famous herbaceous plants are— Drosera (Sundew), Dionaca (Fly Trap), Utricularia (Bladderwort), Nepenthes (Pitcher Plant), etc.

SYMBIOSIS RELATION

- Symbiosis is a mutually beneficial relationship between two organisms. It is therefore, also called mutualism.

Symbiotic Nitrogen Fixation: Nitrogen fixing bacteria occur in root nodules of legumes. The bacteria get shelter and food from the plant. In return, they provide the plant with a major portion of nitrogen fixed by them.

Mycorrhiza: It is a mutually beneficial association between a fungus and the root of higher plants. The fungus absorbs water, salts (from organic matter) and protects the plant from soil borne pathogens. In return, it gets shelter and nourishment from the plant.

Myrmecophily: It is the symbiotic relationship between ants and some higher plants. The ants obtain food and shelter from the plant. They protect the plant from other animal.

- Angiosperms evolved about 130 million years back (cretecious period of Mesozoic era). They constitute about 50% of total plants, i.e., 250,000 species. Angiosperms are chrecterised by presence of flower, fruit, vessles and sieve tubes.
- Smallest Angiosperm is Wolffia (0.1 mm).
- Largest Angiosperm/Tallest Plant is Eucalyptus regnans with a height of 114 m (375 ft) Sequoia sempervirens (Red Wood Tree) is 111 m tall. It is a gymnosperm.
- Zostera is a marine Angiosperm.

MINERAL OR INORGANIC NUTRITION

Land plants absorb their mineral requirements from the soil in the region of their roots. Mineral absorption can be passive or active. Minerals usually occur in two forms, cations and anions.

- **Passive Mineral Absorption:** No energy is required. It can occur through (a) Diffusion. (b). Mass Flow. (c). Donnan Equilibrium. (d)Ionic Exchange.
- **Active Mineral Absorption:** Metabolic energy is utilized for this. Rate of respiration increases to meet the requirement of energy. The excess respiration is called salt respiration.
- **Essential Elements:** Only 16 elements are essential. The important characteristics of an essential element are

(i) The element is involved in the nutrition of plants.

(ii) It is required for completion of vegetative or reproductive growth of the plant.

(iii) The element cannot be replaced by another element. Deficiency of the element produces disorders which can be corrected only by the supply of that element. Essential elements are differentiated into two categories, macro-elements and micro elements. their ionic forms are respectively called macronutrients and micronutrients. Mineral salts dissolved in soil solution are constantly passing downwards along with percolating (gravitational) water. The phenomenon is called leaching.

- **Macronutrients (Major Elements) :** They are those essential elements which are required in quantity of less than 1 milligram / gram of dry matter. Micronutrients are six in number – Mn, Zn, Cu, Mo, B, CI.
- **Deficiency Symptoms:** (i). Chlorosis. Appearance of yellow colour due to nonsynthesis or destruction of chlorophyll. (ii). Necrosis. Death of cells e.g., deficiency of P, K, Mg, Ca, Mn, and Cl.
- **Framework Elements:** They are elements involved in building up of walls and products of plants, viz., C,H,O.
- **Protoplasmic Elements:** They are elements which become components of protoplasmic constituents like nucleic acids, proteins, chlorophyll, etc., viz., C, H, O, N, P and S.
- **Balancing Elements:** The elements overcome the toxic effects of other elements, e.g., Ca, Mg and K against Mn, Ni, Zn, Mn, B, Cu, Pb.
- **Functional Elements:** nonessential elements taking part in metabolic activity. e.g., Silicon, Cobalt, Sodium.
- **Sodium and Iodine:** Essential for animals but not for plants.
- **Potassium:** Most free elements of cell which is required for functioning of some 40 enzymes.
- **White Bud:** In acute Zn-deficiency the leaves of Maize become white and the buds lose green colour – hence white bud.
- Nonmineral Elements: C, H and O Nitrogen is both mineral and nonmineral.
- **Mineral Elements:** Elements obtained from soil, e.g., P, K, S, Mg, Ca, Fe, Mn, Zn, Cu, Mo, B, Ci and N Sulphar can be absorbed from air as SO_2.
- **Active Ion Uptake:** Salt / mineral uptake occurs through active absorption involving metabolic activity and expenditure of energy (salt respiration).
- **Chlorophyll:** Mg is component. Chlorophyll synthesis requires Fe (also Cu, Zn, and Mn).

ESSENTIAL ELEMENTS

1. **Nitrogen**

- **Functions :** Constituent of amino acids, proteins hormones, enzymes, coenzymes, chlorophyll ATP.
- **Deficiency :** Chlorosis appearing first in order leaves growth stunted, premature leaf fall.

2. **Phosphorus**

- **Functions:** Constituent of nucleotides, nucleic acids, certain protein phospholipids, NAD^+, $NADP^+$
- **Deficiency :** Poor growth, leaves dull green, chlorosis (mottled) followed by necrosis first in older leaves, premature leaf fall.

3. **Potassium**

- **Functions :** Synthesis of proteins, cell membrane, opening and closing of stomata, turgidity of cells, activator of some enzymes.
- **Deficiency :** Marginal chlorosis and necrosis appearing first in older leaves, premature death, cereals may show lodging.

4. **Calcium**

- **Functions :** As calcium petite in middle lamella, development of root and stem apices, cell membrane permeability, activator of some enzymes.
- **Deficiency :** Degeneration of meristems especially root tips, leaves with chlorisis and curling appearing first in young leaves, stunted growth, premature flower abscission.

5. **Magnesium**

- **Functions :** Constituent of chlorophyll, activator of enzymes of phosphate metabolism, fat synthesis, carbohydrate metabolism, maintenance of ribosomes.
- **Deficiency :** Interveinal chlorosis appearing first in order leaves, veins green, anthocyanin pigmentation and curling towards margins.

6. **Sulphur**

- **Functions :** Constituent of certain amino acids, proteins, vitamins, coenzyme A and ferredoxin

- **Deficiency :** Chlorosis, leaf curling, less juice content in citrus, reduced nodulation in legumes defoliation in Tea.

7. **Iron**

- **Functions :** Constituent of ferredoxin and cytochromes,activator of catalyst and required for chlorophyll synthesis.
- **Deficiency :** Intervenial chlorosis with green veins appearing first in young leaves, reduced growth.

8. **Manganese**

- **Functions :** Photolysis of water, activates carboxylases
- **Deficiency :** Intervenial chlorosis with grey sports or streaks, flowers sterile.

9. **Molybdenum**

- **Functions :** Activator of certain enzymes involved in nitrogen metabolism including nitrogen fixation.
- **Deficiency :** Mottled chlorosis with marginal infolding and necrosis, whiptail in crucifers, upper leaf half withering in monocots.

10. **Boron**

- **Functions :** Calcium metabolism, pollen germination, cell differentiation, carbohydrate transport, root nodulation.
- **Deficiency :** rowing of cauliflower, heart rot or brown heat, internal cork, top sickness, stunted growth, resetting of levels, decreased nodulation in legumes.

11. **Copper**

- **Functions :** Plastocyanin, cytochrome, oxidase, activator of certain enzymes.
- **Deficiency :** Dicback, exanthema, leaf tip necrosis (reclamation disease). Blackening of potato tuber.

12. **Zinc**

- **Functions :** Carbonic anhydrase. Auxin synthesis, activator of certain carboxylases.
- **Deficiency :** Little leaf disease, leaf rosette, internodes short, intervenal chlorosis appearing first marginally on older leaves followed by necrosis.

13. **Chloride**

- **Functions :** Photolysis of water, solute concentration and ionic balance (alongwith Na and K).
- **Deficiency :** Bronze coloured leaves, wilting, swollen root tips. Flower abscission. Little Leaf Disease. Smaller-sized leaves, e.g, Zinc Deficiency. Internal Cork of apple in boron deficiency.

HYDROPONICS

- **Hydroponics (soilless or Bengal Culture):** It is cultivation of plants on nutrient solution kept in tanks and having wire netting or other support for plants. Solution is acrated, changed or replenished and pH corrections made from time to time. A modification of hydroponics is aeroponics. Here the roots do not dip in culture solution but are regularly sprayed with the same.

CRITICAL ELEMENTS

- **Critical Elements:** Macronutrients which become commonly deficient in the soils are called critical elements. they are number – NP and K. most fertilizers contain critical elements. they are called complete fertilizers.

NITROGEN FERTILITY

- **Nitrogen Fertility:** Nitrogen is present in large abundance as gas in the atmosphere. However plants absorb their nitrogen salts by the phenomenon of nitrogen fixation. It is carried out by some bacteria and blue green algae (= cyanobacteria). They may be free living or symbolic. An example of symbiotic nitrogen fixation is Rhizobium leguminosarum (= R. radicicola) that gets associated inside the nodules of legume roots. Crops rotation with legumes maintains the nitrogen fertility of the soil.

ROOTS

Root is generally non-green underground, positively geotropic, positively hydrotropic and often negatively phototropic organ of the plant body. It is without nodes, internodes, leaves, flowers and fruits. Buds are absent except when roots take part in vegetative propagation, e.g., Ipomoea, Dalbergia, Populus, Dahlia. Root possesses a root cap (at its tip) and fine thread like root hairs (in subapical region). Primary functions of roots are:

1. Fixation of the plant to the soil.

2. Absorption of the water and mineral salts from the soil.

3. Conduction of absorbed water and minerals to the stem.

4. Soil binding.

Tap Root System

Tap root is the primary root which develops directly through elongation of the radicle of embryo and persists throughout the life of the plant. Tap root grows vertically downwards. It bears horizontal or obliquely oriented secondary roots (branches of first order). Secondary roots bear tertiary roots acropetally. Tertiary roots are oriented in different directions. Final root branches are called rootlets. They bear root caps and root hair.

Modification of Tap Root System:

- **Fleshy Tap Roots:** Tap roots become swollen due to storage of food. Secondary roots are thin and thread like.

1. **Conical:** Fleshy root is like a cone, being thicker towards

the base (soil surface) and gradually tapering towards apex, e.g., Carrot.

2. **Fusiform:** The root is swollen like a spindle, being thickest in the middle and narrowing towards both apex and base. In Indian Radish only the base is formed of swollen hypocotyl.

3. **Napiform:** Like a 'top' or sphere that thins out abruptly at the apex. In Turnip, the swollen part is hypocotyl. In beet the swollen part is formed jointly by hypocotyl and tap root.

4. **Tuberous:** Tap root is thickened except at the base without producing a definite shape, e.g., Mirabills, Trichosanthes.

- **Nodulated Roots**: In legumes (e.g., pisum sativum, Cicer arietinum) the roots bear numerous irregular swelling called called nodules and tubercles. The nodules contain nitrogen fixing bacteria of genus Rhizobium. Both bacteria and legume are benefited by this association called symbiosis. Due to it legumes are rich in proteins and are used in crop rotation.

- **Pneumatophores:** Pneumatophores or respiratory roots are short, vertical and negatively geotropical roots which occur in mangrove plants. The roots come out of swamp like in Avicennia, Sonneratia, Heritiera.

- **Buttress Roots:** They are laterally compressed horizontal roots which travel along the ground for some distance and provide extra mechanical support, e.g., Ficus elastica (Rubber Tree), Ficus religiosa (Peepal), Bombax (Simabl).

- **Reproductive Roots:** Some taproots or their branches develop adventitious buds and help in vegetative reproduction, e.g., Delbergia, Populus.

Adventitious Root System

It is a complex formed by roots that develop from parts of the plant other than primary root or its branches. Adventitious root is similarly defined as a root that develops from part of the plant other than the prolongation of radicle.

- **Fibrous Roots:** They are thin thread-like adventitious roots which often develop in groups. Even the main roots are narrow. Fibrous roots provide firm anchorage to the plant, e.g., Grass.

- **Fleshy Adventitious Roots:** Adventitious roots are swollen due to storage of food. They are of several types.

a. **Root Tubers:** Swollen roots occur singly, e.g., Ipomoea batatas (Sweet Potato).

b. **Fasciculated Roots:** Swollen adventitious roots occur in groups or fascicles, e.g., Asparagus (at intervals), Dahlia (at stem base).

c. **Palmate Roots:** Fleshy root is branched to give the appearance of a human hand, e.g., Orchis.

d. **Nodulose Roots:** The adventitious roots are swollen near their tips, e.g., Curcuma amada (Mango Ginger), Maranta (Arrow Root).

e. **Moniliform Roots:** The fleshy roots give a beaded appearance, e.g.,Momomrdica,some grasses.

f. **Annulated Roots:** The roots bear series of ring –like swelling , e.g., Ipecac (Cephaelis).

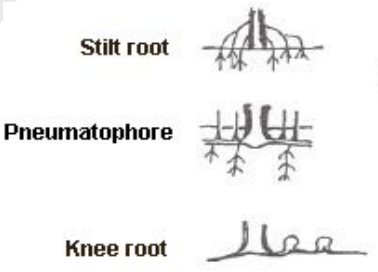
- **Prop roots:** They are pillar –like roots which give support to heavy stem branches, e.g.,Ficus bengalensis (Banyan Tree). Here the young prop roots hang in the air. They appear red on absorption of water. Rhizophora, a mangrove plant, also develops prop roots possess lenticels for aeration.

- **Stilt Roots (Brace roots) :** They grow obliquely downwards into the soil and develop fibrous roots. Stilt roots give additional support to the long unbranched stem, like supporting wires of a tall T.V. antenna pipe, e.g., Maize, Sugarcane.

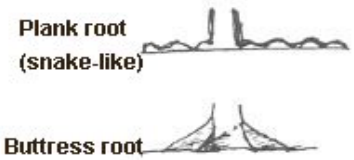
- **Haustoria or Parasitic Roots (Sucking Roots):** The adventitious roots penetrate the host to suck nutrition, e.g.,Cuscuta.

- **Clinging or Climbing Roots:** The adventitious roots help the plant in climbing by penetrating the cracks of the support, e.g., Betel (Piper betle), Black pepper (Piper nignum), Money plant (Potatos), Ivy (Hedra).

- **Epiphytic Hygroscopic Roots:** The roots occur in epiphytes. They hang in the air and posses Velamen or spongy tissue for absorbing moisture directly from atmosphere. The epiphytic roots are devoid of root hairs and caps, e.g., Vanda, Dendrobium.



- **Epiphyllous Roots:** The roots develop from leaves, especially the injured parts, e.g., Bryophyllum, Begonia.



- **Floating Roots:** The roots store air and, therefore, appear swollen and spongy. Floating roots the aquatic plants to remain on the surface of water, e.g., Jussive.

- **Modification of roots :**

Type	Examples
Fusiform	Radish
Napiform	Turnip & Beet
Conical	Carrot
Tuberous	Mirabilis
Fasciculated	Dahlia & Asparagus
Nodulose	Turmeric

	(All these are with the purpose of storage of food)
Prop root	Banyan, Rubber plant
Climbing	Betel, Pothos
Buttress root	Terminatia
	(All these are for support of the trees)
Sucking root	Cuscuta, Casytha
Respiratory root	Jussiaea
Epiphytic root	Orchids
Assimilatory roots	Tinospora

STEM

The stem is the ascending aerial portion of a plant and develops from the plumule. It is differentiated into nodes and internodes and bears leaves, branches and flowers. Leaves and branches develop from the nodes. In contrast to the root, they possess, buds which may be situated in the axil of the leaf or terminally. A bud is a young undeveloped condensed shoot consisting of a short stem and a number of tender leaves arching over its growing apex. The habit to the plant is displayed by its stem. Herbs are small plants with soft stems. Medium sized plants with hard and woody stems, that branch profusely to attain bushy appearance are called Shrubs. Trees are plants having stout and long trunks with professed branching according to their life span. The plants may be annuals, biennials, and perennials. Plants which complete their life cycle in one season only are termed annuals, eg. rice, sunflower, etc. Biennials complete their life cycle in two seasons eg. radish, cabbage. Plants that usually survive for a number of years and produce flowers and fruits during specific period each year are termed perennials eg. mango, bamboos.

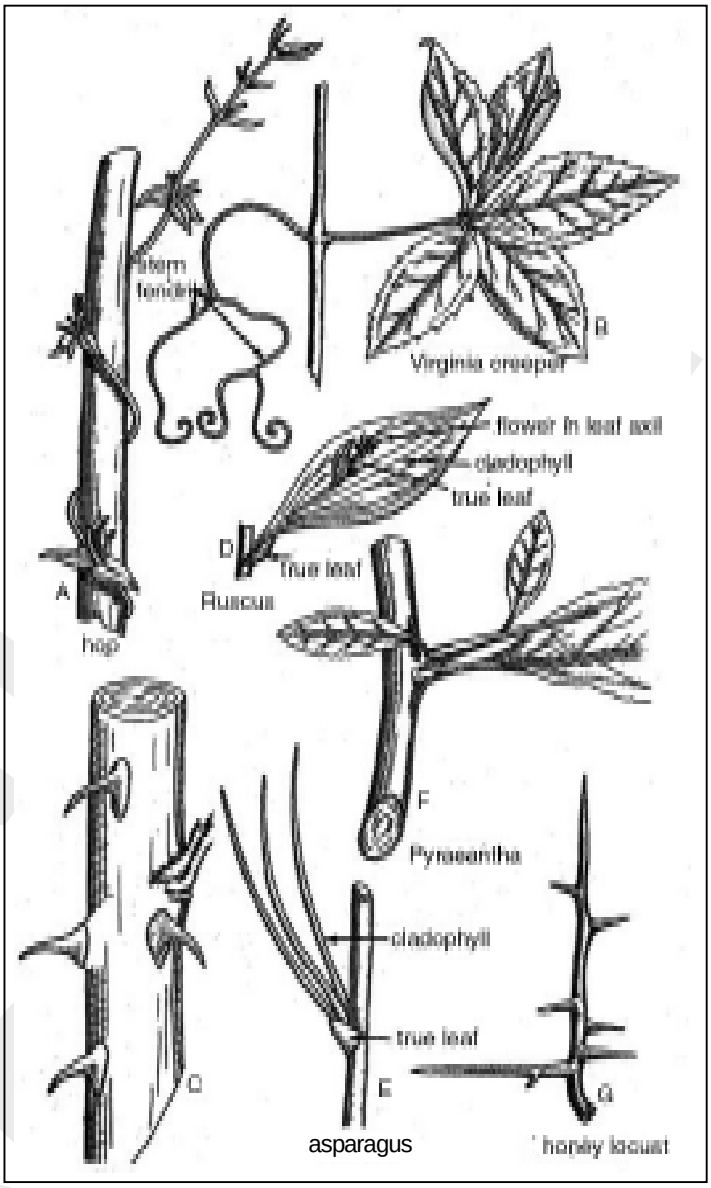
Buds: Bud is a condensed, undeveloped, compact shoot having a growing point covered with crowded overlapping immature leaves. Cabbage represents the largest bud; it is a vegetative bud.

Forms of Stem

Depending upon their placement, stems are of two types- aerial and underground.

A. Aerial or Epiterranean Stems

- **Reduced Stem:** The stem is very small. Reduced stem is like a green disc in vegetative phase Radish, Carrot and Turnip. It bears radical leaves. In bulb (e.g., Onion, Garlic) the reduced stem is a non-green disc.
- **Erect Stem:** The stem is vertical and strong enough to stand erect.
- **Weak Stem:** The stem is soft and weak. It requires a support for spreading. Weak stem can be upright or prostrate.



- **Upright Weak Stems:** They are those weak stems which grow upright with the help of support. Upright weak stems are of two kinds, twiners and climbers.

1. **Twiners:** They are weak stemmed plants where the stem coils or twines around an upright support. Clinging organs are absent, e.g., Ipomoea, Convolvulus, Quisqualis.
2. **Climbers:** The weak stemmed plants rise up an upright support with the help of special clinging or coiling structures. Depending upon the clasping structures, climbers are of the following kinds.

(a) **Tendrill Climbers:** Tendrils are narrow thread-like green sensitive structures which can coil around the support and help the plant to cling and climb. Tendrils can be modification of stem, leaf or leaf parts. Stem Tendrils- Grape Vine; Leaf Tendrils- Nepenthes or Pitcher Plant.

(b) **Root Climbers:** Betel, Pepper.

(c) **Scramblers:** Climbing rose.

- **Prostrate Weak Stems :** The weak stems grow over the ground and take its support for spreading. They are of four types—

1. **Trailers:** The shoots spread over the ground without rooting at intervals, e.g., Euphorbia Prostrata.

2. **Runners:** Runners are special, narrow, green, horizental branchs which develop at the base of crown and root at intervals where new crowns are also formed, e.g., Lawn Grass.

3. **Stolons:** They are special above ground (e.g., Strawberry) or underground (e.g., Colocasia) horizontal branches, which develop at the base of a crown, can arch over small obstacles, root at intervals and form new crowns.

4. **Offsets:** They are one internode long runners formed in rosette plants at ground or water level, e.g., Water Lettuca, Water Hyacinth.

B. Underground Stems :

Underground or subterranean stems are nongreen like roots but differ from the latter in (i) absence of root caps and root hairs (ii) presence of terminal bud, nodes and internodes, occurrence of leaves (scale or foliage) on the nodes and exogenous branching. Underground stems are of the following five types.

- **Sucker:** It is non-green narrow stem, which develops at the underground base of a crown, grows horizontally for some distance and then comes out obliquely to form a new crown, e.g., Chrysanthemum, Mentha (Mint). Banana possesses sucker-like structures for formation of new leafy trunks.
- **Rhizome:** It is an indefinitely growing perennial main stem, which occurs underground and gives rise to annual aerial branches or leaves under favourable conditions e.g. Ginger, Turmeric, Canna (Exception Banana).
- **Corm:** It is annual, vertically growing thick, swollen, spherical or subspherical underground stem, which bear circular nodes, sheathing leaf bases and scales. Buds present on corms give rise to new aerial shoots and new corms, e.g., Elephant Foot.
- **Bulb:** It is an underground, condensed shoot having a reduced discoid stem, fleshy scales, buds and adventitious roots e.g., Onion, Garlic, Lily.
- **Stem Tubers:** They are swollen tips of underground branches, which do not bear roots. Each tuber has a number of eyes (nodes with leaf scar or ride and bubs) e.g., Potato.

Thorns, Spines and Prickles: They are sharp, pointed, straight or curved hard structure performing similar functions. Thorms are modified stem structure while spines are modified leaves of leaf parts. Both of them connected with the internal structure of axis and possess vascular tissue. Prickles are epidermal outgrowths or emergences, which do not have vascular supply.

Branching of the Stem

In most of the cases new branches arise from the sides of the main stem that is called lateral branching which is of two types:

(i) **Racemose:** Indefinite or monopodial type of branching. The main stem continues to grow indefinitely by its terminal bud. The mode of branching is termed acropetal eg. Casuarina, Ashok tree.

(ii) **Cymose:** In this case the terminal bud of a branc ceases to grow but lateral branches, verying in number soon develop and grow vigorously from below. The mode of branching is basipetal, eg. Datura, Croton, etc.

- **Pseudostem/False Stem:** A trunk formed by leaf bases as in Banana. A space passes through it to become aerial.
- **Largest Bud:** Cabbage.
- **Liana:** Woody climber or twiner.
- **Creeper:** Plant spreading on the ground and rooting at intervals. Viz., runner, stolen.
- **Allyl Sulphide:** Characteristic smell of Onion and Garlic.

LEAF

Typical life is a green expanded exogenous lateral outgrowth, which arises from the node of a stem or its branch. The leaf is a flattened lateral outgrowth of the stem and bears a bud in its axil. A typical angiosperm leaf consists of three parts: (1) Leaf base, (2) Petiole (3) Lamina. The largest leaves are those of floating leaved Aquatic Victoria (1m in diameter).

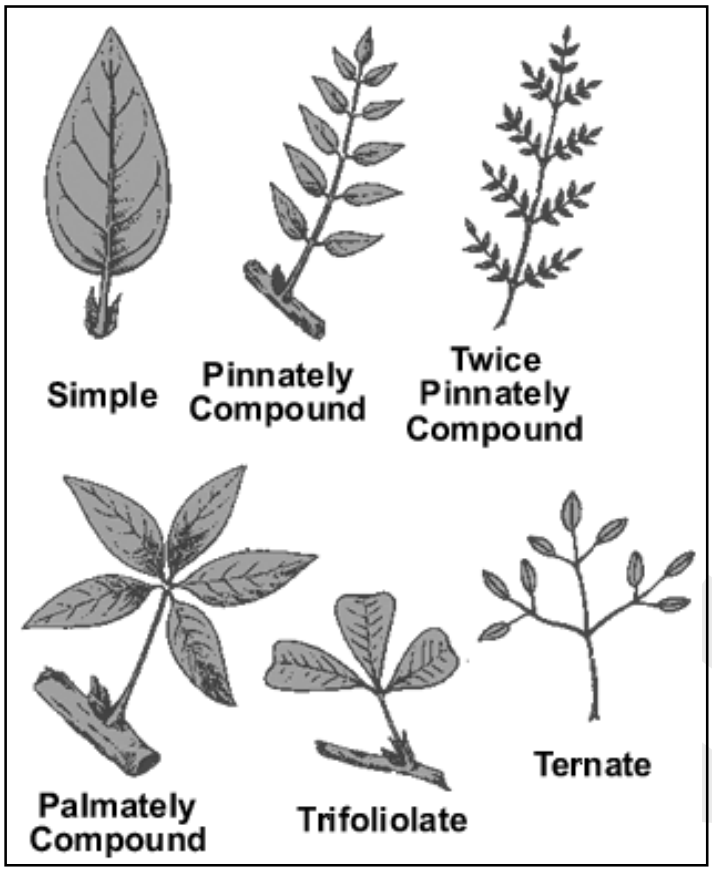
Leaf Duration

- **Caducous:** Falling off soon after their formation, e.g., Opuntia.
- **Deciduous (Annual):** Falling off under unfavorable conditions or at the end of growing season, e.g., Poplar, Mulberry.
- **Persistent (Evergreen):** Leaves remain on the plant for more than one year, fall off individually at different times so that the plant gives an evergreen look, e.g., Mango, Eucalyptus.

Simple and Compound Leaf

A leaf is said to be simple, when its lamina is entire or incised but the incisions do not touch the mid rib. When the incision of the lamina goes down to the mid-rib the leaf becomes compounds and it has a number of leaf segments, these leaf segments are known as leaflets. A leaflet is like a simple leaf but it lacks a bud in its axil. A compound leaf is said to be pinnate when the leaflets are lateral to the mid-rib, it may be unipinnate. eg. Rose; Bipinnate, eg. Gold mohur (Delonix) and Tripinnate, eg. Moringa. In palmetely compound leaves the petiole bears a number of leaflets which resemble a palm. Depending upon the number of leaflets, it may be Unifoliate, eg. Lemon; Bifoliate, Trifoliate, eg. Wood apple; Quadrifoliate eg. Marsilea and Multifoliate eg. Bombax, Cleome.

In many plants the leaf base is swollen and is termed pulvinus. The arrangement of veins in the lamina is termed as vegation. It is of two types:



1. **Reticulate:** When the veins are forming a network, it is characteristic feature of the dicots.
2. **Parallel:** When the veins are parallel and do not form a network. It is characteristic of monocots.

- **Phyllotaxy:** It may be defined as the arrangement of leaves on the stem. It is of three main types:

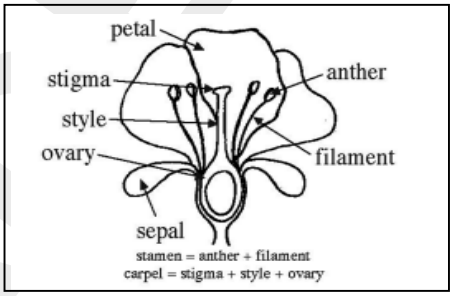
1. Alternate, eg. China rose
2. Opposite, eg. Guava, Calotropis
3. Whorled, eg. Nerium

Modification of leaves

Some of the important modifications of leaves are:

- **Tendril:** Leaf or leaf parts are modified into thread like sensitive structures called tendrils. Leaf tendrils are unbranched and maked. Modified for the purpose of climbing, eg. Pea.
- **Whole Leaf Tendrils:** The whole leaf is modified into tendril for climbing in Wild Pea.
- **Leaflet Tendrils:** Upper leaflets of sweat Pea and Edible Pea are transformed into tendrils.
- **Spine:** Modified for the purpose of defence, eg. Opuntia.
- **Scale leaves:** eg. Onion.
- **Pitcher:** In some of the insectivorous plants, eg. Nepenthes, the lamina assumes the form of a pitcher with a lid to trap the insects, the inner walls of the pitchers possess a number of digestive glands which secrete a fluid.
- **Phyllode:** When the petiole becomes leaflike, it is termed as phyllode, eg. Australian Acacia.
- **Plant with single Leaf:** Monophyllea.
- **Plant with Two Leaves only :** Welwitschia (a gymnosperm).
- **Bradest Leaf:** Victoria amazonica (= V.regia. amazon Lily), an aquatic plant with floating leaves diamenter 15-18 m.
- **Longest Leaf:** Rophia vinifera (Bamboo Palm, Wine Raffia Palm) 10-15 m.

FLOWER



The flower is a highly specialised condensed structure. The axis of the flower is known as **thalamus**. A typical flower shows four sets of members arranged in successive whorls. They are calyx, corolla, androceium, and gynaecium. Calyx and Corolla consitute accessory worls and Androecium and Gynaecium constitute the essential whorls of the flower. When calyx and corolla are undistinguishale, they are known as **perianth** (common among monocots). In absence of accessory whorls, it is known as **achlamydeous**. When all the four parts of a flower are present, it is termed as complete. In the absence of any one of these, it is termed as incomplete. When both male and female components (androecium and gynoecium respectively) are present in the same flower, it is termed as **bisexual or hermaphrodite**. Unisexual flowers may be staminate (when gynaecium is absent) or pistillate (when androecium is absent). A flower without any functional stamen or pistil, it is known as neuter or sterile. If male and female flowers develop on the same plant, it is called **monoecious**, otherwise, it is **dioecious**.

A flower is said to be an **actinomorphic** when its symmetry remains undisturbed, even after cutting the flower into two halves through the axis, whereas **zygomorphic** flowers are those where their symmetry get disturbed, after cutting the flower into more than two halves through their main axis. All the flowers, broadly, can be divided into 3 types, depending upon the relative positions of the floral parts on thalamus, i.e.

1. **Hypogyny:** When the other floral part i.e. sepals, petals, stemens are inserted on thalamus below the ovary in the flower, eg. China rose.
2. **Epigyny:** When the other floral parts are inserted above the ovary in the flower, the ovary in this case is said to be inferior, eg. Guava, Cucumber etc.

3. **Perigyny:** When the other floral parts are inserted at the same level at the ovary, eg. Rose, Pea etc.

- **National flower of India**— Lotus
- **Anthology—** Collection of flowers (and flowering plants).
- **Polygamous—** (i) A plant bearing intersexual male and female flowers. E.g., Mango, Litchi,. (ii) A male consorting with more than one female.
- **Largest Flower—** Refflesia(1m).parasitic.
- **Longest Stigma—**Maize

FRUIT

Fruit is ripened ovary, which consists of pericarp (Fruit wall from ovary and attached parts) and seeds formed after fertilization of ovules. Fruits are of three basic types:

(i) **Eucarps (Eucarpic Fruits):** They are true formed from superior ovary, having functional seeds but no additional floral parts fused with them, e,g, Grape, Mango.

(ii) **Pseudocarps (Accesory of False Fruits):** They are fruits generally formed from inferior ovary, having functional seeds and additional floral parts fused with pericarp, e.g., Apple.

(iii) **Parthenocarps (Parthenocarpic Fruits):** Seedless fruits. The fruits are formed without fertilization so that functional seeds are absent are absent, e.g., Bannana.

Fruits Categories

Fruit is a characteristic feature of the flowering plants. It may develop either after fertilization or without fertilization. The fruit which is produced without fertilization is called parthenocarpic fruit, eg. Banana, Citrus, Grape etc. Fruits are of two types:

(a) **True Fruits:** which develop from the ovary.

(b) **False Fruits:** which develop from any other floral parts except ovary.

The pericarp (fruit wall) is usually differentiated into three layers - an outer epicarp, a middle mesocarp and an inner endocarp.

Fruits are usually classified into three group - simple, aggregate and multiple.

I. **Simple Fruits:** When only one fruit is produced from ovary of flower, it is called simple fruit. Simple fruits are of two types:

1. Dehiscent fruits, eg. Mustard, Pea, Lady's finger, Gossypium, Datura, Poppy.
2. Indehiscent fruits, eg. Mango, Coconut, Betelnut, Chestnut.

Simple fruits have been further divided into two classes:

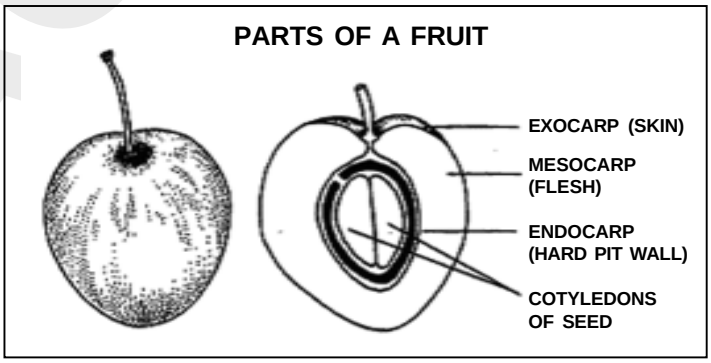
- **Succulent Fruits:** It includes following types:
  (a) Drupe - eg. Mango, Plum, Coconut, Chestnut, Almond, Betel nut etc.
  (b) Berry - eg. Tomato, Chilli, Grapes, Banana, Papaya, Brinjal etc.
  (c) Pepo - eg. Cucumber, Watermelon etc.
  (d) Pome - eg. Apple, Pear etc.
  (e) Hespiridium eg Citrus, Orange etc.
  (f) Balausta - eg. Pomegranate
- **Dry Fruits:** It includes following types:

(a) Achenial - It has been further divided into:
  (i) Achene - eg. Rose, Climatis etc.
  (ii) Caryopsis - eg. Wheat, Paddy, Maize etc.
  (iii) Cypsela - eg. Marigold, Sunflower etc.
  (iv) Nut - eg. Cashew nut, Litchi etc.

(b) **Capsular Fruits:**
  (i) Legume or Pods - eg. Pea, Bean etc.
  (ii) Follicle - eg. Magnolia (Champa), Caltoropis.
  (iii) Siliquala - eg. Mustard, Radish etc.
  (iv) Capsule - eg. Poppy, Datura, Lady's finger, Gossypium etc.

(c) **Schizocarpic Fruits:**
  (i) Lomentum - eg. Groundnut, Tamarind, Acacia etc.
  (ii) Cremocarp - eg. Coriander
  (iii) Carcerulus - eg. Osmimum

II. **Aggregate Fruits: They are of following types:**
  (i) Etaerio of achenes - eg. Lotus
  (ii) Etaerio of follicle - eg. Magnolia



  (iii) Etaerio of barries - eg. Mulberry
  (iv) Etaerio of drupes - eg. Strawberry

III. **Composite Fruits:** They are of the following types:
  (i) Sorosis - eg. Jack fruit, Pineapple, Mulberry etc.
  (ii) Syconus - eg. Fig, Banyan etc.

Reproduction

Flowers constitute the reproductive organs: A flower is a specialized shoot essentially meant for sexual reproduction and has evolved as a result of progressive speculation of reproductive structures.

Inflorescence

It is a reproductive shoot bearing a number of flowers in terminal or axillary position. It is of three types — racemose, cymose and special type. In racemose, the main axis is unlimited in growth, whereas in cymose, the growth of main axis is limited. It is of following types:

1. **Receme:** The main axis of inflorescence bears stalked flowers, eg. Mustard, Radish etc.
2. **Spike:** This is like raceme but the flowers are sessile, eg. Adhatoda.
3. **Catkins:** The main axis of inflorescence which is a long and pendulous bears unisexual flowers, eg. Mulberry.
4. **Spadix:** The main axis inflorescence is fleshy enclosed by one or several large and brightly coloured bracts called the spathes, eg. Banana.
5. **Corymb:** The main axis is short and bears stalked flowers in such a manner that they are placed almost at the same level, eg. Lantana, Cherry.
6. **Unbel:** It has very shortened and suppressed axis, flowers have stalks of equal length, it is umbrella like in appearance eg. Coriander, Carrot.
7. **Head of Capitulum**: The main axis is flattened, more or less convex structure order, eg. Sunflowers.

Special types of inflorescence :

- **Hypanthodium:** The main axis forms a cup shaped receptacle with a small opening at the top. Flowers are arranged within the cup, eg. Ficus.
- **Cyathium:** Here, one central flower (represented by a single pistil) is surrounded by a large number of male flowers (each represented by single stamens) the whole structure is enclosed in cup like structure, eg. Euphorbia, Pedialanthus.
- **Verticillaster:** Flowers are sessile and appear in a false whorl or vertically around the stem, eg. Ocimum (Tulasi).

POLLINATION

Pollination is the transfer of pollen grains from anthers to stigmas. It is of two types – self pollination and cross pollination.

1. **Self Pollination:** Self pollination is the transfer of pollen grains from anthers to the sigma mature simultaneously. The phenomenon is called homogamy. Self poltination is of two types – autogamy and geitonogamy.

- **Autogany:** It is self pollination which occurs between anther and sigma of the same flower. Mirabilts or Four O' Clock the Potato, Sunflower, Peanut (= Groundnut), Wheat, Tobaco, tomato, Linseed, Jute, etc.
- **Geitonogamy:** It is the transfer of pollen grains from anthers of one flower to another flower of either the same or genetically similar plant. Geitonology resembles cross pollination in the requairment of pollen transfer or pollinating agency.

Importance: Self pollination maintains purity of race and superiority of variety once developed it, however, ultimately leads to degeneration.

2. **Cross Pollination:** It is the transfer of pollen grains from the anthers of one flower to the sigma of a genetically dissimilar flower. Cross pollination is also called Xenogamy. Both xenogamy and geitonogamy are included under allogamy though this term is more commonly used for cross pollination. Cross plination is of following types. Cross pollination is useful in increasing yield and adaptability. It eliminates defective traits and is helpful in production of new varieties. Cross pollination may bring in hybrid vigour. It is, however, wasteful and may dilute very good characters of the race.

- **Anemophily (Wind Pollination):** In anemophily, air currents pick up pollen from dehiscing anthers. The receptive stigmas pick up the pollen from air currents. Hay fever is allergic reaction to the presence of pollen in the air. Plants commonly causing hay fever are Amaranthus, Chenopoditnm, Castor and Sorghum.
  Examples—Date Palm, Coconut Palm, Poplar, Mulberry, Willow, Grass, Maize, Chenopodium, Amaranthus, Cannabis.
- **Hydrophily:** It is pollination brought about through the agency of water. (e.g., Lemna, Vallisneria) and hypohydrophily (e.g., Zostera, Ceratophyllum), Vallisneria (Tape Grass or Eel Grass).
- **Entomophily:** It is pollination brought about through the agency of insects. Entomophily is the most common and specialized type of pollination. The important traits of entomophilous flowers are —

(i) Flowers are coloured.

(ii) Flowers commonly possess an aroma or scent.

(ii) Visiting insects are fed by either nectar (e.g., Jasmine, Buttercup, Larkspur, Adhatoda, or edible pollen (e.g., Magnolia, Papaver).

(iv) Pollen grains have a sticky surface due to pollenkitt.

(v) Stigmas are sticky.

(vi) Flowers are strong enough to bear the weight of visiting insect. They may also provide insects with shelter.

- **Ornithophily:** It is allogamy performed by birds. Two types of long-beaked small birds take part in pollination – sun birds and humming birds (hover over the flower). Other birds performing pollination are Crow. Bulbul, Parrot, Meynah, etc. ornithophilous flowers are large and strong with abundant nectar or edible part, e.g., Erythrina, Bombax, Agave, Bignonia, Grevillea.

- **Chiropterophily:** It is allogamous pollination performed by bats, e.g., Anthocephatus (Kadam), Bauhnia megalandra, Kigelia pinnata (Sausage Tree), Adansonia (Boabab Tree).
- Malacophily is cross pollination brought abount by the agency of snails, e.g., Arisaema and some other aroids.

VEGETATIVE PROPAGATION

Vegetative Propagation is the formation of new plants from detached vegetative parts or propagules of the parent.

Vegetative Propagation in Lower Plants —

(i) **Binary Fission:** A mature nuclei divides into two daughters e.g., bacteria, diatoms, Euglena.

(ii) **Budding:** A small outgrowth of the cell that grows and separates, e,g., Yeast.

(iii) **Fragmentation:** Mechanical disturbance, emptying of intercalary cells, decay older parts, change in environment, etc. cause breakage of the plant body into two or more parts, each of which behaves as independent plant, e.g., Marchantia, Spirogyra, Nostoc.

(iv) **Gemmae:** Gemmae are small undifferentiated multicellular green propagules which separate and form new plants, e.g., Marchantia, Funaria.

(v) **Tubers:** Underground perennating structures, e.g., Selaginella chrysocaulos, marsilea, mosses.

Vegetative Propagation in Higher Plants : Natural modes of vegetative propagation in higher plants are :

(i) **Roots:** Tap root branches can develop adventitious buds and form new plants in Guava, Poplar (Populs) and Dalbergia. Fleshy advemtitious roots also take part in vegetative propagation in sweet Potato, Dahlia and Asparagus.

(ii) **Underground Stems:** (a). Stem tubers develop new plants in the region of eyes, e.g., Potato, Artichoke, (b). Buds present inside bulbs sprout to form new plants in Onion, Garlic and Narcissus. (c). Corms bear bunds for growth of daughter plants, e.g., Crocus, Colocasia, Amorphophallus, Fressia. (d). Rhizomes take part in vegetative propagation due to presence of buds, e.g., Ginger, Turmeric, Banana (also suckers), ferms. (e). Breaking of suckers forms independent plants in mint and Chrysanthermum.

(iii) **Subaerial Stems (Creeping stems):** Runners, stolons and offsets are meant for forming new crowns at their tips as well as nodes in case of the former two. Breaking of these horizontal stems converts the different crowns into independent plants, e.g., Eichhomia, Pistia (offsets), Grass (runners), Strawberry (stolons).

(iv) **Aerial Shoots:** Segments of Opuntia and other cacti produce new plants after falling on ground.

(v) **Leaves:** Injured leaf of Begonia develops new plants in contact with soil while uninjured fallen Bryophyllum leaf does so from buds present in its marginal notches.

(vi) **Bulbils:** They are fleshy buds which on falling down produce new plants. E.g., Oxalis, Agave, Dioscorea, Lily etc.

Horticultural or Artificial Methods of Vegetative Propagation—

1. **Use of special Vegetative Organs:** Many plants are multiplied vegetatively by using their specialized vegetative structure like tubers (e.g., Sweet Potato, Dahlia), corm (e.g., Crocus, Colocasia, Galdiolus), bulb (e.g., Garlic, Onion), part of rhizome (e.g., Banana, Ginger) and stem tuber (e.g., Potato), bulbil (e.g., Pineapple).

2. **Cuttings:** Sansevieria is propagated by leaf cuttings. Root cuttings are used in case of Blackberry. Stem cuttings (20-30 cm segments of one year old stem) are employed in case of Rosa, Clerodendron, Duranta, Citrus, Bougainvillea, Tea, Coffee and Cocoa. Rooting of stem cutting is hastened by dipping in NAA or IBA.

3. **Layering:** The middle part of a soft basal branch is defoliated, slightly injured (tongueing, notching, ringing) and pegged in the soil to develop adventitious roots. Later on the branch or layer is separated and planted, e.g., Cherry, Jasmine, Grape Vine. In serpentines layering the branch is pegged at several places so as to form many plants. In mound layering the shoot is pruned and lower part covered by soil when a number of new shoots develop, e.g., Gooseberry, Current. In air layering (gootee) a ring of bark is removed from an aerial shoot. It is covered by grafting clay, hay, cow dung, clay, water) with small quantity of root promoting hormone and wrapped in polythene. After 1-3 months, roots appear and the shoot is removed to be used for planting, e.g., Litchi, Pomegranate.

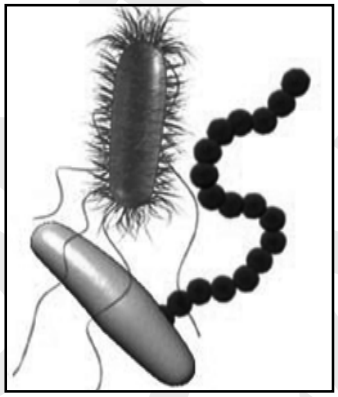
4. **Grafting:** Cambium bearing shoot (= scion = graft) of one plant is joined to cambium bearing stump (root system = stock) of a related plant through different unions like tongue grafting (= whip or slice grafting), wedge grafting, crown grafting, side grafting, In crown grafting several scions are joined to a single stock. Grafting is used for quick multiplication and proper growth of better varieties with weak roots, e.g., Mango, Apple, Pear, Rubber, Orange, etc. In bud grafting the scion is a bud with a small piece of bark, e.g., Rose, Apple and Peach. ■■■

MICROOORGANISMS

BACTERIA

Bacteria, microscopic & unicellular organisms, are often coccus- (spherical) or rod-shaped and 0.5-5 µm in the longest dimension, although the wide diversity of bacteria can display a huge variety of morphologies. The study of bacteria is known as bacteriology, a branch of microbiology.

Bacteria are ubiquitous in the environment, living in every possible habitat on the planet including soil, underwater, deep in the earth's crust, and even such environments as sulfuric acid and nuclear waste. There are typically ten billion bacterial cells in a gram of soil, and one hundred thousand bacterial cells in a millilitre of sea water. Bacteria play an important role in the cycling of nutrients in the environment. They play many important steps in the nutrient cycle as catalysts, such as the fixation of nitrogen from the atmosphere.



There are more bacterial cells on each of our bodies than there are cells of our own and bacteria are a natural component of the human body, particularly on the skin and in the mouth and intestinal tract. Bacteria are important to human health, as they are the causative agent of many infectious diseases, including cholera and tuberculosis. Historically, bacteria have been responsible for such diseases as bubonic plague and leprosy, but after the discovery of antibiotics many bacterial diseases are able to be controlled. Bacteria are also important to numerous industrial processes, such as wastewater treatment and more recently the industrial production of antibiotics and other chemicals.

The first bacteria were observed by Anton van Leeuwenhoek in 1674 using a single-lens microscope of his own design. The name *bacterium* was introduced much later, by Ehrenberg in 1828, derived from the Greek word meaning "small stick".

Cell Morphology and Arrangement

Bacterial cells are typically 0.5-5 ìm in length, however some species, for example Thiomargarita namibiensis and Epulopiscium fishelsoni, may be up to 500 µm (0.5 mm) long and are visible to the unaided eye. Among the smallest bacteria are members of the genus Mycoplasma which measure just 0.2 µm; approximately the same size as the largest viruses.

Most bacteria are either spherical, called coccus or rod-shaped, called bacillus (*pl*. baccili, from Latin *baculus*, stick). Some rod-shaped bacteria, called vibrio, are slightly curved or comma-shaped, while others, called spirilla, form twisted spirals. Many bacterial species exist simply as single cells, while others tend to associate in diploids / pairs (for example Neisseria), or chains (such as Streptococcus), while members of the genus Staphylococcus, form a "bunch of grapes" clusters. Bacteria can also be elongated to form filaments, for example the Actinomycetes.

The bacterial cell is bound by a lipid membrane, or plasma membrane, which encompasses the contents of the cell, or cytoplasm, and acts as a barrier that holds nutrients, proteins and other essential molecules within the cell. Bacteria do not have membrane-bound organelles in the cytoplasm and thus contain few intracellular structures. They lack mitochondria, chloroplasts and the other organelles present in eukaryotic cells, such as the golgi apparatus and endoplasmic reticulum.

Bacteria do not have a membrane-bound nucleus and their genetic material is typically a single chromosome located in the cytoplasm as an irregularly-shaped body called the nucleoid. The nucleoid consists mainly of the chromosome but has also associated proteins and RNA. Like all living organisms bacteria contain ribosomes for the production of proteins.

External to the cell membrane is the bacterial cell wall. Bacterial cell walls are composed of peptidoglycan, different from the cell walls of plants and fungi which have cell walls of cellulose and chitin, respectively. The cell wall is essential to the survival of bacteria; the antibiotic penicillin is able to effectively kill bacteria by inhibiting a step in the synthesis of peptidoglycan and stopping the production of the cell wall.

Flagella are rigid protein structures, about 20 nm in diameter and up to 20 µm in length, that are used for motility.

Some bacteria also produce nutrient storage granules, such as glycogen, polyphosphate, sulphur or polyhydroxyalkanoates. These storage compounds enable bacteria to store compounds for later use. Certain bacterial species, such as the photosynthetic Cyanobacteria, produce internal gas vesicles which they use to regulate their buoyancy to regulate the optimal light intensity or nutrient levels.

Bacteria serve as a link between plants and animals. They are now regarded as the simplest plants because of the following reasons:

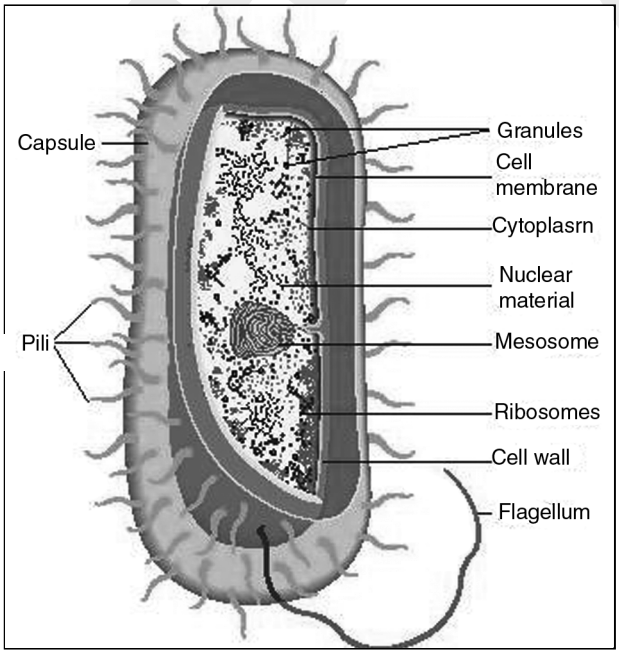
- They have a rigid cell wall made up of mucopoly-sacchrides.
- Some of the bacteria like chlorobium are autotrophic, like green plants.
- Some forms of bacteria are capable of sythesizing vitamins just like green plants.
- Bacteria take in their nutrition in the form of solution only.

Bacteria *differ* from the eukaryotic cells of other plants in the following respects:

- The mitochondria and endoplasmic reticulum are lacking in the cytoplasm.
- The nuclear body does not divide by mitosis.
- The photosynthetic lamellae when present are not organised into chloroplast.
- No protoplasmic streaming movements seen.
- Contains no vacuoles.

Respiration in Bacteria

Most bacteria make use of the free oxygen of the atmosphere or oxygen dissolved in the liquid environement, they are called aerobes or aerobic bactria. Free oxygen is necessary for their respiration. There are many bacteria which are able to live and multiply in the absence of free oxygen. They obtain oxygen from oxygen containing compounds such as sugar. They are called the anaerobes or anaerobic bacteria, but the amount of energy available from anaerobic respiration is much less than that from aerobic respiration, *Syphilis* and *Tetanus* bacteria are e.g. of obligate anaerobes. There are some bacteria which can live and grow whether oxygen is present or not. They are called *facultative anaerobes*.



Growth and Reproduction

All bacteria reproduce through asexual reproduction (one parent) binary fission, which results in cell division. Two identical clone **daughter cells** are produced. Some bacteria, while still reproducing asexually, form more complex reproductive structures that facilitate the dispersal of the newly-formed daughter cells.

Bacteria, as asexual organisms, inherit an identical copy of their parent's genes (i.e. are clonal). All bacteria, however, have the ability to evolve through selection on changes to their genetic material (DNA) which arise either through mutation or genetic recombination. Mutation occurs as a result of errors made during the replication of DNA.

The most frequent genetic changes in bacterial genomes come from random mutation. Some bacteria can also undergo genetic recombination. This can occur when bacteria take-up exogenous environmental DNA from closely related genera in a process called transformation. In the process of transduction, a virus can alter the DNA of a bacterium by becoming lysogenic and introducing foreign DNA into the host chromosome, which can then be transcribed and replicated.

Because of their ability to quickly grow, and the relative ease with which they can be manipulated, bacteria have historically been the workhorses for the fields of molecular biology, genetics and biochemistry. By making mutations in bacterial DNA and examining the resulting phenotypes, scientists have been able to determine the function of many different genes and enzymes.

Benefits and Dangers

Bacteria are both harmful and useful to the environment and animals, including humans. Some bacteria act as pathogens and cause tetanus, typhoid fever, pneumonia, syphilis, cholera, food-borne illness, leprosy, and tuberculosis(TB). Sepsis, a systemic infectious syndrome characterized by shock and massive vasodilation, or localized infection, can be caused by bacteria such as *Streptococcus*, *Staphylococcus* bacteria. Some bacterial infections can spread throughout the host's body and become *systemic*. In plants, bacteria cause leaf spot, fireblight, and wilts. The mode of infection includes contact, air, food, water, and insect-borne microorganisms. The hosts infected with the pathogens may be treated with antibiotics, which can be classified as bacteriocidal and bacteriostatic, which at concentrations that can be reached in bodily fluids either kill bacteria or hamper their growth, respectively. Antiseptic measures may be taken to prevent infection by bacteria, for example, by swabbing skin with alcohol prior to piercing the skin with the needle of a syringe. Sterilization of surgical and dental instruments is done to make them *sterile* or pathogen-free to prevent contamination and infection by bacteria. *Sanitizers* and disinfectants are used to kill bacteria or other pathogens to prevent contamination and risk of infection.

In soil, microorganisms which reside in the rhizosphere (a zone that includes the root surface and the soil that adheres to the root after gentle shaking) help in the transformation of molecular dinitrogen gas as their source of nitrogen, converting it to nitrogenous compounds in a process known as nitrogen fixation. This serves to provide an easily absorbable form of nitrogen for many plants, which cannot fix nitrogen themselves. Many other bacteria are found as symbionts in humans and other organisms. For example, the presence of the gut flora in the large intestine can help prevent the growth of potentially harmful microbes.

The ability of bacteria to degrade a variety of organic compounds is remarkable. Highly specialized groups of microorganisms play important roles in the mineralization of specific classes of organic compounds. For example, the decomposition of cellulose, which is one of the most abundant constituents of plant tissues, is mainly brought about by aerobic bacteria that belong to the genus *Cytophaga*. This ability has also been utilized by humans in industry, waste processing, and bioremediation. Bacteria capable of digesting the hydrocarbons in petroleum are often used to clean up oil spills.

Bacteria, often in combination with yeasts and molds, are used in the preparation of fermented foods such as cheese, pickles, soya sauce, sauerkraut, vinegar, wine, and yogurt. Using biotechnology techniques, bacteria can be bioengineered for the production of therapeutic drugs, such as insulin, or for the bioremediation of toxic wastes.

"Friendly bacteria" is a term used to refer to those bacteria that offer some benefit to human hosts, such as *Lactobacillus* species, which convert milk protein to lactic acid in the gut. The presence of such bacterial colonies also inhibits the growth of potentially pathogenic bacteria (usually through competitive exclusion). Other bacteria that are helpful inside the body are many strains of *E. coli*, which are harmless in healthy individuals and provide Vitamin K.

Bacteria That Cause Food-borne Illness

Food-borne illness often shows itself as flu-like symptoms such as nausea, vomiting, diarrhoea, or fever, so many people may not recognize the illness is caused by bacteria or other pathogens on food. They can grow in just about any food, but are fond of protein foods, such as meat, poultry, seafood, eggs, and dairy products in particular, as well as high-protein vegetables such as beans and grains.

Bacteria multiply rapidly between 40° and 140° F. To keep food out of this "danger zone," keep cold food cold and hot food hot. Store food in the refrigerator (40° F or below) or freezer (0° F or below); cook food to 160° F; maintain hot cooked food at 140° F; reheat cooked food to 165° F.

Bacterial Diseases in Plants & Animals

	Bacterial Diseases in Plants		
1.	***Paddy blight***	***Rice***	***Xanthomonas oryzae***
2.	***Citrus canker***	***Citrus group of fruits***	***Xanthomonas citris***
3.	***Brown rot of Potato***	***Potato***	***Pseudomonas -solanacearum.***
4.	***Ring rot of Potato***	***Potato***	***Corynebacterium sepidonicum.***
5.	***Tundu Disease***	***Wheat***	***Corynebacterium tritici***
6.	***Crown gall***	***Plum, Cherry, Apple, Peach, Pear, etc.***	***Arobacterium tumefaciens.***
	Bacterial Diseases in animals		
7.	***Tuberculosis***	***Mycobacterium tuberculosis***	***All animals***
8.	***Johne's disease or Paratuberculosis***	***Mycobacterium paratuberculosis***	***Not in sheep but cattle and horse***
9.	***Epizootic lymphengities***	***Histoplasma farciminonsum***	***Horse***
10.	***Anthrax***	***Bacillus anthracis***	***Goat, sheep, cattle***
11.	***Black Quarter or Symptomatic anthrax***	***Clostridium chauvoei (Gram+ve)***	***Cattle & sheep***
12.	***Black deasese or Infectious necrotic hepatitis***	***Cl. novyi type B or Cl. Oedematiens***	***Sheep & cattle***
13.	***Tetanus or Lockjaw***	***Cl. tetani***	***All animals***
14.	***Botulism***	***Cl. tetani***	***AB + E***
15.	***Lambsiekte***	***Cl. botulinum Type D***	***Cattle***
16.	***Forage poisoning***	***Cl. botulinum Type C***	***Horse***
17.	***Brucellosis or Bang's disease, contagious abortion***	***Brucella abortus***	***Cattle, sheep, pigs, horses***
18.	***Leptospirosis or Weil's disease, stuttgard disease***		***Leptospira spp. Cattle, pig, sheep, dog & man***
19.	***Bacillary white diarrohea or Pullorum***	***Salmonella pullorum disease***	***Chicks***
20.	***Chronic Respiratory Disease (CRD)***	***Mycoplasma gallisepticum***	***Fowl***
21.	***Salmonellosis or Paratyphoid***	***Salmonella pullonum S. gallinarum***	***Poultry***

- **Botulism**: It is a rare but serious paralytic illness caused by a nerve toxin, botulin, that is produced by the bacterium *Clostridium botulinum*. Botulinic toxin is one of the most powerful known to man, with a lethal dose of a microgram. It acts blocking nerve function and leading to respiratory and musculoskeletal paralysis.

Some other bacteria cause more serious illness than others, but only a few are responsible for the majority of cases. Below is the information regarding nine prominent bacteria.

- **Campylobacter jejuni:** Found in intestinal tracts of animals and birds, raw milk, untreated water, and sewage sludge. Transmission through contaminated water, raw milk, and raw or under-cooked meat, poultry, or shellfish.
- **Clostridium botulinum**: It is widely distributed in nature: in soil and water, on plants, and in intestinal tracts of animals and fish. Bacteria produce a toxin that causes illness. Improperly canned foods, garlic in oil, and vacuum-packaged and tightly wrapped food can

Bacterial Diseases in Humans

Disease	Causative Pathogen	Mode of Transmission	Incubation
Septic Sore throat	Streptococcus Sp.	Bacteria infect throat and nasal membranes by droplets and direct contact.	3-5 days
Diphtheria	Irregular rod (Coryne-bacterium diptheriae)	Bacteria infect respiratory tract by carrier, direct contact, droplets and food.	1-7 days
Pneumonia	Diplococcus pneumoniae	Bacteria transmitted to respiratory tract, including the lungs by droplet infection.	variable
Tuberculosis	Irregular rod (Mycoba-cterium tuberculosis)	Bacteria transmitted to lungs, bones and other organs by direct contact, droplet infection, food and milk.	variable
Plague or Bubonic plague	Short rod (Yersinia pestis)	Rat flea spreads disease from rat to man	2-10 days
Tetanus or lock-jaw	Clostridium tetani	Bacteria in soil, enter through wound	2-40 days
Typhoid	Salmonella typhi	Flies, food, faeces, water and carriers	10-14 days
Cholera	Vibrio Cholerae	Flies, food, stools, water and carriers	1-2 days
Whooping cough	Bordetella pertussis	Droplets projected during coughing and sneezing	7-14 days
Gonorrhoea (Clap)	Diploccus	Sexual intercourse	2-8 days
Syphilis	Treponema paltidium	Direct contact, chiefly sexual intercourse	10-90 days
Leprosy	Mycobacterium leprae	Long and close conact with infected persons.	—
Botulism	Clostridium botulinum	Organism produces poison in food	18-66 hrs.

invite it..

- **Clostridium perfringens:** Found in soil, dust, sewage, and intestinal tracts of animals and humans. It is called "the cafeteria germ" because many outbreaks result from food left for long periods in steam tables or at room temperature. Bacteria is destroyed by cooking, but some toxin-producing spores may survive.
- **Escherichia coli O157:** Found in intestinal tracts of some mammals, raw milk, unchlorinated water; one of several strains of *E. coli* that can cause human illness. It is transmitted through contaminated water, raw milk, raw or rare ground beef, unpasteurized apple juice or cider, uncooked fruits and vegetables; person-to-person.
- **Salmonella:** Found in intestinal tract and feces of animals; *Salmonella enteritidis* in raw eggs. It transmits through raw or undercooked eggs, poultry, and meat; raw milk and dairy products; seafood.
- **Streptococcus A:** Found in noses, throats, pus, sputum, blood, and stools of humans. Transmission- people-to-food from poor hygiene, ill food handlers, or improper food handling; outbreaks from raw milk, ice cream, eggs, lobster, salads, custard, and pudding allowed to stand at room temperature for several hours between preparation and eating.
- **Listeria monocytogenes:** Found in intestinal tracts of humans and animals, milk, soil, leaf vegetables, and processed foods; can grow slowly at refrigerator temperatures. Transmission-soft cheese, raw milk, improperly processed ice cream, raw leafy vegetables, meat, and poultry. Illness caused by bacteria that do not produce toxin.
- **Shigella :** Found in human intestinal tract; rarely found in other animals. Transmission- person-to-person by fecal-oral route; fecal contamination of food and water. Most outbreaks result from food, especially salads, prepared and handled by workers using poor personal hygiene.
- **Staphylococcus aureus :** Found in on humans (skin, infected cuts, pimples, noses, and throats). Transmission - people-to-food through improper handling. Multiply rapidly at room temperature to produce a toxin that causes illness.

Biotechnology and Bacteria

Biochemistry is defined as the application of organisms such as bacteria, fungi and algae to the manufacturing and services industries. These include:

- Fermentation processes, such as brewing, baking, cheese and butter manufacturing, chemical manufacturing such as ethanol, acetone, organic acid, enzymes, perfumes, etc.
- Pharmaceuticals, such as antibiotics, vaccines and steroids.
- Energy, in the form of biogas.
- Food products, such as beverages, dairy products, amino acids and proteins.
- Agriculture, such as animal feed, composting processes, pesticides, nitrogen fixation, plant cell and tissue culture.
- Microbial mining, which is the bacteria and other microorganisms are cultured in container and then used to bring these processes e.g., copper extraction.

Genetic engineering and bacteria: Genetic engineering is the manipulation of genes. It is also called recombinant DNA technology. In genetic engineering, pieces of DNA (genes) are introduced into a host by means of a carrier (vector) system. The foreign DNA becomes a permanent feature of the host, being replicated and passed on to daughter cells along with the rest of its DNA. Bacterial cells are transformed and used in production of commercially important products. The examples are production of human insulin (used against diabetes), human growth hormone (somatotrophin used to treat pituitary dwarfism), and infections which can be used to help fight viral diseases.

Fibre retting: Bacterial populations, especially that of Clostridium butyclicum, are used to separate fibres of jute, hemp, flax, etc, the plants are immersed in water and when they swell, inoculated with bacteria which hydrolyze pectic substance of the cell walls and separate the fibres.These separated fibres are used to make ropes and sacks.

Digestion: Some bacteria living in the gut of cattles, horses and other herbivores secrete enzyme cellulose that helps in digestion cellulose contents of cell wall. Cellulose in the major source of energy in these animals.

Vitamins synthesis: Escherichia coli living in human colon synthesize vitamin B and release it for human use. Similarly, Clostridium butyclicum is used for commercial preparation of riboflavin, a vitamin B.

Waste disposal: Aerobic and anaerobic bacteria are used to decompose sewage wastes. They break down organic matter to harmless, soluble sludge in settling tanks. The methane gas produced is used as energy source. Similarly toxic chemicals synthesized by living organisms and those present in the pesticides are disposed with the help of bacteria. Pseudomonas putida has been created by using genetic engineering techniques and can break down, xylene, and camphor.

Agents of disease: Organisms which cause disease are called pathogens. Some bacteria are pathogens Some bacteria are pathogenic and cause diseases both in animals and plants. However, pathogenic bacteria more commonly affect animals than plants.

Food spoilage: Saprotrophic bacteria attack and decompose organic matter. This characteristic has posed problem to mankind as food such as stored grains, meant, fish, vegetable and fruits are attacked by saprotrophic bacteria and spoiled. Similarly milk and products are easily contaminated by bacteria and spoiled.

Vaccine Manufacturing Bacteria: Bacteria are used in a very large scale to produce antibiotic drugs. A bacterial vaccine is a preparation of dead or weakened bacteria. Vaccine of diptheria, pnenumonia, cough, cholera, tetanus, etc. is prepared using bacteria.

Some Useful Bacteria

Name	*Use*
Lactobacillus	*Curding of milk*
Rhizobium and Clostridium	*Nitrogen fixation in soil*
Streptomyces griseus	*Streptomycin*
Streptomyces venezullae	*Chloromycetin*
Streptomyces remosus	*Terramycin*

Antibiotics Manufacturing Bacteria	
Name of antibiotic	*Bacteria used*
Chloromycetin	*Streptomyces Venezuelae*
Aureomycin	*S. aurefaciens*
Terramycin	*S. ramosus*
Streptomycin	*S. griseus*
Subtilin	*Bacillus subtilis*

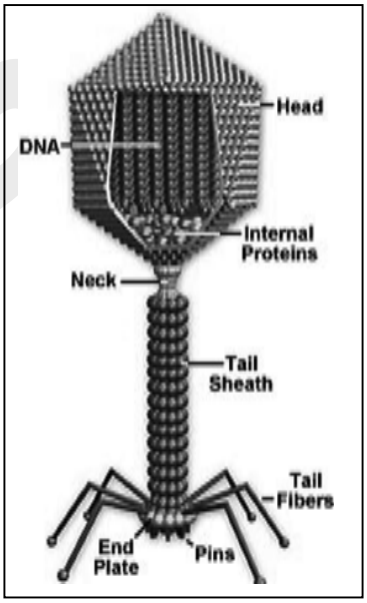
VIRUSES

The viruses were first discovered by **Iwanowski** (1892) as extremely small micro organisms. The viruses are the simplest forms of life which instead of having cellular organization (viz. plasma membrane, cytoplasm and nucleus) similar to bacteria, blue-green algae, plants and animal, contain definite genetically determined macromolecular organization, genetic material and characteristic mode of inheritance.

The viruses are submicroscopic, acellular, forms of life and are much smaller than bacteria. They range in size from 20 to 80 m. Iwanowski showed that mosaic disease in the leaves of tobacco is caused by the ultramicroscopic agents that can pass even through the pores of fine filter paper which did not allow even bacterial cells to pass through.

The viruses possess a regular geometrical and macromolecular organization. Basically all viruses consist of a core of only one type of nucleic acid (DNA/RNA) which remains wrapped in a coat of protein called **capsid. T**he capsid is composed of numerous protein molecules called **capsomeres**. The capsomeres determine the shape of the virus particle or viron, thus the viruses may contain three types of symmetry such as cubic (eg Bacteriophase x 174, Turnip yellow mosaic virus, etc.) Helical (eg Potato spindle tuber virus) have no capsid around the nucleic acid core or viral chromosomes. There are some highly specialized viruses such as influenza virus and mumps containing a membranous envelop around the capsid.

Viruses contain only one kind of nucleic acid as the hereditary material. The DNA viruses have single DNA molecule which may be either linear (having free and) or circular (having no free end) in shape, mostly, the linear DNA molecule is double stranded (eg P_{22} bacteriophage). The circular DNA molecule may be either single stranded (eg x 174 bateriophage) or double stranded as in most animal viruses. The RNA viruses are the only biological systems known in which RNA is the genetic material mostly, the RNA is present in its usual single stranded form (eg Plant viruses, Influenza etc.) but some viruses such as Retrovirus have a core of double stranded RNA similar in properties to DNA.



The viruses lack in necessary energy yielding and synthetic enzyme systems. Therefore, they cannot lead a free living mode

of life for the performance of fundamental life activities such as reproduction, genetically determined structures and functions, they have to lead a parasitic mode of existence. All viruses are, therefore, invariably intercellular parasites of specific hosts which may be bacteria plants, or animals. The viruses may be classified into following 3 groups according to the type of host:

(i) **Bacterial viruses or Bavteriophages:** Viruses that parasitize bacterial cells are called bacteriophages.

At the time of infection of T4 bacteriophage, a phage becomes anchored to the bacterial cell wall by its tail fibres. An enzyme at the core of the tail of the phage digests the part of the bacterial cell wall so as to produce a hole and finally, the phage DNA is infected into the bacterial cell.

(ii) **Plant Viruses:** The plant viruses parasitize the plant cells and disturb their metabolism and cause severe disease in them. All plant viruses consist of ribonucleoproteins in their organization. Some of the important plant viruses are tobacco mosaic virus (TMV) potato virus, and turnip yellow viruses (TYV).

(iii) **Animal Viruses:** They infect the animal cells and cause different diseases in animals and human beings. Generally, they have a spherical shape and genetic material in the form of DNA and sometimes RNA. The capsid of animal viruses is surrounded by an envelope. Some of them are Small pox virus, Influenza virus, mumps, pea virus etc. Poliomyelitis is an extensively studied animal virus which has got RNA as its genetic material.

DIFFERENCES BETWEEN BACTERIA AND VIRUSES

1. Viruses have only one type of nucleic acid either DNA or RNA, whereas bacteria have got both.
2. Viruses are devoid of ribosomes and the enzyme systems needed to generate ATP molecules, whereas bacteria have got ribosomes as well as enzymes needed in ATP synthesis.
3. Viruses lack various cytoplasmic organelles, whereas bacteria have cytoplasmic organelles.
4. Viruses do not have cell wall but bacteria have well defined cell wall.
5. Viruses cannot multiply or synthesize their proteins and enzymes independent of the host cell, but, bacteria can.

- A virus may not harm one type of host but may injure or kill another. For example *healthy potato virus do* not affect potato plant but harm the tomato plant.
- Viruses may cause the wild growth and reproduction of cells rather than their direct destruction. For instance *malignant tumour or cancer* warts.
- A mild viral disease may grant its host immunity. For example, *cow-pox* makes a persons lightly ill but provide resistance against small-pox.
- Viruses pass from one host to another by direct or indirect contact.
- A given vaccine is usually effective against one type of virus but forever. Viral vaccines may have either mild live virus which causes mild infection but body produces antibodies or killed virus which induce the human body to produce antibodies. For vaccination purposes virus are killed by formaldehydes. Viral vaccines are used against many diseases like yellow fever, rabies, influenza, polio, small-pox, measles, mumps, rubella etc.
- Viral vaccines are not useful for plants because they do not produce antibodies. But the breed-plants, resistant to virus can solve this problem.
- *Antibiotics* and *Sulfa-drugs* are generally used against virus.

ALGAE

Algae are used by man in a great many ways. Because many species are aquatic and microscopic, they are cultured in clear tanks or ponds and either harvested or used to treat effluents pumped through the ponds.

Food Stuff : Algaculture on a large scale is an important type of aquaculture today. Certain species are edible like **red dulse**, which is dried and marketed in Ireland. It is eaten raw, fresh or dried, or cooked like spinach. Porphyra, commonly known as **purple laver**, is also collected and used as "laver bread" and jelly in UK. Chondrus crispus, common name: **Irish moss**, is also used as carrageen for the stiffening of milk and dairy products, such as ice-cream. Ulva lactuca, common name: **sea lettuce**, is used locally in Scotland where it is added to soups or used in salads.

Fertilizer: For centuries seaweed has been used as manure. There are also commercial uses of algae as **agar**. **Maerl** is harvested as fertiliser of organic gardening. Chemical analysis of maerl showed that it contained 32.1% $CaCO_3$ and 3.1% $MgCO_3$ (dry weight).

Energy Source: Algae can be used to make biodiesel, and by some estimates can produce vastly superior amounts of oil, compared to terrestrial crops grown for the same purpose. Because algae grown to produce biodiesel does not need to meet the requirements of a food crop, it is much cheaper to produce. Also it does not need fresh water or fertilizer. Algae like Chlamydomonas reinhardtii (a green-algae) can be grown to produce hydrogen. Algae can be grown to produce biomass, which can be burned to produce heat and electricity.

Pollution Control: Algae are used in wastewater treatment facilities, reducing the need for more dangerous chemicals. Algae can be used to capture fertilizers in runoff from farms and if this algae is then harvested, it itself can be used as fertilizer. Algae bioreactors are used by some

Viral Diseases in Humans

Disease	Causative Pathogen	Mode of Transmission	Incubation
Small Pox	Variola virus	Direct contact (droplets), indirected by infected articles	12 days
Chicken Pox	Varicella virus	Direct contact (droplets), indirected by infected objects	12-16 days
Common Cold	Rhinovirus	Contact	2-5 days
Influenza/Flu	Orthomixo-virus	Contact (droplets), virus transmitted through discharge from respiratory tracts of persons infected with disease	1-2 days
Measles	Measles virus (Paramyxo virus)	Direct contact, virus transmitted through air by droplets during talking Coughing and sneezing.	10-14 days
Mumps	Mumps virus	Direct contact, virus in saliva & secretion of nose invades salivary glands	12-21 days
Viral encephalitis	Encephalitis virus (arbovirus)	Some domestic animals reservoir of virus, transmitted by mosquito bite to man	4-21 days
Poliomyelitis	Poliovirus	Contact, housflies, fleas, food and and water	7-14 days
Rabies	Rabies virus	Bite of a mad (rabid) dog	2-16 days
Dengue fever	Dengue virus	Mosquito (Aedes) bite	4-8 days
Herpes simplex	Herpes virus simplex	Contact, Saliva, stools, contaminated articles.	
Herpes Zoster	Herpes virus zoster	Contact droplets	7-14 days
Acquired Immuno Deficiency Syndrome (AIDS)	Human T-cell Leukemia virus (HTLV-III); also called LAV	Via blood and sperm among homosexuals, heterosexuals, intravenous drug users, haemophiliacs, promiscuous individuals and prostitutes	2 months to 10 yrs.

Viral Diseases in Plants

1. Tabacco mosaic	***Tobacco, tomato***	***Tobacco mosaic virus***
2. Leaf curl	***Tobacco, tomato, Papaya***	***Tobacco virus-16***
3. Carrot red leaf	***Carrot***	***Carrot red leaf virus***
4. Cauliflower mosaic	***Cauliflower***	***Cauliflower mosaic virus***
5. Bunchy top	***Banana***	***Banana virus-1***
6. Potato mosaic	***Potato***	***Potato virus x.***
7. Potato leaf roll	***Potato***	***Solanum virus 14***

Viral Diseases in animals

1. African Horse Sickness	***Horse, dog***	***Orbivirus***
2. Bluetongue	***Sheep, cattle, goat***	***Reoviridae***
3. Border disease	***Sheep***	***Pestivirus***
4. Hog cholera or swine fever	***Pig***	***Pestivirus***
5. Cowpox	***Cattle***	***Orthopox virus***
6. Bovine viral diarrhoea	***Cattle***	***Pesti virus***
7. Foot & mouth disease	***Cattle, Sheep, goat, pig***	***Aptho virus***
8. Goat Pox	***Cattle***	***Capripox virus***
9. Louping ill	***Sheep***	***Flavi virus***
10. Pseudorabies or Aujeszky's disease	***Pig***	***Alphaher-pesvirinae***
11. Rabies	***Cattle, horse, sheep, goat, pig man***	***Lyssa virus***
12. Rinderpest	***Cattle, sheep, goat***	***Morbilli virus***
13. Canine distemper or Carre's disease	***Cat, Dog***	***Pantropic virus***
14. Infectious canine Hepatitis or Rubarth's disease	***Dog***	***Adeno virus***
15. Equine encephalomyelitis or Blind staggers	***Horse, mules, mas***	***Japanese B encephalitis virus***
16. Ranikhet disease or New castle disease or Doyle's disease	***Fowl***	
17. Avian Monocytosis / Pullet disease or Blue comb	***Fowl***	
18. Gumboro Disease	***Fowl***	

Some Useful Algae

Product	Secreted by
Iodine	Laminaria (brown algae)
Agar and Caragheen	Red algae
Alginic Acid	Brown algae
Soil Fertilizer	Blue green algae
Edible forms	Vulva, porphyra, Chlorella

powerplants to reduce CO_2 emissions. The CO_2 can be pumped into a pond, or some kind of tank, on which the algae feed. Alternatively, the bioreactor can be installed directly on top of a smokestack.

Nutritional Value of Algae: Algae is commercially cultivated as a nutritional supplement. One of the most popular microalgal species is **Spirulina**, which is a Cyanobacteria (known as blue-green algae). Other algal species cultivated for their nutritional value include; **Chlorella** (a green algae), and **Dunaliella** (*Dunaliella salina*), which is high in beta-carotene and is used in vitamin C supplements. Algae is sometimes also used as a food, as in the Chinese vegetable known as **fatchoy** (which is actually a cyanobacterium). The oil from some algae have high levels of unsaturated fatty acids. Arachidonic acid (a polyunsaturated fatty acid), is very high in Parietochloris incisa, (a green alga) where it reaches up to 47% of the triglyceride pool.

Dyes & Pigments: The natural pigments produced by algae can be used as an alternative to chemical dyes and coloring agents. Many of the paper products used today are not recyclable because of the chemical inks that they use but inks made from algae are much easier to break down. There is also much interest in the food industry into replacing the coloring agents that are currently used with coloring derived from algal pigments.

- **Blue-Green Algae (Moneran):** They contain a blue pigment ***phycocyanin*** in addition to chlorophyll and other pigments. Only asexual reproduction occurs among them. They contaminate drinking water, causing very disagreeable odour and taste. They bring about the raddish colour of the Red Sea, used as soil fertilizer. Some species thrive in the digestive tract of human without causing ill effects. Some members - Gloeocapsa and Nostoc have formed a partnership with fungi, making up the separate group of organism known as ***lichens.***
- **Euglena** : Found in stagnant ponds, swimming pools, aquariums, water become greenish, unpleasant flavour.
- **Green Algae** : Self-food maker, add O_2 to water available for fish and other organism, also serve food for these creatures. They often cause water pollution in lakes, tanks etc. may cause unpleasant flavours and odours, their respiration may lower the O_2 content of the water. So the fish in this area may die of suffocation ($CuSO_4$ can eradicate unwanted green algae). *Spirogyra* - B.G. Algae
- **Brown Algae :** (brown pigment ***flucoxanthin***): They are marine plants and are the source of food for fish and others- It is the major source of Alginic acid. By removing from sea can be used as cattle feed. Some species yield Iodine, some make excellent fertilizers. *Kelps* - B. Algae include the largest member of the group. *Macyosist Pyrifera*- giant kelp, longest plant of world (30 mt. or more). *Gulfweed or sargassum* - B. Algae in Sargossa sea (West Indies to Azores).
- **Diatoms (yellowish green to yellowish brown):** They have cell-wall, contain silica and are harmless to man. They often make up the bulk of the ***plankton*** as sea animal food. It serves as filter and clarify many liquids. They are excellent insulating material for boilers, blast furnacesy refrigerators and are used as a milk abrasive in polishes and scouring powders
- **Red Algae : (red, brown and violet):** They are multicellular and generally used as food for sea animals and fish, as food for human (in Europe and Far East). *Irish moss* is also used for curing leather and for shoe polish and creams and shampoos. *Ceylon moss* yields an gelatinous material known as agar-agar, observe a great deal of water, used by researchers as growth material for bacteria, also serves to thicken soups and broths, as a sizing material for textiles, as a mild laxative, to provide body for puddings, pastries, ice-creams, etc. Some algae secrete lime so they have helped to build coral reefs (dating back to Ordovician times).

Ecological Role

Although often inconspicuous, fungi occur in every environment on Earth and play very important roles in most ecosystems. Along with bacteria, fungi are the major decomposers in most terrestrial and some aquatic ecosystems, and therefore play a critical role in biogeochemical cycles and in many food webs.

Many fungi are important as partners in symbiotic relationships with other organisms, as mutualists, parasites, or commensalists, as well as in symbiotic relationships that do not fall neatly into any of these categories. One of the most critically important of these relationships are various types of mycorrhiza, which is a kind of mutualistic relationship between fungi and plants, in which the plant's roots are closely associated with fungal hyphae and other structures. The plant donates to the fungus sugars and other carbohydrates that it manufactures from photosynthesis, while the fungus donates water and mineral nutrients that the hyphal network is able to find much more efficiently than the plant roots alone can, particularly phosphorus.

The fungi also protect against diseases and pathogens and provide other benefits to the plant. Recently, plants have been found to use mycorrhizas to deliver carbohydrates and other nutrients to other plants in the same community and in some cases can make plant species that would

normally exclude each other able to coexist in the same plant community.

Lichens are formed by a symbiotic relationship between algae or cyanobacteria and fungi, in which individual photobiont cells are embedded in a complex of fungal tissues. As in mycorrhizas, the photobiont provides sugars and other carbohydrates while the fungus provides minerals and water. The functions of both symbiotic organisms are so closely intertwined that they function almost as a single organism.

Certain insects also engage in mutualistic relationships with various types of fungi. Several groups of ants cultivate various fungi in the Agaricales as their primary food source, while ambrosia beetles cultivate various kinds of fungi in the bark of trees that they infest.

Some fungi are parasites of plants, animals (including humans), and even other fungi. Pathogenic fungi are responsible for numerous diseases, such as athlete's foot and ringworm in humans and Dutch elm disease in plants. Some fungi are predators of nematodes, which they capture using an array of devices such as constricting rings or adhesive nets.

FUNGI

Fungi have a long history of use by humans. Many types of mushrooms and other fungi are eaten, including button mushrooms, shiitake mushrooms, and oyster mushrooms. Of course, many species of mushrooms are poisonous and are responsible for numerous cases of sickness and death every year. A type of single-celled fungus called yeast is used in baking bread and fermenting alcoholic beverages, while mycelial fungus is used to make Shoyu (soya sauce) and tempeh. Fungi are also used to produce industrial chemicals like lactic acid, antibiotics and even to make stonewashed jeans. Some types of fungi are ingested for their psychedelic properties, both recreationally and religiously.

Edible and Poisonous Fungi

Some of the most well-known types of fungi are the edible and poisonous mushrooms. Many species are commercially raised, but others must be harvested from the wild. Button mushrooms are the most commonly eaten species, used in salads, soups, and many other dishes. Portobello mushrooms are the same species, but are allowed to grow to a much larger size. Other commercially-grown mushrooms that have gained in popularity in the West and are often available fresh in grocery stores include straw mushrooms (Volvariella volvacea), oyster mushrooms (Pleurotus ostreatus), shiitakes (Lentinula edodes), and enokitake (Flammulina spp.).

There are many more mushroom species that are harvested from the wild for personal consumption or commercial sale. Milk mushrooms, morels, chanterelles, truffles, black trumpets, and porcini mushrooms (also known as king boletes) all command a high price in the market. They are often used in gourmet dishes.

It is also a common practice to permit the growth of specific species of mold in certain types of cheeses that give them their unique flavour. This mold is non-toxic and is safe for human consumption. This accounts for the blue colour in cheese such as Roquefort or Stilton.

Hundreds of mushroom species are toxic to humans, causing anything from upset stomachs to hallucinations to death. Some of the most deadly belong to the genus Amanita. Stomach cramps, vomiting, and diarrhea usually occur within 6-24 hours after ingestion of these mushrooms, followed by a brief period of remission, usually 1-2 days. Patients often fail to present themselves for treatment at this time, assuming that they have recovered. However, within 2-4 weeks liver and kidney failure leads to death if untreated. There is no antidote for the toxins in these mushrooms, but kidney dialysis and administration of corticosteroids may help. Fly agaric mushrooms are also responsible for a large number of poisonings, but these cases rarely result in death.

Fungi in Biological Control of Pests

Many fungi compete with other organisms, or directly infect them. Some of these fungi are considered beneficial because they can restrict, and sometimes eliminate, the populations of noxious organisms like pests, insects, mites, weeds, nematodes and other fungi, such as those that kill plants. There is much interest on the manipulation of these beneficial fungi for the biological control of pests. Some of these fungi can be used as biopesticides, like the ones that kill insects (entomopathogenic fungi). Specific examples of fungi that have been developed as bioinsecticides are Beauveria bassiana, Metarhizium anisopliae, Hirsutella, Paecilomyces fumosoroseus, and Verticillium lecanii.

In Brief:

- **Mycorrhizal** (fungus root) **:** some fungus invade the roots of the plant but instead of harming the seed plants it helps them by assisting in transporting water and minerals from the soils to the roots of the plant. The seed plant in turn supplies food to fungi. Fungi of this kind are called Mycorrhizal. A good example of symbiosis.
- **Downy mildews :** they produce a downy growth on the surface of infected plant parts usually on leaves. One of the best known downy mildews is the late blight of potatoes. They also cause other plant diseases, they attack tobacco, cabbage, cucumbers, etc.
- **Black bread mould group :** usually called mucors. Most of them occurs as fluffy growth on bread, fruits, vegetables and preserved food. They are white at first

but soon becomes dark as their spores mature in large number. It develops on bread.

- **Yeast :** occurs wherever simple sugars are available like on fruits, in the sap from trees, in soil (particularly in orchards and vine yards).
- **Brewer's Yeast :** has been bred for high alcoholic fermentation; used in making beer, liquors, commercial alcohol.
- **Baker's Yeast :** is placed in bread dough, it causes the dough to 'rise' or expand by producing CO_2.
- **Candida Albicans :** responsible for thrush, a disease of mouth and throat.
- **Blue and Green Moulds Group :** Aspergillus, (primary source of citric acid, used in flavouring candies & fruits) Penicillium (used for antibiotics).
- **Powdery Mildews :** as powdery white substance on leaves. They are plant parasites, causes disease of crop plants and ornamentals, including grape, apple, rose, etc.
- **Rusts and Smuts :** parasitic, attack higher plants. Most common species is wheat barberry rust.
- **Mushrooms and Toadstools :** The first is edible while the second one is poisonous.
- **Imperfect fungi :** from the class 'Deuteromycotina', parasitic. They are often very destructive to crop and ornamental plants and causes disease in human beings, responsible for ringworm.
- **Lichens :** a combination of fungus and an algae; symbiosis; through photosynthesis the algae manufactures all the organic food that they both require. The fungus brings in water and minerals and offers protection to the algae. Certain kinds of lichens yields litmus a dye used as chemical indicators.
- **Yeasts :** one celled are eukaryotic micro-organisms classified in the Kingdom Fungi. Most reproduce asexually by mitosis and also by budding. Used in baking bread and alcoholic beverages.
- **Mushrooms :** complex is the fleshy, spore bearing fruiting body of a fungus. Are neither angosperms nor gymnosperms and do not undergo photosynthesis. Edible mushrooms are consumed by humans for their nutritioned and medicinal value and are cultivated.

■ ■ ■

DIET & NUTRITION

CHRONICLE
IAS ACADEMY
A CIVIL SERVICES CHRONICLE INITIATIVE

The sum total of all the processes starting from taking the food upto its utilisation is called nutrition**.** Depending upon the mode of nutrition, the organisms can be classified as autotrophs and heterotrophs. **Autotrophs** manufacture their own organic food from inorganic raw materials. They are of two types, photoautotrophs and chemoautotrophs. **Heterotrophs** are unable to manufacture their own food. They obtain organic food from outside. All animals, including man and non-green plants show hetertrophic mode of nutrition. Heterotrophic organisms or heterotrophs obtain all their energy requirements mainly from organic substances like carbohydrates and fats. They derive their foodstuffs directly or indirectly from the plants.

Hetertrophic nutrition is of two types: (i) **Saprozoic** or **saprophytic**, (ii) **Holozoic.** In saprophytic nutrition, as in non-green plants, the organisms secrete starch digesting enzymes to digest the food and then absorb the nutrients. In saprozoic organisms like the malarial parasite in man and monocystis in earthworm the already digested food is aobsorbed by the process of diffusion. But nutrition in most of free living animals is holozoic. In this type of nutrition, food may be a small organism, a plant or an animal.

Depending upon food, nutritionally animals are:

(i) Herbivores: Feeding on plant food e.g., Goat, Cow, Rabbit.

(ii) Carnivores: feeding on other animals e.g., Lion, Tiger.

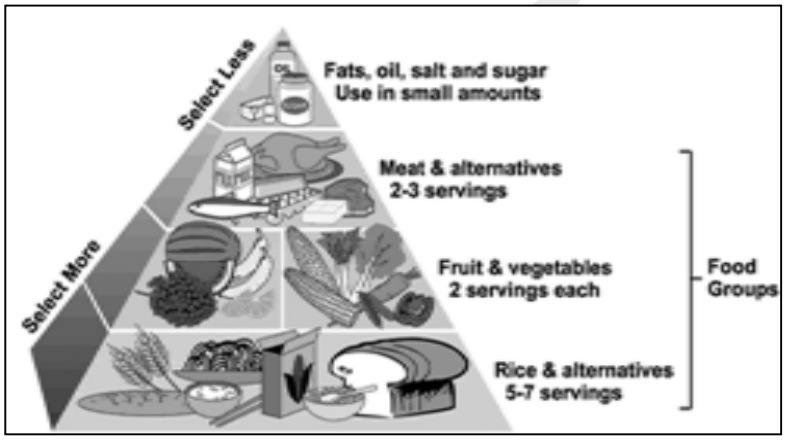
(iii) Omnivores: Feeding on all types of food e.g., humans.

(iv) Detrivores: Feeding on detritus or organic remains e.g., Earthworm.

(v) Scavengers: Feeding on carrions (carrion eaters), e.g., Vulture.

(vi) Frugivorous: Feeding on fruits, e.g., Parrot.

(vii) Sanguivores: Taking meal of blood, e.g., Leech, female Mosquito.



(viii) Insectivores: Eating insects, e.g., common bats.

(ix) Cannibals. Eating other members of own species, e.g., many snakes.

NUTRITIONAL REQUIREMENTS

The nutritional requirements of man are more complex than those of the other organisms. Man obtains his energy primarily as a result of the oxidation of nutrients seen as glucose, amino acids, and fatty acids, derived from the breakdown of carbohydrates, protein and fats. But these digested food stuffs do not constitute the complete diet of an individual. A balanced diet should have a proportionate amount of proteins, fats, carbohydrates, minerals, salts, water vitamin content and non-digestible 'roughage' which is comprised of green vegetables. The cellulose found in the roughage is not digested in man and other carnivorous animals because enzyme cellulase is missing. The food-stuffs used by mankind includes different nutrients like carbohydrates, fats, proteins, minerals, vitamins and water which can broadly be divided into following groups:

(i) Energy yielding food: Carbohydrate and fats,

(ii) Body building food: Protein and minerals,

(iii)Protective food: Vitamin and minerals.

Balanced Diet is the diet that contains all the components in optimum proportions and quantity required for maintaining the body in perfect state of health, activity and development. Various components of balanced diet are carbohydrates (60%), fats (25%), proteins (15%), vitamins (traces), minerals (traces) and roughage.

CARBOHYDRATES

It is starchy and sugar element of diet, the fuel of human body. One gram of carbohydrate provides 4.1 Cal. energy. It is manufactured by green plants through the process of **photosynthesis.** Herbivorous animals take it indirectly form plants while the carnivorous animals take it indirectly. Liver convert the excess carbohydrate into glycogen and store in itself and muscles. Glycogen is known as animal starch because it is not produced in plants. Excess carbohydrate is ultimately converted into fat. There are three forms of carbohydrates:

A. Monosacharides ($C_6H_{12}O_6$): It is the simplest form and animals can derive energy only in this form. The examples are ***glucose*** (dextrose or grape sugar), ***galactose*** (soluble milk sugar), ***fructose*** (fruit sugar).

B. Disacharides ($C_{12}H_{22}O_{11}$): It is formed by hydrolysis of two monosacharide molecules e.g. ***sucrose*** (cane sugar), ***lactose*** (milk sugar), ***maltose*** (malt sugar). On

SIMPLE & COMPLEX CARBOHYDRATES

These are often confused with refined and unrefined carbohydrates, but the terms simple and complex refer to how complicated the chemical structure of a carbohydrate is rather than to whether it's wholegrain or not. Complex carbohydrates are the most common and are of three kinds:

Glycogen is our body's major fuel source and is sometimes referred to as blood sugar. It's formed from glucose, which is found in almost all foods, and is converted into energy.

Starch is only found in plants and, contrary to popular belief, is not fattening (it is the rich sauces, fats and oils often added to pasta, potatoes, rice, noodles and bread that are the culprits).

Fibre (non-starch polysaccharide) is abundant in unrefined carbohydrates, fruit and vegetables, and is important because it helps your body to process waste efficiently and helps you to feel fuller for longer. If you decide to increase the amount of fibre you eat, try to drink more water too. Your body doesn't digest fibre, so you need the extra water to help it flow through your digestive system with ease. Nutritionists recommend that your dietary intake must include 18g of fibre every day.

an average, we have the equivalent of four teaspoons of sugar circulating in our bloodstream.

C. Polysacharides [$C_n(H_2O)_n$]: It is a complex form of chains of monosacharides. However it is difficult to digest the ploysacharides easily. Human can digest all forms of carbohydrates except cellulose. The major polysacharides are ***starch, glycogen, cellulose,*** etc.

Living cells receive carbohydrates from blood mostly as glucose. Glucose is also called **blood sugar.** Normal content of glucose in blood is 80— 100 mg /100 ml. Glucose is absorbed from alimentary canal. Excess is stored in liver muscles as glycogen. The process of formation of glycogen from glucose is called **glycogenesis.** When level of blood glucose falls, glycogen of liver is hydrolysed to produce it. The phenomenon is called glycogenolysis. Excess carbohydrate of food is changed to fat through the process of **lipogenesis.** Pentose sugars are components of nucleotides, coenzymes and nucleic acids. Daily requirement of an adult is 500 gm.

Refined carbohydrates refers to foods where machinery has been used to remove the high fibre bits (the bran and the germ) from the grain. White rice, white bread, sugary cereals, and pasta and noodles made from white flour are all examples of refined carbohydrates. **Unrefined carbohydrates** still contain the whole grain, including the bran and the germ, so they're higher in fibre and will keep you feeling fuller for longer - great if you're trying to lose weight and hate feeling hungry. Examples include wholegrain rice, wholemeal bread, porridge oats and wholewheat pasta.

FATS

It is a concentrated source of energy and supplies per unit weight more than double the energy furnished by either protein or carbohydrates. They act as stock food of the body because they consume less space and do not absorb water. One gram of fat provides 9.3 Cal. of energy. Fats are stored as future food. It also protects some vital organs from shock and injury. Subcutaneous fat acts as insulating material and preserve the body.

Fats are a group of chemical compounds that contain fatty acids. Energy is stored in the body mostly in the form of fat. Fat is needed in the diet to supply essential **fatty acids**, substances essential for growth but not produced by the body itself. There are three main types of fatty acids:

RECOMMENDED DAILY FAT INTAKE

Total calories per day	Saturated fat in grams	Total fat in grams
1,600	18 or less	53
2,000	20 or less	65
2,200	24 or less	73
2,500	25 or less	80
2,800	31 or less	93

saturated, monounsaturated and polyunsaturated. All fatty acids are molecules composed mostly of carbon and hydrogen atoms. A saturated fatty acid has the maximum possible number of hydrogen atoms attached to every carbon atom. It is therefore said to be **"saturated"** with hydrogen atoms.

Some fatty acids are missing one pair of hydrogen atom in the middle of the molecule. This gap is called "unsaturation" and the fatty acid is said to be **"monounsaturated"** because it has one gap. Fatty acids that are missing more than one pair of hydrogen atoms are called **"polyunsaturated."** Saturated fatty acids are mostly found in foods of animal origin. Monounsaturated and polyunsaturated fatty acids are mostly found in foods of plant origin and some seafoods. Polyunsaturated fatty acids are of two kinds, **omega-3** or **omega-6**. Polyunsaturated and monounsaturated fats do not promote the formation of artery-clogging fatty deposits the way saturated fats do.

PROTEINS

It is the primary food-stuff of the animals, the chief substance of the cells of the body. They form important constituents of muscles and other tissues and vital fluids like blood, enzymes and anti-bodies. Proteins are made of **amino-acids** which are the only source of nitrogen in the body. Nitrogen is essential for replacement of body cells and for growth. Nitrogen cannot be stored in the body so it must be included in everyday intake of food. Proteins are the raw materials for manufacturing of harmones, enzymes, antibodies etc. because proteins are the largest molecules in the nature. Amino-acid was first discovered by **William Rosh** of USA. One gram of protein provides 4.1 Cal. of energy and is most commonly found in cheese, lean meat, soyabean, peanuts etc.

Animal proteins are called **first class proteins** because they supply all the amino acids required for building various proteinaceous substances. Plant proteins often lack one or more

CHOLESTEROL

Cholesterol is sort of a "cousin" of fat. Both fat and cholesterol belong to a larger family of chemical compounds called lipids. All the cholesterol the body needs is made by the liver. It is used to build cell membranes and brain and nerve tissues. Cholesterol also helps the body produce steroid hormones needed for body regulation, including processing food, and bile acids needed for digestion.

• People don't need to consume dietary cholesterol because the body can make enough cholesterol for its needs. Only foods of animal origin contain cholesterol.

• Cholesterol is transported in the bloodstream in large molecules of fat and protein called lipoproteins. Cholesterol carried in low-density lipoproteins is called LDL-cholesterol; most cholesterol is of this type. Cholesterol carried in high-density lipoproteins is called HDL-cholesterol.

• A high level of LDL-cholesterol in the blood increases the risk of fatty deposits forming in the arteries, which in turn increases the risk of a heart attack. Thus, LDL-cholesterol has been dubbed "bad" cholesterol.

• An elevated level of HDL-cholesterol seems to have a protective effect against heart disease. For this reason, HDL-cholesterol is often called "good" cholesterol.

Triglycerides and VLDL: Triglyceride is another form in which fat is transported through the blood to the body tissues. Most of the body's stored fat is in the form of triglycerides. Another lipoprotein—very low-density lipoprotein, or VLDL—has the job of carrying triglycerides in the blood.

amino acids which human beings cannot build from others. The amino acids which cannot be formed by humans from other amino acids are called **essential amino acids.** They are eight in number—methionine, threonine, tryptophan, valine, leucine, isoleucine, lysine, and phenylalanine.

Protein plays an essential role in building and repairing your body. Although all animal and plant cells contain some protein, the amount and the quality of the protein varies a lot. **High biological** value foods contain enough indispensable amino acids for an adult diet and are considered to be good quality protein. Meat, fish and eggs come in this category. **Low biological** value foods don't contain enough indispensable amino acids. Plant foods, such as pulses, nuts and seeds, are in this group.

Some plant foods are low in one kind of amino acid whereas other plant foods are higher in that amino acid. Foods such as eggs, nuts, seeds, beans, pulses, vegetable protein foods and soya products all contain protein. There are also small amounts in grains and dairy products. Health professionals recommend that protein makes up ten to 15 per cent of your diet. They suggest men eat 55.5g protein a day and women eat 45g. In real terms, eating a moderate amount of protein - in one or two meals every day - should give you all the protein you need. The need to eat protein every day is worth emphasising, because your body can't store it. Eggs contain all eight essential amino acids, making them a perfect source of protein.

When excess proteins are taken they are converted into glycogen and finally into fat. Conversion of proteins into carbohydrates is known as **Gluconeogenesis**. The deficiency of protein into human body may cause **Kwashiorkar** which means red haired. The chief characteristics of this deficiency disease are loss of body weight, inflamation of joints, red hair in the children, large belly in children etc.

MINERALS

Vitamins and minerals are called **micronutrients** while protein, carbohydrates and fats are called **macronutrients.**

Minerals and their Functions

Mineral / Element	*Food Sources*	*Function in the body*	*Deficiency Diseases*
Sodium Chloride Potassium	*Table salt, vegetables Green veg. and fruits*	*Osmoregulation of body fluid As for sodium and transmission of nerve impulses*	*Cramp after prolonged deficiency Rarely deficient Fatigue musde weakness*
Calcium	*Milk, Cheese*	*Healthy growth of bones and teeth, for blood clotting*	*Rickets*
Phosphorus	*Almost*	*For healthy teeth all types of foods*	*Rarely deficient and bones*
Iron	*meat, eggs liver*	*Haemoglobin of blood*	*Anaemia*
Iodine	*marine food*	*proper functioning of thyroid gland*	*Goitre*
Fluorine	*drinking water, added to drinking water where deficient*	*develop resistance in tooth enamel*	*Dacaying tooth*

A large number of minerals which accounts 4 per cent of the body weight performs a variety of functions. Calcium and phosphate form about three-fourths of the mineral elements. Five other minerals- potassium, sulphur, sodium, chlorine and magnesium account for most of the rest. Minerals maintain the body metabolism and preserve the physical shape of the body cell. They maintain the proper osmotic pressure in the cells.

- **Sodium.** It is main cation of extracellular fluid, component of bile salt which is involved in osmotic balance, acid-basic balance, absorption of glucose, electro-chemical impulse conduction in nerves and muscles.
- **Chlorine.** Main anion of extracellular fluid, involved in HCL synthesis and acid-base balance.
- **Potassium.** The cation is present in intracellular as well as vextracellular fluid. It takes part in muscle and nerve activity, glycogen and protein synthesis.

- **Magnesium.** It is an enzyme activator, component of bones and teeth besides being required for muscle relaxation. Deficiency produces convulsions.
- **Sulphur.** It is a constitutent of many proteins, enzymes and coenzymes.
- **Cobalt.** A component of B_{12}. Deficiency causes pernicious anaemia.
- **Fluorine.** Maintains enamel and checks dental decay. In excess, it is harmful to teeth and bones.
- **Calcium.** It is the major component of bones and teeth. Calcium is also required for blood clotting, muscle contraction. ATP-ase, nerve impulse transmission, heart functioning, etc. Vitamin D is essential for calcium absorp-tion. Deficiency produces rickets and muscle spasms.
- **Phosphorus.** Alongwith calcium, it occurs in bones and teeth. Phosphorus is a component of nucleic acids, phospholipids, ATP and some coenzymes. Phosphorylation activates sugars and fatty acids. Phosphate is pH buffer. Deficiency reduces growth metabolism and causes rickets in children.
- **Iron.** It is re-used in the body. Iron is a component of haemoglobin, myoglobin, cytochromes and ferredoxin. Deficiency leads to anaemia.
- **Iodine.** It is essential for production of hormone thyroxine of thyroid glands. Deficiency causes goitre.

Adequate requirements of some important minerals in the diet per day are as follows:

Chloride – 3500 mg	Magnesium – 400 mg
Sodium – 3000 mg	Iron – 18 mg
Calcium – 1200 mg	Zinc – 15 mg
Phosphorus – 1200 mg	Iodine – 0.15 mg

- **Anaemia:** This results from insuffcient iron in the diet, consequently, there is deficiency of haemoglobin in the Red Blood Corpuscles (RBC).
- **Hypokalemia:** Sometimes, severe loss of potassium occurs in the body due to excessive secretions of hormones of the adrenal cortex or in the course of severe vomiting and acute diarrhoea. This causes rise in heart beat rate, kidney damage, weakness and paralysis of muscles.
- **Hyponatremia:** An increased loss of sodium from the body after intense vomiting and diarrhoea, leads to dehydration, low blood pressure and even loss of body weight.
- **Goitre:** It is caused by deficiency of iodine. Consquently, the thyroid fails to secrete enough thyroxine. The absense or very low level of thyroxine steps up the production of Thyroid Stimulating Hormones (TSH) by the anterior pituitary. The increasing level of TSH brings about the enlargement of thyroid known as goitre. People living in areas with low iodine content in water are therefore advised to use iodized common salts containing 0.01% potassium iodate.
- **Osteoporosis:** Calcium is a mineral that strengthens your bones and teeth, and ensures everything runs smoothly with your muscles and nerves. It's especially important for growth. Calcium can continue to add to the strength of your bones until you reach the age of 30 to 35, when peak bone mass is reached. After this point, as a natural part of the ageing process, your bones lose their density and grow weaker. If you haven't had enough calcium in your diet prior to this, there's an increased risk that your bones won't be strong enough to cope with any weakening, which can result in the brittle bone disease, osteoporosis.

WATER

An average man contains about 45 litres of water which is 70 per cent of the body weight. The cell contains 30 litres and 3 litres are in the blood plasma, where the suspended cells take a total volume of blood upto 5 litres. The remaining 12 litres fill the space between groups of cells. This is tissue fluids which baths all the cells of the body.

Water is absolutely necessary for the digestion and absorption of the foods taken in. It is a universal solvent and neutraliser in the body. It is the substance in which the bodily reactions take place. It is the carrier or transporting medium of all nutrients and body substances. It also regulates the body temperature. Acidosis, alkalosis, dehydration, oedema, fever, shock, uraemia and constipation are some of the clinical signs of inadequate salt and water in the body.

VITAMINS

Although these have no energy value, they are important accessory substances which contribute to the maintenance of health. 'Funk' for the first time used the term 'Vitamin'. Plants can make vitamins from simple substances, but animals mostly obtain them readymade directly or indirectly from plants. Vitamins are complex organic substances and are essential for growth, metabolism and full utilisation of food. Most of them are not synthesized by the animals. However **Vitamin-B** is synthesized by bacteria present in the intestine. Vitamin A, D, E and K are fat soluble while vitamin B and C are water soluble.

Pulses are rich source of minerals but they are rich in vitamin-B. Dried pulses do not contain **Vitamin-C** but if they are germinated, significant amount of Vitamin-C is regulated. Egg is the rich source of all nutrients except vitamin-C. Milk is also a source of all vital nutrients except Vitamin-C and iron. Animal foods are rich is fat soluble while plant's foods are rich in water soluble vitamins. Excess of vitamins-B and C is not dangerous because they are washed away. But excess of Vitamin A and D is harmful and is known as **Hypervitaminosis.** It is characterised by tirdness, brittle nail, elongated lever, dry and scaly skin, loss of hair and loss of calcium from the bones.

Vitamin-A (Ratinol): Known as anti-infective vitamin, strengthen the integrity of skin, mucous membranes, epithelial cells. Essential for the formation of visual Rods and

Cones of the ratina of the eyes. It also helps in the growth and formation of teeth and bone; so is more essential for children and nursing mothers. ***Carotene*** is the pro-vitamin of Vitamin -A and the conversion takes place in the liver.

- **Sources :** Animal oils such as liver oils of certain fish, egg yolks, green and yellow vegetables.
- **Deficiency Symptoms :** Night blindness, Xerophthalmia, abnormal changes in various epithelial membranes, retarded growth.

Vitamin-B_1 (Thiamine): It is the first vitamin to be discovered by Eijkman. Essential for healthy nerves and mucous membranes. Essential daily intake is around 1.5 mg. It is easily lost into heat.

- ***Source :*** Cereal grains, especially the outer seed coats, meats, yeast, green vegetable, lever etc.
- ***Deficiency symptoms :*** Beri-beri (nerve paralysis, weakness, staggering gait, nerve-pain), Polyneurities, loss of apetite and weight, etc.

Vitamin-B_2 (Riboflovin): It is essential for normal growth and healthy cornea. The essential daily intake is around 2 mg.

- ***Sources:*** Associated with B_1 and other members of B-complex found in milk products, egg, lever, yeast and green vegetables.
- ***Deficiency Symptoms :*** Cataract, defective skin patches around mouth and tongue (Ariboflavinosis), slow metabolism and retarded growth.

Vitamin-B_6 (Pyridoxin): Essential for protein metabolism and blood formation. Deficiency is rare because it is found in most of the food

- ***Sources :*** Meats, eggs, nuts and cereals
- ***Deficiency Symptoms :*** Mild anaemia atrophied lymph tissue, insufficient leucosytes and antibodies, low resistance to infection.

Vitamin-B_{12} (Cytamine/Cobalamin): Essential for the development of red blood cells-RBC

- ***Source :*** Liver
- ***Deficiency Symptoms :*** Pernicious anaemia (acute form of anaemia) also known as Megaloblastic anaemia.

Vitamin-P-P (Niacin): Essential for healthy digestive tracks. Essential daily intake is of 17 mg.

- ***Sources :*** Part of B-complex
- ***Deficiency Symptom :*** Pellagra, dirrahoea

Vitamin-C (Ascorbic Acid): Most abundent vitamin found in nature. Animal foods are generally deficient in vitamin-C. Plants are rich in it but is easily lost due to heat and storage. Fresh potato contains vitamin-C. It provides the ***collagen*** which binds the cell together and helps in keeping the skin elastic and supple. Deficiency leads to leakage of blood within the body. Essential for quick healing of wounds and for proper absorption of ions in the body. Essential daily intake is of 30-50 mg.

- ***Sources :*** Citrus fruits like lemons, oranges, goose-berry, cabbage, leafy vegetables etc. Milk is deficient in it.
- ***Deficiency Symptoms:*** Scurvy (spongy gum), retarded growth.

Vitamin-D (Calcipherol): Essential for absorption of calcium and phosphates in the body so it regulates the bone and teeth formation. It is more needed by the children and nursing mothers. It can also be produced in the human body. ***Ergosterd*** is the pro-vitamin of calcipherol. Ergosterd is the colouring matter found in sub-cutinous fat and converted into vitamin-D by kidney in presence of ultra-violet rays.

- ***Sources :*** Animal oils, butter, milk, fish-liver, solar ultra-violet rays, etc.
- ***Deficiency Symptoms:*** Degenerate calcium metabolism, rickets in children and osteomalacia in adults. Slow growth.

Vitamin-E (Tocopherol): Anti-sterility vitamin

- ***Sources:*** Unpolished grain, animal & vegetable oil, wheat
- ***Deficiency Symptoms:*** Sterility in Rats (not in man), muscular paralysis.

Vitamin-K: Vitamin K occurs in two forms—K_1 and K_2, the former occuring in many plants and the latter in fish meal. The vitamin has a role in photosynthesis. It helps in coagulation of blood in higher animals by the release of Piothrombin into the blood. 'K' stands for Kgulation or coagulation Essential for manufacturing of protein ***Prothrombin.*** It can be absorbed in body only in presence of bile and can be synthesised by intestinal bacterias

- ***Sources:*** Leafy vegetable
- ***Deficiency Symptoms:*** Improper coagulation of blood, slow growth.

Lathyrism: This disease is caused by a water soluble neurotoxin, which is consumed with 'Kesari dal' (Lathyrus sativus) common symptoms are lesions on the lower spinal segments followed by paralysis of legs.

NUTRITIONAL DISORDERS

1. **Marasmus:** It is a disorder caused by deficiency of food or protein energy malnutrition (PEM), Marasmus occurs in infants (1-2 years), when they do not get sufficient mother's milk and weaning diet.
2. **Kwashiorkor :** It is a protein energy malnutrition that occurs in children of 1 — 4 years due to constant reduced protein availability. A kwashiorkor child has **mat stick legs,** protruded belly, blotchy skin, anaemia, oedema of certain parts and repeated diarrhoea.
3. **Obesity :** Obesity is a **luxury nutritional disorder** caused by greater intake of food than the requirement of body. It is quite common in persons having higher intake of sweets, carbohyd rate rich food, fried articles, fat rich food and absence of roughage in food.

4. **Hyper-cholesterolemia :** It is characteriseed by high blood cholesterol due to higher intake of cholesterol rich eggs, red meat, butter and ghee or reduced biotin intake. Cholestorol gets deposited on the walls of blood vessels making their lumen narrow and walls stiffer. This increases blood pressure or hypertension. It leads to other cardio-vascular disorders.

5. **Rickets :** The disorder is due to deficient ossification of bone ends leading to their bending and swelling of joints (knee, wrist, elbow). It occurs in children of 6 months to 2 years when their diet is deficient in vitamin D, calcium or phosphorus.

6. **Osteomalacia :** The disorder occurs in adults when their food is deficient in vitamin D_1, calcium or phosphorus. Bones of vertebral column become weak. Pelvic and other bones bend and become soft.

7. **Xerophthalmia :** It is vitamin A deficiency disorder which is caused by stoppage of lacrimal activity. Cornea and eye lids become dry and ulcerated. It leads to swelling of dry eye lids and opacity of cornea. Xerophythalmia, if untreated leads to blindness.

8. **Night Blindness (Nyctalopia) :** Dietary deficiency of vitamin A results in deficiency of rhodopsin or visual purple. The latter impairs the ability to see in dim light or night.

9. **Beri-Beri :** Beriberi is a debility produced by deficiency of thiamine as during excessive intake of polished rice. It results in loss of appetite, slow reflexes, body rigidity and neuritis. There is inflammation of peripheral nerves, weakening of muscles, paralysis and progressive oedema.

10. **Pellagra :** The disorder is due to deficient vitamin nicotinamide (= niacin = nicotinic acid). It is characterised by extra-pigmentation, thickening cracks and eruptions in exposed regions of skin (dermatitis), glossistis (swollen tongue), swollen lips, peripheral neuritis, and dementia.

11. **Scurvy (Sailor's Diseases)** : Vitamine C (ascorbic acid) deficiency leads to scurvy characterised by bleeding gums, falling of teeth, fragile blood vessels, fragile bones and slow healing of injuries.

12. **Cheilosis :** Inflammation and cracking of mouth corners due to riboflavin (B_2) deficiency.

13. **Anaemia :** It is a disorder in which haemoglobin content of the blood is low due to either few red blood corpulscles or their haemoglobin content. It is of three types (a) **Microcytic** (most common) due to iron deficiency leading to fewer and smaller erythrocytes with reduced haemoglobin. (b) **Megablastic** due to fewer abnormal red blood cells caused by deficiency of folic acid or B_{12} (c) **Pernicious** due to production of haemoglobin free immature RBCs caused by B_{12} deficiency as a result of deficient intrinsic factor. **Sickle cell anaemia** is genetically controlled.

NUTRITION IN PLANTS

Plants green in colour and capable of synthesising their own organic food requirements are known as autotrophic plants. Some other plants such as fungi and bacteria which do not possess photosynthetic pigments and which are not capable of manufacturing their own organic food have to depend for their organic food requirements on outside sources and are called heterotrophic plants. Among heterotrophic plants those which totally depend on living plants and animals for their organic food requirements are known as parasites and those plants which depend on dead and rotting organic remains of plants and animals are called saprophytes.

Partially autotrophic and partially heterotrophic are insectivorous plants which posses the green pigments and can manufacture carbohydrates but are not capable of synthesising nitrogenous compounds and proteins. Insectivorous plants have to depend on insects which they catch and digest by specific devices developed in them.

Symbiosis: The common examples are Lichens and Mycorrhizae. In case of parasites only parasites are benefitted and the host are always at loss, but in symbiosis both the plants are benefitted. In case of lichens's algae manufacture the food whereas fungal members help in the water absorption. Association of nitrogen fixing bacteria with leguminous plants (nodules) is symbiosis. Such plants are known as symbionts and the mode of nutrition is called mutualistic modes of nutrition.

Major Plants Macro Nutrients are as follows:

- **Nitrogen (N):** N_2 deficiency in the plants leads to decrease in angle between stem and leaf. In cereals and many other grasses, tomato and potato, the leaves assume a more erect position than usual is due to Nitrogen deficiency. Chlorophyll synthesis is retarded and leaves turn yellow, this yellowing is rather more pronounced in older leaves. Nitrogen deficiency in wheat leads to formation of longer roots.

- **Phosphorus (P):** Its deficiency is reflected by abnormal colour of leaf, generally these symptoms appear in older leaves. In cereals, phosphorus deficiency is similar to those of nitrogen i.e. lessened leaf angle, reduced fillering, prolonged dormancy, premature leaf fall, and decreased number and size of flower. Often, phosphorus deficiency leads to accumulation of carbohydrates and reduction of nitrogen fractions.

- **Calcium (Ca):** Calcium is the chief constituent of plants as calcium pectate of middle lamella of cell wall. The deficiency of calcium appears in the young leaves and near the growing points of stem and root. In its deficiency, margins of leaves, often appear irregular in form or often show brown scorching or spotting effects. It also leads to impaired development of lateral roots and nuclear division. Sometimes root hairs of calcium deficient plants become bulbous. Fresh supply of calcium helps in greater production of nuts in groundnut.

- **Iron (Fe):** It acts as a catalyst and electron carrier in respiration. In extreme deficiency conditions scorching of leaf margins and tips may occur. In mild deficiency it produces a mottled pattern or leaf may show complete bleaching. In deficiency chlorosis of the

leaves occurs and young leaves are severely affected. Principal veins may remain green.

- **Manganese (Mn):** It is metallic cofactor for some respiratory enzymes such as malic dehydrogenase. It also serves as an activator for enzyme connected with reduction of nitrate. Mn influences absorption of other elements such as K and Ca. Its deficiency leads to chloroplast disintegration. In its deficiency the root system is often poorly developed and badly affected.
- **Zinc (Zn):** It is also found in soils in very small quantities and largely it results from concentration and addition from growing plants and added residue. Zinc deficiency symptoms in citrus fronts are widespread where it causes the condition known as '*mottle leaf*'.
- **Boron (B):** It favours the absorption of calcium. It is essential for translocation of sugars and is involved in reproduction and germination of pollens. Its deficiency is responsible for several diseases such as *'Heart rot of sugar beet and marigold'*, Hard fruits of citrus and top sickness of tobacco.

■■■

DIGESTIVE SYSTEM

The canal or body parts in which digestion takes place is called Alimentary canal. It starts from the mouth and passing through oesophagus, stomach and small intestine finally ends into large intestine. Absorption of digested food mainly takes place in small intestine. Undigested and unabsorbed material then pass down into the colon and rectum which absorb the excess water and with the help of **putrefying bacteria** form faeces. Finally the faeces passes out through the anus.

HUMAN DIGISTIVE SYSTEM

• Mouth

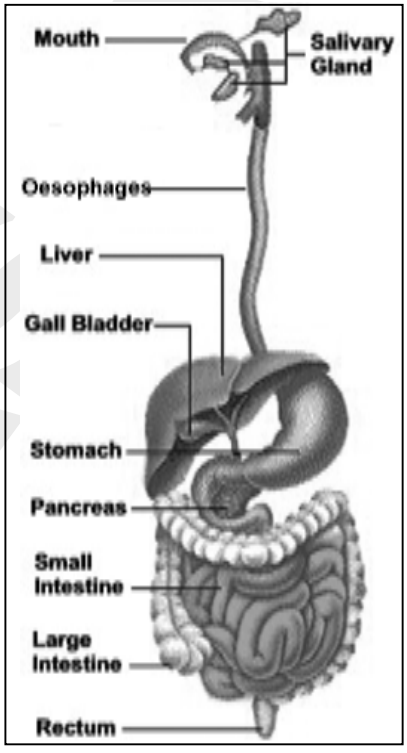
It is a transverse slit bounded by two movable lips. **Vestibule** is the space between gums and lips. Its lining has mucous glands. **Buccal Cavity** (Oral Cavity) is a large space bounded by palate above, throat with tongue below and jaws with teeth on the sides. Salivary glands open into it.

• Palate

Palate or roof of the buccal cavity is differentiable into anterior hard palate and posterior soft palate**.** Hard palate has transverse rugae supported by bones for holding food under mastication. Soft palate has smooth surface. It takes part in swallowing. There is a hanging flap called **uvula.** It is meant for closing internal nares.

• Tongue

Tongue is a muscular, protrusible flattened structure which extends into a part of pharynx. There are different areas for different tastes — sweet (tip), salt (tip and sides), sour (sides) and bitter (base). Tongue is involved in speech, swallowing, taste, ingestion and moving food below teeth. The basal region also contains two tonsils or **lingual tonsils.** Tonsils contain lymphoid tissue. **Tonsillitis** is inflammation of tonsils.



• Taste

We have roughly 10,000 tastebuds on our tongue, which come alive the moment we put food in our mouth. As nerve endings, they are responsible for sussing out the chemicals in the food we have eaten and transmitting messages to our brain. Without them we wouldn't be able to experience salty, bitter, sweet or sour sensations. While our tastebuds are busy at work, our teeth grind the food into easily digestible pieces and our saliva moistens everything, so it doesn't scrape our digestive (gastrointestinal) tract on the way down.

• Pharynx

It lies between soft palate and sixth cervical vertebra. Pharynx is distinguishable into three parts — nasopharynx, oropharynx and laryngopharnx. It contains two internal nares, openings of two eustachian tubes, openeing of larynx or glottis, opening of oesophagus or gullet. Glottis can be closed by raising of larynx to bring in contact with epiglottis. Internal nares can be closed by uvula. This is done during swallowing.

• Oesophagus

The Oesophagus is an organ in vertebrates which consists of a muscular tube through which food passes from the mouth to the stomach. The esophagus is continuous with the laryngeal part of the pharynx at the level of the C6 vertebra.

Function: Food is passed through the esophagus by using the process of peristalsis. Specifically, in mammals, it connects the pharynx, which is the body cavity that is common to the digestive system and respiratory system behind the mouth (buccal cavity), with the stomach, where the second stage of digestion is initiated (the first stage of digestion is in the mouth, with teeth and tongue masticating food and mixing it with saliva).

The Oesophagus is lined with mucous membrane, and is more deeply lined with muscle that acts with peristaltic action to move swallowed food down to the stomach.

Gastroesophageal junction: The junction between the Oesophagus and the stomach (the gastroesophageal junction or GE junction) is not actually considered a valve, although it is sometimes called the cardiac valve, cardia or cardias, but is actually more of a stricture.

Oesophageal diseases: Many people experience acid reflux, where stomach acid gets pushed up into the esophagus, causing a burning sensation, commonly termed heartburn. Some people also experience a sensation known as globus esophagus, where it feels as if a ball is lodged in the lower part of the esophagus.

HUMAN DIGESTIVE ENZYMES & THEIR ACTION

Parts	Digestive juice	Enzyme present	Enzyme act on	Changed into
Mouth	Saliva	Ptylin	Starch	Dextrin Maltose
Stomach	Gastric Juice	(a) Pepsin+HCl	Proteins	Simpler Polypeptides
		(b) Rennin	Milk	Curdled into Cashein
		(c) Gastric Lipase	Fat	Fatty acids and Glycerol
Liver	Bile juice	No enzyme		
Pancreas	Pancreatic juice	(a) Trypsin	Simpler Polypeptides	Tri, Di & Mono peptides
		(b) Amylase	Starch	Maltose
		(c) Pancreatic	Emulsified fat	Fatty acids & Glycerol
Small Intestine	Succus entericus	(a) Peptidases	Poly, Tri & Dipeptides	Amino acids
		(b) Invertase	Sucrose	Glucose & fructose
		(c) Lipase	Fat emulsions	Fatty acids and glycerol
		(d) Maltase	Maltose	Glucose
		(e) Lactase	Lactose	Glucose + Galactose

● Stomach

It lies between a muscular tube called the oesophagus and the small intestine. It is a J-shaped elastic sac which is the widest part of your digestive system which takes part in storing food, breaking food down and mixing it with juices secreted by your stomach lining. Once we have swallowed the food, it's carried down the oesophagus to our stomach. Here, our stomach walls churn the food up to make sure it's mixed with our acidic digestive juices. By the time our tummy has finished, the food is a creamy mixture called **chyme**. Once it's liquefied it can be squirted through a small hole into our small intestine.

Food store: Your stomach is a short-term food-storage facility. This allows you to consume a large meal quickly and then digest it over an extended period of time. When full, your stomach can hold around one litre of chewed up food. Swallowed food is propelled down your oesophagus into your stomach. Food is enclosed in your stomach by two circular muscles, known as sphincters.

Chemical breakdown: As soon as food enters your stomach, your stomach lining releases enzymes that start breaking down proteins in the food. Your stomach lining also secretes hydrochloric acid, which creates the ideal conditions for the protein-digesting enzymes to work. The potent hydrochloric acid kills bacteria, protecting your body from harmful microbes which can enter your body in food.

Your stomach protects itself from being digested by its own enzymes, or burnt by the corrosive hydrochloric acid, by secreting sticky, neutralising mucus that clings to the stomach walls. If this layer becomes damaged in any way it can result in painful and unpleasant stomach ulcers.

Physical breakdown: Waves of muscular contraction along your stomach wall, known as peristalsis, break down food into smaller pieces, mix it with fluids secreted from your stomach lining and move it through your stomach. This creates a mixture that resembles thick cream.

When food has been broken down sufficiently, small amounts are squirted out of your stomach into your small intestine for further processing. This normally occurs within four hours of eating a meal, but can take six or more hours if your meal has a high fat content.

Ruminant Stomach: In ruminant animals, the stomach is differentiated into chambers-

(i) rumen (paunch) for churning, breaking of food by cornified surface of villi, fermentation of cellulose by symbiotic microoganisms (anaerobic bacteria and ciliates)

(ii) reticulum (honey comb)

(iii) omasum (Spsalterium) for mechanical churning and breaking of food, absorption of fluid and

(iv) abomasum (rennet) for mixing gastric juice.

Ruminates chew the cud. This is done by breaking small part of food present in rumen and sending it to buccal cavity fo chewing. Omaisum is absent in Camel. Here rumen and reticulum have diverticula or water pockets for temporary storage of food.

● Small Intestine

This is where most of the nutrient-digesting action happens. To help our small intestine cope with the acidity of the chyme, our pancreas releases alkaline and lots of enzymes, which break down the food's carbohydrates, fat and protein. Meanwhile, our gall bladder donates some bile to ensure any fat is melted down thoroughly. Once the food is reduced to tiny particles, it's absorbed through the walls of the small intestine and the nutrients are carried into our bloodstream.

It is the longest and narrow tubular part of alimentary canal that lies coiled in the abdomen. Small intestine has circular folds and villi. Villi contain lacteals. Small intestine is differentiated into three parts — duodenum, jejunum and and ileum.

1. **Duodenum.** It is 20 — 25 cm long wider tube that forms a C-shaped arch with stomach. Duodenum has an ampulla where common bile duct and pancreatic duct open jointly.

ABC OF APPENDIX

Attached to the first part of your large intestine it is a narrow, muscular, worm-like pouch, usually around nine centimetres long.

Function: The appendix has no known function in humans. Evidence suggests that our evolutionary ancestors used their appendixes to digest tough food like tree bark, but we don't use ours in digestion now. Some scientists believe that the appendix will disappear from the human body. The appendix is rich in infection-fighting lymphoid cells, suggesting that it might play a role in the immune system. Whether the appendix has a function or not, it can be removed without any ill effects.

Appendicitis: Indigestible food delivered from the small intestine to the large intestine flows into the appendix and is forced out by contraction of the muscular walls of the appendix. A blockage in the opening where the appendix attaches to the large intestine can lead to inflammation of the appendix, known as appendicitis. This can cause acute pain, fever, nausea, vomiting and loss of appetite, but can be cured easily by removing the appendix.

2. **Jejunum.** It is middle the part of small intestine, 0.80—1.5 m. Jejunum is rich in digestive glands.

3. **Ileum.** It is 1.8 — 2.5 m terminal narrow part of small intestine which is characterised by club-shaped villi and Peyer's patches. Major digestion and absorption occurs in small intestine. It also produces a number of hormones.

Chemical digestion: After food is churned up in your stomach, a **sphincter muscle** at the end of your stomach opens to squirt small amounts of food into the top of your small intestine. This first section of the small intestine is called the **duodenum**. Your pancreas releases digestive juices through a duct into your duodenum. This fluid is rich in enzymes that break down fats, proteins and carbohydrates. It also contains sodium bicarbonate which neutralises acid produced in your stomach. Your gall bladder squeezes out bile down a duct into your duodenum. Bile helps break down fats in your food.

Peristalsis: Digesting food is pushed through the small intestine by peristalsis. Peristalsis is a muscular movement in which alternating waves of muscle contraction and relaxation cause food to be squeezed along the digestive tract.

Absorbing nutrients: Most of the nutrients in the food you eat pass through the lining of your small intestine into your blood. The lining of the small intestine is covered by tiny **microvilli**. These are microscopic, finger-like protrusions which give the lining of the small intestine a massive surface area for absorption of nutrients to occur across. The microvilli give the inside of the intestine the look and feel of velvet. Each microvillus contains a minute blood capillary. When nutrients are absorbed into a microvillus, they enter its blood capillary. This is how nutrients from your food enter your blood.

• Large Intestine

It is a 1.5 metre-long tube, surrounding our small intestine, which convert food waste products into faeces. Our large intestine is the final part of digestive tract. Undigested food enters our large intestine from small intestine. It then reabsorbs water that is used in digestion and eliminates undigested food and fibre. This causes food waste products to harden and form faeces, which are then excreted. Any nutrients that can't be digested end up here, including fibre, which has certain components that can't be absorbed by the human body. Our large intestine begins at the colon, where some of the remaining nutrients can be mopped up. After this point, anything that's left over is waste matter and is stored in the rectum, waiting for the journey's end.

It is known so because of its larger diameter (4-6 cm) as compared to small intestine (3.5 — 4.5 cm). Large intestine is about 1.5 m long. It is differentiated into four parts — caecum, colon, recrum and anal canal.

1. **Caecum.:** In humans, caecum is pocuh-like small (about 6 cm) junction between ileum and colon. It bears a blind tube, having lymphoid tissue, called **vermiform appendix** (7-9 cm long, 1 cm diameter). Infection of the latter is called **appendicitis**. Caecum is prominent in herbivorous animals.

2. **Colon**: It is the largest part of large intestine.

3. **Rectum::** It is 12 – 15 cm long tube which is wider than colon and bears longitudinal folds. Englargement of rectal veins causes piles or **haemorrhoids.**

4. **Anal Canal:** It connects rectum with anus. Anal canal is about 3 cm long.

- An average stool is 75 per cent water. The remainder is made up of fibre, dead cells and bacteria.
- The acids in our stomach are so strong, they kill bacteria and are similar to those used in industrial metal cleaner.
- **Anus** is the terminal inferiror opening of alimentary canal which is guarded by an internal involvuntary sphincter and an external voluntary sphincter.

• Digestive Glands

They include salivary glands, gastric glands, liver, pancreas and intestinal glands.

1. Salivary Glands

There are three pairs of salivary glands. About 1.0—1.5 liters of saliva is produced daily. It contains water some salts, mu cin, lysozyme and ptyalin. pH is 6.7. **Ptyalin** or **salivary amylase** functions at or near neutral pH in humans and pigs. It is absent in herbivores. Ptyalin converts starch and glycogen of cooked or baked food into limit dextrins, maltose and isomaltose, making the food sweet (on

thorough chewing). Lysozyme is antibacterial. Mucin and water lubricate the food for proper chewing and swallowing. **Mumps** is a viral infection of parotid glands.

2. Gastric Glands

They are branched and unbranched tubular glands. **Cardiac glands** mostly secrete mucus. **Pyloric glands** also secrete mucus. Some of them produce hormone **gastrin. Peptic Cells** (chief or zymogen cells) yield **pepsinogen** (a zymogen) and **gastric lipase.** In Calf, another proenzyme called **prorennin** is also produced. **Oxyntic Cells** (parietal cells) yield **HCL.** and HCl makes the gastric juice acidic (pH 2.0 — 3.7). **Argentaffin Cells** produce somatostatin, histamine and 5-hydroxytryptamine.

Secretion of gastric glands is called **gastric juice.** Mucus protects stomach wall against HCL action and protein digesting enzyme. HCL changes pepsionogen and prorennin into active enzymes **pepsin** and **rennin.** Pepsin functions in acidic medium and changes proteins into peptones. Milk protein casein is converted into calcium paracaesinate for curdling it. In calf this is done by rennin (also believed to be produced by infants). Gastric lipase is active in infants. It changes milk fat tributyrin into fatty acids and glycerol.

● Liver

Under our diaphragm, more to the right side of our body, liver is a wedge-shaped, spongy organ which works to get rid of toxins, to regulate our blood sugar levels and to produce bile. Our liver is the largest internal organ. A big blood vessel, called the **portal vein**, carries nutrient-rich blood from your small intestine directly to your liver.

1. **Hepatic cells** make up about 60 percent of our liver tissue. These specialised liver cells carry out more chemical processes than any other group of cells in our body. They change most of the nutrients we consume into forms our body cells can use. They convert sugars and store and release them as needed, thereby regulating your blood sugar level; break down fats and produce cholesterol; remove ammonia from your body and produce blood proteins, including blood clotting factors. Other functions of your hepatic cells are to detoxify drugs and alcohol; produce bile, which breaks down fats in the food you eat.
2. A second important group of liver cells are the **Kupffer cells**. They remove damaged red blood cells, destroy microbes and cell debris.
3. Because our liver fulfils so many vital functions, we would die within 24 hours if it stopped working. A common sign of a damaged liver is jaundice, a yellowness of our eyes and skin. This happens when **bilirubin**, a yellow breakdown product of your red blood cells, builds up in your blood.

● Pancreas

Behind the stomach and level with the top of the small intestine, Pancreas is a pistol-shaped organ which secretes digestive enzymes and hormones that control blood sugar levels.

1. **Digestion:** When you eat, your pancreas releases digestive juices through a duct into your duodenum - the first part of your small intestine. This fluid is rich in enzymes that break down fats, proteins and carbohydrates. It also contains sodium bicarbonate which neutralises acid in your stomach.
2. **Blood sugar levels:** Your pancreas produces insulin and glucagon, two hormones that regulate sugar levels in your blood. Insulin and glucagon are secreted from your pancreas directly into your blood.
3. When the concentration of glucose (a sugar) rises in your blood, insulin is released. Insulin lowers blood glucose levels by stimulating cells throughout your body to use and store glucose.
4. Glucagon has the opposite effect of insulin. It triggers the release of stored sugars, increasing the concentration of glucose in your blood. Glucagon acts as a control mechan-ism whenever your body produces too much insulin.
5. It is possible to live without your pancreas provided you take insulin to regulate blood sugar concentration and pancreatic enzyme supplements to aid digestion.

● Gall Bladder

On the underside of our liver it is a pear-shaped, green, muscular sac which store and concentrate bile produced in our liver.

1. Bile is a greenish-yellow, slightly acidic fluid that is made in our liver. We produce about one litre of it a day.
2. Bile is stored in our gall bladder and once it gets there, it is concentrated by the removal of water.
3. After a meal, our gallbladder contracts, squeezing bile into our small intestine. Bile breaks down fat in the food we eat.
4. **Gallstones:** Most gall bladder disorders are due to the presence of gallstones. Gallstones are formed when cholesterol, one of the components of bile, crystallises to form a stone-like material.

● Intestinal Glands

They secrete mucus and a little of enzymes. The digestive juice of intestinal glands is called intestinal juice or **succus entericus.** It is slightly alkaline (pH 7.5), contains mucin, inorganic salts and many enzymes — **aminopeptidases** (breaking larger peptides into smaller peptides by separating amino acids), **depeptidases** (dipeptides into amino acids), **nucleotidases** (nucleotides into nucleosides and phosphate), **nucleosidases** (nucleosides into nitrogen bases and pentose surgars), **intestinal lipase** (fat into fatty acids, glycerol, monoglycerides), **isomaltase** (limit dextrins and isomaltose into glucose), **maltase** (maltose to glucose), **lactase** (lactose to glucose and galactose) and **sucrase** (= invertase, sucorse to glucose and fructose).

ABSORPTION OF DIGESTED FOOD

Digestion changes proteins into Amino acids; carbohydrates into Monosaccharide glucose, fructose and galactose; and fats into fatty acids and glycerol. These end products of digestion are finally absorbed in the wall of the small intestine. Intestine has a vast surface for absorption owing to the presence of numerous finger-like folds of the intestinal wall called '***villi***'.

Amino acids and monosaccharide sugars are easily absorbed and passed directly into the blood capillaries of the villi, and thence to the hepatic portal circulation which carries them into the liver. Fatty acids and glycerols do not reach the blood stream, but pass into the lymph capillaries of the villi called '***Lacteales***'. In lacteales, fats are re-synthesised into small fat molucules called '***Chylomicrons***'. Lacteales finally pours it into the blood circulation.

Digestion and absorption of proteins

During digestion the proteins, first get hydrolysed, the end products of protein digestion, are amino acids. Digestion of proteins is initiated in the stomach by the action of the enzyme *pepsin*.

The amino acids enter the blood from where these go to the liver. In certain cases, some of the unchanged proteins may act as antigens for producing antibodies. A common stock or metabolic pool of free amino acids is maintained in blood, liver, and tissues from the amino acids absorbed in the gastrointestinal tract and those obtained for the breakdown of body protein.

The body proteins are continuously renewed e.g. half of the protein of liver and muscle is renewed every 10th and 160th days, respectively. The synthesis of protein from amino acids is under the control of anabolic hormones such as testosterone and GH. Break down of proteins to amino acids is controlled by catabolic hormones such as ACTH. The protein metabolism in the body therefore, is in a state of constant flux.

More than 50 per cent of energy content of the common diet comes from carbohydrates. For a normal person about 70 g of proteins and about 400 to 500 g of carbohydrates are recommended. Glycogen is an insoluble carbohydrate found in the liver and muscles of animals. In the event of deficiency of energy, glycogen is rapidly converted into glucose which is carried to the different parts of body by the blood. Cellulose is present in all plants since it is the main constituent of cell wall. Very few animals can digest it. Herbivores have special part in their gut where microorganisms act on cellulose and break it down. But in most animals it remains unchanged and contributes the roughage in the diet.

Digestion & Absorption of Carbohydrates

In carbohydrate digestion the complex carbohydrate molecules are broken down into monosaccharides by the addition of water. This process is known as hydrolysis. Of these, glucose is directly absorbed in the blood. The first step, in the digestion of starch is its conversion to maltose with the help of amylase, a large amount (40%) is digested in the mouth by salivary amylase. When the 'chyme' enters the stomach, part of the undigested starch is hydrolysed by the HCI present in the gastric juice. The total digestion is accomplished in the intestine, where it is exposed both to pancreatic and intestinal amylase.

The other carbohydrates, that is the disaccharide sucrose, lactose, and maltose are digested in the intestine by the enzymes invertase, b-glucosidase, and -galactosidase respectively. The digested carbohydrates are absorbed through the intenstinal villi. There are two mechanisms of absorption in the intestine i.e. diffusion and active absorption. Fructose is transported by simple diffusion in response to a concentration gradient by the absorptive cells of the villi. Glucose and galactose are actively transported. Of the three monosaccharides, glucose is immeditely transported throughout the body fluids. Fructose and galactose, however are converted into glucose in the liver and then transported to different parts of the body, thus the end product of carbohydrate digestion is glucose. The concentration of glucose in blood is about 90 mg/100 ml. (optimum level). Some of the excess glucose is taken up by tissues for oxidation, but most of it is taken up by muscle and liver for storage as glycogen, this process is facilitated by the hormone insulin. When blood glucose level falls, the glycogen is reconverted to glucose under the influence of a hormone glucagon and transferred to blood, this is called glycogenolysis. Hence liver is an efficient buffer organ for blood glucose level as when glucose level rises, it is stored and when the glucose level falls it is again compensated.

Sucrose $\rightarrow$ Glucose + Fructose

Maltose $\rightarrow$ Glucose + Glucose

Lactose $\rightarrow$ Glucose + Galactose

When the blood glucose level falls very low and is not adequately compensated by the liver glycogen, glucose is synthesized from proteins and to some extent from fats. This is known as gluconeogenesis, and is a very important phenomenon as it provides glucose to the blood even during starvation, because the amount of glycogen present in liver is not sufficient to maintain the blood glucose for more than 24 hours. When glucose is not available cells are able to utilise fats for energy. The ganglion cells of the brain are unable to utilize fats, and without glucose they die quickly.

Like carbohydrates, fats contain only carbon, hydrogen, and oxygen but in different proportion. They are compounds of glycerol with fatty acids. The layers of fatty tissues lying just below the skin have insulating function. During starvation, after fat reserves have been depleted, the body can use protein for energy.

Digestion and Absorption of Fats

The digestion of fat, is also a hydrolytic process in which the lipids are broken into fatty acids, glycerol and glycerides. Fats are digested by the enzyme lipase secreted in the stomach, pancreas, and intestine. Small part of the fat is digested in the stomach with the help of gastric lipase. But most of the fat digestion takes place in the small intestine. When the fat enters the small intestine they are acted upon by the bile salts simultaneously released from liver. As the

bile salts have a detergent action, they emulsify the fat into small globulins known as micelles which offer a greater surface area for lipases to act, and are further degraded by intestinal and pancreatic lipases into the product of fat digestion - fatty acid, glycerol and mono and diglycerides. In the fat digestion only 50% fat is completely digested to fatty acid and glycerol, the remaining 50% glycerides.

DIGESTIVE DISEASES

- **Gastroenteritis** is inflammation of the intestines and is the most common disease of the intestines. It can arise as the result of food poisoning.
- **Ileus** is a blockage of the intestines.
- **Ileitis** is an inflammation of the ileum.
- **Colitis** is an inflammation of the large intestine.
- **Appendicitis** is inflammation of the vermiform appendix located at the cecum. This is a potentially fatal disease if left untreated; most cases of appendicitis require surgical intervention.
- **Coeliac disease** is a common form of malabsorption, affecting up to 1% of people of northern European descent. Allergy to gluten proteins, found in wheat, barley and rye, causes villous atrophy in the small intestine. Life-long dietary avoidance of these foodstuffs in a gluten-free diet is the only treatment.
- **Crohn's disease** and ulcerative colitis are examples of inflammatory bowel disease. While Crohn's can affect the entire gastrointestinal tract, ulcerative colitis is limited to the large intestine. Crohn's disease is widely regarded as an autoimmune disease.
- **Irritable bowel syndrome** is the most common functional disorder of the intestines, and specifically the bowel. Functional constipation and chronic functional abdominal pain are other disorders of the intestines that have physiological causes, but do not have identifiable structural, chemical, or infectious pathologies. They are aberrations of normal bowel function but not diseases.
- **Diverticular disease** is a condition that is very common in older people in industrialized countries. It usually affects the large intestine but has been known to affect the small intestine as well. Diverticular disease occurs when pouches form on the intestinal wall. Once the pouches become inflamed it is known as Diverticulitis, or Diverticular disease.

TRIVIA

- **Largest Gland**: Liver which is about 1.5 kg, roughly 1/40 of total body weight.
- **Centre for Appetite/Hunger:** Hypothalamus. Stimulation is provided by decreased availability of glucose in blood.
- **Coprophagy:** Feeding on faeces e.g., Rabbit.
- **Maximum Number of Teeth:** Opossum — 50, Horse and Pig-44.
- **Monophyodont Teeth in Humans:** Molars.
- **Starch:** About 30% hydrolysed in mouth.
- **Stomach:** Absent in Labeo, Lamprey and Hagfish.
- **Gall Bladder:** Absent in Rat and Horse.
- **Vomiting:** Due to blockage or reverse peristalsis.
- **PUFA:** Poly-unsaturated fatty acids. Found in abundance is corn oil and sunflower oil.
- **FFA:** Free fatty acids. Circulate in blood in combination with albumins.
- **Vitamin P/Hesperidin/Citrin:** Essential for permeability and wall strength of blood capillarises — hence **permeability factor.**
- **Erythrocyte Maturing Factor** (EMF): Vitamin B_{12} or cyanocobalamine/cobalamine. ■■■

SKELETAL & MUSCULAR SYSTEM

CHRONICLE IAS ACADEMY
A CIVIL SERVICES CHRONICLE INITIATIVE

Skeletal system is a system of hard internal or external living or nonliving parts that forms the supporting framework of the body giving it shape's physical strength, protection to softer parts and place for attachments of muscles. The various functions of skeleton include:

- Providing shape & supporting framework.
- Protection to delicate and vital organs.
- Presence of joints for functioning as levers.
- Formation of blood cells (ends of long bones, inside scapula and sternum).
- Hearing through ear ossicles & sound production in larynx.
- Mineral storage, fat storage.
- Attachment of muscles, making body an integrated unit.

Exoskeleton : It is the hard protective and supportive framework present on the outside of the body and being made of either dead tissues or chemical secretions. Exoskeleton is found in both invertebrates (e.g. shells of snails, bivalves, corals, sclerites of insects) and vertebrates (e.g., hair, claws, nails, hoofs, horns, feathers, scales).

Endoskeleton : It is hard supportive framework of the body which occurs inside the body. It is present in corals, echinoderms and vertebrates. Endoskeleton of vertebrates is made of cartilages and bones, both of which are living connective tissues hardened by deposition of organic and inorganic substances. Bones are as hard as graphite with a tensile strength equal to that of cast iron. Bones can be long (e.g., femur, tibia, fibula), short (metacarpals, metatarsals, phalanges), flat (e.g., cranial, scapula) and irregular (e.g., vertebrae, carpals, tarsals). Human skeleton is made of 270 bones which are fused variously to become 206. Out of these 6 occur as ear ossicles. The remaining 200 bones are distributed into axial and appendicular skeleton.

Axial Skeleton : The skeleton occurs in the mid-axial part of longitudinal axis of the body and is made of skull, vertebral column, sternum and ribs.

Appendicular skeleton : The skeleton lies laterally and is attached to axial skeleton at an angle. It has pectoral girdle, pelvic girdle, arm bones and leg bones. Pectoral girdle and arm (force limbs) bones constitute upper extremity while pelvic girdle and leg (hind limbs) bones form lower extremity. Limbs end in fine digits.

HUMAN SKELETAL

This system comprises a network of bones, cartilages, ligaments and tendons. It provides the proper and definite shape to the body and protects vital organs from harm. It is also the major ground of the RBC and WBC formation and works as the storehouse of calcium and phosphorus. Besides it provides anchorage to muscles and levarage for the easy movement of the body.

Bones

At the time of birth the total number of bones are 350 while in adults it is 206. Each bone meets with the other except *Hyoid bone* (U-shaped) of the neck. It is helpful in crime identification. Constituent of Bones: 20% water, 30-40% organic parts and 40-50% inorganic parts. Organic parts is made: up of a protein called "Ossein". Inorganic parts consist of calcium carbonate, megnesium phosphate, calcium fluoride, etc.

In children bones, are supple (more elastic) due to more fibrous tissues and less mineral salts. But in old aged persons the bones are brittle due to high level of mineral salts and less fibrous tissues. Long bones like ***femur*** (longest) ***humerus, tibia, ulna*** are cylindrical with shafts and act as levers. Short bones like ***skull bone (cranium), knee-cap*** are thinner. ***Vertebrae,*** 26 in number, are irregular bones ***Ossicles*** of the inner ear is the smallest bone. It is 3 in number- ***Malleus, Incus*** and ***Stapes.*** Stapes is smallest of all the three.

Cartilage

It is tough connecting tissues, found in bone joints. It is more elastic and provides easy movement. They act as buffers in the effect of a blow or shock and to deepen the bony sockets of various joints by surrounding the edges in the form of ring. They also line the surfaces of gliding bones, thereby making motion easier. Cartilages are made of Chondrocyte (cellular part), Chondrin (Non cellular part; protein) and yellow / white fibres. Cartilages are covered by a membrane *synovial Membrane.* For easy movement of the joints synovial membranes are lubricated by *Synovial Fluid.* Lack of synovial fluid causes pain in joints which occurs mostly in old age persons. *Sark* is a cartilaginous animal and the whole skeleton systems is made of cartilages.

Ligaments

These are tough bands of fibrous connecting tissues, usually found in bone joints. They are non-elastic in nature. They hold some important organs in the body, like uterus.

Tendon

They are tough bands of fibrous connecting tissue which connects a bone with muscles. They act as a structural framework to which the muscle fibres and bones are attached. They are also non-elastic in nature.

Joints

Joints are the point where two or more bones meet. The bones at a joint are held by strong cords called ligaments, which provide necessary freedom to the bones and protect the joints from external injury and prevent dislocation. The joints in our body fall into these categories:

(a) **Immovable Joints:** They permit no movement of the bones and are usually found in the skull and the pelvic girdle, where movements of bones are not desirable.

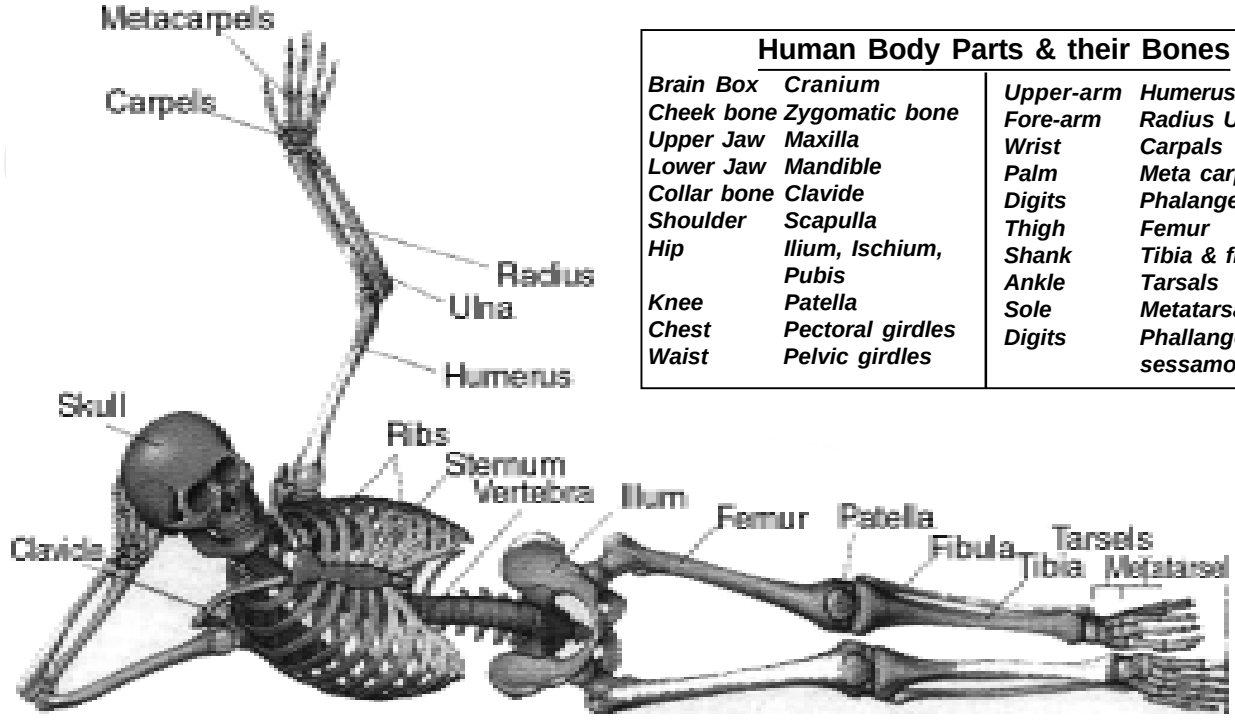
(b) **Slightly Movable Joints:** They allow a limited degree of movement: The movement of a vertebrae in respect of another vertebrae is such an example.

(c) **Movable Joints:** Here greatest freedom of movement is allowed. They are also called synovial joints. Movements of hip and shoulder joints, joints of ankle and wrist, etc. come in this category. Bone ends bear synovial membranes and enclose a cushion of synovial fluid. Joints are of Six types.

- **Ball and Socket Joint:** Articular end of one is like a ball and that of the other like a cup-shaped socket, e.g., hip joint, shoulder joint. The joint allows movement in many planes.
- **Saddle Joint:** Articular end of one bone is fixed while that of the other can rotate over it. e.g., carpo-metacarpal joint of human thumb.
- **Ellipsoid or Angular Joint:** One articular end is oval and convex while the other end is elliptical and concave, e.g., wrist or radio-carpal joint of humans.
- **Pivot Joint:** Articular end of one bone iis fixed while that of the other can rotate over it, e.g., between atlas and axis is humans.
- **Hinge Joint:** Articular end of one bone is deeper convex and that of other is deeper concave, allowing movement in one plane e.g., elbow joint, knee joint.
- **Gliding Joint:** Articular ends of two bones are either flat or slightly curved to allow sliding or gliding movement, e.g., bones of palm and sole, between prezygapophyses and postzygapophyses of vertebrae.

COMMON HUMAN BONES

1. **Shoulder:** Our shoulder is made up of a collarbone (clavicle) and a shoulder blade (scapula). These bones project out from our body forming a scaffold for our arm to hang from. Our collarbone is a thin bone that bridges the top of our sternum, in the front of our ribcage, to our shoulder socket at the end of our shoulder blade. It is the only bone in our shoulder that connects directly to our ribcage.
2. **Arm:** Our arm is made up of three long bones: humerus in our upper arm and ulna & radius in our lower arm. Our upper and lower arms are connected at the elbow by a hinge joint between humerus and ulna. Our radius and ulna are linked at elbow in a way that allows us to rotate hand and forearm by more than 180 degrees. Our ulna bone forms the point of elbow.
3. **Fingers & Toes:** More than half of the bones in your body are found in hands and feet. There are 27 in each hand and 26 in each foot, and the way that they are arranged is remarkably similar. Each finger contains three bones, except for thumbs, which only have two. The same is true for toes. Our big toes contain two bones, and other toes each contain three. The bones in fingers and toes are called phalanges.
4. **Metacarpals & Metatarsals:** The palms of our hands are made up of five bones called metacarpals. We can see them when we clench our fists, because our knuckles are the ends of our metacarpals. The soles of our feet consist of five bones arranged in the same way as our metacarpals, but they are called metatarsals.



Human Body Parts & their Bones

Brain Box	*Cranium*	*Upper-arm*	*Humerus*
Cheek bone	*Zygomatic bone*	*Fore-arm*	*Radius Ulna*
Upper Jaw	*Maxilla*	*Wrist*	*Carpals*
Lower Jaw	*Mandible*	*Palm*	*Meta carpals*
Collar bone	*Clavide*	*Digits*	*Phalanges*
Shoulder	*Scapulla*	*Thigh*	*Femur*
Hip	*Ilium, Ischium, Pubis*	*Shank*	*Tibia & fibula*
		Ankle	*Tarsals*
Knee	*Patella*	*Sole*	*Metatarsals*
Chest	*Pectoral girdles*	*Digits*	*Phallanges*
Waist	*Pelvic girdles*		*sessamoid*

5. **Wrist:** Our wrists consist of eight small nugget shaped bones, held together by ligaments. These are called carpals. They are arranged in two irregular rows that are held together by ligaments.

6. **Heel:** The two largest bones in our feet carry most of our weight. Calcaneus, or heel bone, and the talus, which lies between our heel bone and the bottom of shinbone, are two of seven tarsal bones that make up the back part of each of our feet.

7. **Leg:** Leg bones are the longest and strongest bones in our body. Each leg is made up of four bones. The three long bones are femur, tibia and fibula. The fourth bone is small patella, which is better known as the kneecap. Femur, or thighbone, is the largest bone in our body. The head of femur fits into hip socket and the bottom end connects to knee. The two bones beneath knee that make up the shin are tibia and fibula. Our upper and lower leg are connected by a hinge joint. Our patella, or kneecap, rests on the front of femur. The bones of leg have roughened patches on their surfaces where muscles are attached. When our muscles contract, they pull the bone they're attached to, making our leg move.

8. **Spine:** Also known as backbone, spine is a strong, flexible column of ring-like bones that runs from skull to our pelvis. It holds head and body upright and allows us to bend and twist our body. It also offers protection to our spinal cord - a large bundle of nerves that runs through the cavity in the centre of spine that relays messages between brain and the rest of body. Spine is made up of 33 irregularly shaped bones called vertebrae. Each vertebra has a hole in the middle through which the spinal cord runs. The spinal cord can be divided into five different regions, from top to bottom:

- Our 7 cervical vertebrae support head and neck and allow us to nod and shake our head.
- Our ribs attach to 12 thoracic vertebrae.
- Five sturdy lumbar vertebrae carry most of the weight of our upper body and provide a stable centre of gravity when we move.
- Our sacrum is made up of five fused vertebrae. It makes up the back wall of our pelvis.
- Coccyx is made up of four fused vertebrae. It is an evolutionary remnant of the tail found in most other vertebrates.

9. **Pelvis:** Pelvis is a ring of bones that supports the weight of our upper body. Commonly referred to as hipbones, the two major bones in our pelvis are our coxal bones. Each coxal bone is made up of three smaller bones that fuse together: ilium, ischium and pubic bone. When we put our hands on our hips, they are resting on illia. These are most pronounced in women. Ischia are our sitting bones. They carry all our weight when we sit down. Our pubic bones meet at the front of our pelvis and are linked together by a bridge of flexible cartilage. A woman's pelvis is shallower and wider than a man's, making it wide enough for a baby to pass through during birth.

10. **Rib Case:** Our ribcage is assembled from three types of bone - sternum, 12 pairs of ribs and 12 thoracic vertebrae. All of our ribs attach to spine, but only the top seven pairs connect to sternum. These are known as 'true ribs' and they are connected to our sternum by strips of cartilage. The next three pairs of ribs are known as 'false ribs'. Instead of attaching directly to our sternum, they all attach to lowest true rib. The last two pairs of ribs are called 'floating ribs'. These only attach to our spine.

11. **Skull:** Skull is made up of two sets of bones - the bones of face and the bones of cranium, which make up our forehead and the back of our head. Cranium is the large bony case that surrounds our delicate brain, protecting it from bumps and knocks. It is made up of eight large flat bones, joined together by fixed joints known as sutures. Our frontal bone forms the forehead, and the tops of eye sockets. Most of the top and sides of our head are formed by two parietal bones. And the back of our skull is formed by occipital bone which has an opening in it where spinal cord connects to brain. The fourteen bones at the front of our skull hold our eyes in place and form facial features. Mandible, or jawbone, is the largest, strongest bone in our face. It holds lower teeth in place and we move it to chew food. Apart from mandible and vomer, all facial bones are arranged in pairs. That's why our face is symmetrical. For example, our two zygomatic bones form cheekbones and the outside of eye sockets on either side of face.

12. **Teeth:** Teeth prepare food for digestion by breaking it down and chewing it up. They do this by cutting, tearing, crushing and grinding. Flat front teeth, called incisors, are good for biting, scraping and cutting. Cone shaped canines are good at piercing and tearing food. Teeth that crush and grind the food are blunt premolars and at the broader, larger molars.

Teeth are covered with **enamel**, which is the hardest substance in the body. It covers the exposed part of teeth above gum. The roots of teeth are fixed into a socket in jawbone. Although teeth are hard on the outside, they actually have a soft centre. Inside the teeth is a cavity filled with pulp. **Pulp** is made up of connective tissue, blood vessels, and nerve fibres. It supplies nutrients to teeth. The pulp cavity extends into the root of teeth, forming the **root canal**.

Polyphyodont : In lower vertebrates, the teeth are replaced continuously, the old worn out ones falling out and their places being taken by new ones throughout life. This condition is Polyphyodont.

Diphyodont: It is a condition in which there are only 2 definite sets of teeth a milk or deciduous set in the young animals and a permanent set in the adult, e.g. in most animals. Mammals have 4 different types of teeth, each having their specific functions.

Dental formula: i = Incisor; c= Canines, p = Premolars and m = Molars. Now, for example, take the case of Man (Milk set); we have (only half side, either left or right):

Incisors = 2 on upper jaw and 2 on lower jaw

Canines = 1 on upper jaw and 1 on lower jaw

Premolars = 2 on upper jaw and 2 on lower jaw

Molar = 0 on upper jaw and 0 on lower jaw

So, we can represent it in the following way:

i 2/2, c 1/1, p 2/2, m 0/0 or 2120/2120

Total = 10×2 (Half × 2) = 20

Similarly:

Horse = 3143/3143 = 44

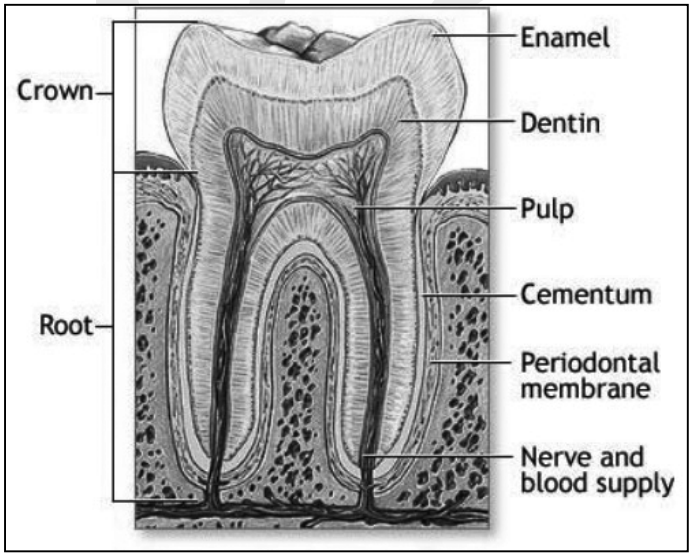
Man (Milk set) = 2120/2120 = 20

Man (Adult) = 2123/2123 = 32

Dog = 3142/3143 = 42

Squirrel = 1023/1023 = 24

- **Milk teeth** are of yellowish colour while the permanent teeth are white. First milk teeth to appear is incisor while the first permanent teeth to appear is 1st molar.
- **Permanent teeth** appear between 3 and 20 years of age.
- **First molar** is largest of all teeth while the third molar is smallest and appears at last.
- Man like the primates also has 32 teeth.
- **Tusks** of elephants are modified incisor teeth. African elephants, both male and female have tusks while in India only male have them.
- The prolonged teeth of wild boars are modified canine teeth.
- **Crown** of the teeth (outside the gum line) covers the 1/3 of total tooth and is coated with **enamel** which is non-living and toughest part of the body. Enamel cannot be replaced but in some animals like the rodents it is replaceable and is formed continuously.
- Nerves in the teeth are very sensitive but are able to make sensation only in the form of pain. So all other effects like cold, heat are converted into the forms of pain only.
- **Wisdom Teeth:** The last teeth that emerge are our wisdom teeth. It's not clear what their function is, but some experts believe they're a remnant from a time when our ancestors had a more rugged diet and, as a result, longer, larger jaws. Now our jaws are smaller, and often isn't enough room for them, which is why wisdom teeth can cause problems.



- **Tooth Decay:** There are bacteria in our mouth that multiply when we eat sweet food. As these bacteria feed on food stuck on our teeth, they produce acid. This acid can dissolve enamel and eat through a tooth, right down to the nerve in its pulp cavity. A hole in a tooth like this provides a route for bacteria in our mouth to cause nasty infections in the root of a tooth. This can result in excruciating toothache.
- The most common dental diseases are **Gingivities** (inflamation of gum) **Pyorrhoea** (formation of puss on the junction of tooth and gum). Bacteria forms acid around the teeth in the mouth which harms the calcium compound of tooth.

MUSCULAR SYSTEM

It is a system of different muscles present in the body of an organism which is specialised to perform various movements inside the body as well as its external parts. Human body has 650 types of muscles. Muscles constitute the bulk weight of human body. The branch of zoology dealing with the study of components, structure and functioning of muscular tissue is known as **myology/ sarcology.** Muscles are specialised to contract. They are of three types— striated, unstriated and cardiac. Striated muscles are also called **skeletal muscles** as they are attached to bones and take part in moving them like levers. The unstriated muscles occur in organs and help in their movements. They are, therefore, called **visceral muscles.** Cardiac muscles occur in the walls of heart.

Voluntary muscles are stripped not independent. They are controlled by spinal-cord. **Involuntary muscles** are smooth, and you cannot Consciously control them. They are controlled by autonomic nervous system. Cardiac muscles are involuntary muscles but are stripped, not smooth. Muscles convert chemical energy (glucose) into mechanical energy. In human this conversion efficiency is 25%.

Types of Muscle

We have got around 650 muscles in your body, and they make up roughly half of your bodyweight. These muscles can be divided into three different groups: skeletal, smooth and cardiac. All of these muscles can stretch and contract, but they perform very different functions.

Skeletal Muscle: The tissue most commonly thought of as muscle is skeletal muscle. Skeletal muscles cover our skeleton, giving the body its shape. They are attached to our skeleton by strong, springy tendons or are directly connected to rough patches of bone. Skeletal muscles are under voluntary control, which means we consciously

control what they do. Just about all body movement, from walking to nodding our head, is caused by skeletal muscle contraction. Our skeletal muscles function almost continuously to maintain our posture, making one tiny adjustment after another to keep our body upright. Skeletal muscle is also important for holding our bones in the correct position and prevents our joints from dislocating. Some skeletal muscles in our face are directly attached to our skin. The slightest contraction of one of these muscles changes our facial expression. Skeletal muscle generates heat as a by-product of muscle activity. This heat is vital for maintaining our normal body temperature.

Smooth Muscle: It is found in the walls of hollow organs like our intestines and stomach. They work automatically without being aware of them. Smooth muscles are involved in many housekeeping functions of the body. The muscular walls of our intestines contract to push food through our body. Muscles in our bladder wall contract to expel urine from our body. Smooth muscles in a woman's uterus (or womb) help to push babies out of the body during childbirth. The pupillary sphincter muscle in our eye is a smooth muscle that shrinks the size of your pupil.

Cardiac Muscle: Our heart is made of cardiac muscles. This type of muscle only exists in our heart. Unlike other types of muscle, cardiac muscle never gets tired. It works automatically and constantly without ever pausing to rest. Cardiac muscle contracts to squeeze blood out of our heart, and relaxes to fill our heart with blood.

Muscles Structure

Skeletal muscles are made up of bunches of elongated, rod-shaped cells called muscle fibres. Each of our muscle cells is packed with thinner fibres called myofibrils. These fibres contain protein filaments, called thick and thin myofilaments, which slide against each other when a muscle contracts.

In a relaxed muscle, thick and thin myofilaments overlap each other a tiny bit. When a muscle cell is stimulated by a nerve impulse, these myofilaments slide past each other until they completely overlap. This makes the muscle cell shorter and fatter. The more shortened muscle cells there are in a muscle, the greater the contraction of the muscle as a whole.

EXERCISE

All types of exercise involve using your muscles to generate movement. Regular exercise can increase muscle size, strength and endurance. Endurance exercises like running or cycling make your muscles stronger and less likely to get tired. This sort of exercise doesn't only benefit your skeletal muscles. If you're doing intense exercise, other systems in your body focus their efforts on helping your muscles. Your heart beats more quickly so that it can pump more blood to your muscles, to provide them with more oxygen and nutrients. Your digestive system slows down so that it does not use up energy that your muscles need.

Slow twitch muscle fibres are good for endurance activities like long distance running or cycling. They can work for a long time without getting tired. Fast twitch muscles are good for rapid movements like jumping to catch a ball or sprinting for the bus. They contract quickly, but get tired fast, as they consume lots of energy. Most of our muscles are made up of a mixture of both slow and fast twitch muscle fibres. But, our soleus muscle in lower leg and muscles in back involved in maintaining posture contain mainly slow twitch muscle fibres. And muscles that move our eyes are made up of fast twitch muscle fibres.

Chickens have fast and slow twitch muscle, too. Dark meat, like in chicken legs, is mainly made up of slow twitch fibres. White meat, like in chicken wings and breasts, is largely made up of fast twitch muscle fibres. Chickens use their legs for walking and standing, which they do most of the time. This doesn't use much energy. They use their wings for brief bursts of flight. This requires lots of energy and the muscles involved tire very quickly.

Muscles that contain a lot of slow twitch fibres are red, because they contain lots of blood vessels. Slow twitch muscle fibres rely on a rich supply of oxygenated blood as they use oxygen to produce energy for muscle contraction. Fast twitch muscle fibres don't use oxygen to release energy, so they don't need such a rich blood supply. This is why fast twitch muscles are lighter in colour than muscles that contain a lot of slow twitch muscle fibres. Fast twitch muscle fibres can produce small amounts of energy very quickly whereas slow twitch muscles can produce large amounts of energy slowly.

- **Muscle Fatigue:** Failure of a muscles to a respond to a fresh stimulus after a prolonged previous activity is called muscle fatigue. It is due to accumulation of lactic acid, consumption of stored glycogen, ATP and CTP, and changes in neuromuscular junction which is sensitive to lactic acid. Recent studies have shown that inorganic phosphate appears to be a major cause of muscle fatigue.
- **Rigor Mortis:** It is the state of body stiffening after death due to nonseparation of actin and myosin filaments caused by nonavailability of ATP/CTP. Rigor mortis persists till decommposition starts.

TRIVIA

- **Osteology:** It is a branch of biological studies that is connected with structure, nature, development and functions of bones.
- **Kinesiology:** Study of body movements.
- **Craniology:** Study of skulls.
- **Smallest bone in human body:** Stapes of middle ear.
- **Longest Bone in Human Body.** Femur.
- **Longest Bone in Frog:** Tibio-fibula
- **Sprain:** Injury to joint due to overstretching or tearing of ligament or tendon. Takes time and rest to heal.

- **Dislocation**: Dislodging of bone end from its normal positon at the joint e.g., slipping from socket.
- **Largest Muscles**: Gluteus maximums (Buttock)
- **Smallest Muscle**: Stapedius of stapes.
- **Arthritis :** Arthritis is painful inflammation and stiffness of joint caused by infection, allergy, hormonal disturbance and faulty food.

(a) **Rheumatoid Arthritis.** A hard tissue deposits over articular cartilage alongwith higher secretion of synovial fluid causing pain and stiffness

(b) **Osteoarthritis.** There is a tearing of articular cartilage and development of bony lumps at places causing pain, stiffness and permanent bending.

(c) **Gout.** Accumulation of uric acid crystals in the region of joints result in painful movement.

- **Slipped Disc :** It is the displacement of a vertebra from its normal position due to displacment or degeneration of a part of intervertebral disc, deposition of hard tissue around it, mechanical injury and ossification of ligaments holding the vertebrae. It is painful to keep body (neck, trunk) straight.
- **Fractures.** (i) **Green Stick Fracture.** Simple crack without breaking the bone into two pieces. (ii) **Simple Fracture.** Breaking into two parts which remain nearby. (iii) **Compound Fracture.** Breaking into two or more parts with a fragment end of one protruding out. (iv) **Comminuted Fracture.** Breaking into more than two pieces. (v) **Avulsion Fracture.** A chip of small pieces breaks but remains attached to ligament.

■■■

RESPIRATORY SYSTEM

Respiration is the process of making energy available to organisms and their living cells through enzyme controlled catabolic breakdown of organic molecules, especially hexose sugars. Respiration is the fundamental process of energy release. It occurs in all living cells. Energy is necessary for growth and maintenance of life. Growth is ultimately dependent upon the products of photosynthesis as their energy source. Energy is released from the continuous breakdown of food stuffs during respiration. During this process (respiration) energy rich foodstuffs are oxidised to simpler substances like water and carbon dioxide coupled with the release of usable energy within all living cells.

The process of respiration can be defined as 'the biochemical oxidation of organic compounds to yield carbon dioxide and water with the release of energy in the form of a chemical compound known as Adenosine Triphosphate (ATP).

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 38$ ATP

Respiration occurs in all living cells of the plant but the most actively respiring regions are the growing regions like floral and vegetative buds, germinating seedlings and root and stem apices.

In the tissues the actual process of respiration occurs. This physical process of the transport of oxygen to the body tissues in higher animals for the purpose of respiration is known as breathing or external respiration. Breathing is an extracellular process whereas respiration is an intracellular process. Thus, breathing is simply a physical process of intake of air rich in oxygen and removal of air rich in CO_2. No energy is released and also enzymes are not involved in the process. Whereas respiration is a biochemical process in which food stuffs (glucose) is oxidised to CO_2 and water and energy in the form of ATP is released and a large number of enzymes are involved in the process.

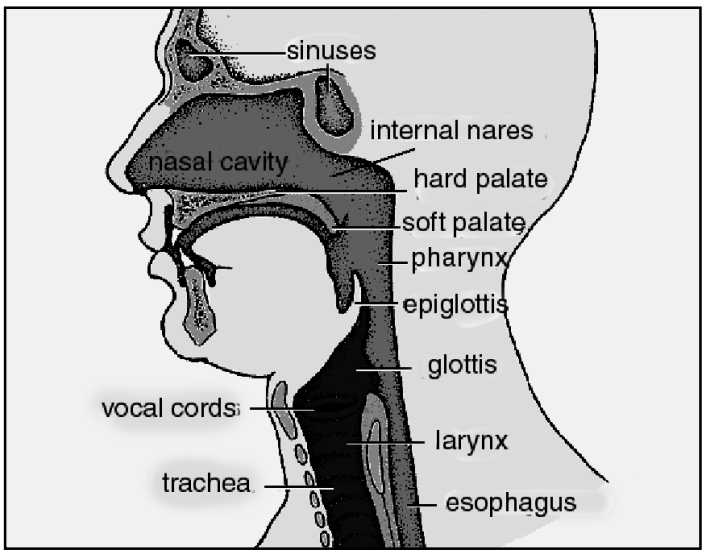
The body of flowering plant is well differentiated into stem, leaves and roots. Aerial part of flowering plants especially leaves are the main sites of gaseous exchange. For this purpose, leaves have got stomata on their undersurface through which oxygen enters and CO_2 is given out. Plants also exchange gases through their general body surface by the process of diffusion. There are inter-cellular spaces (which are abundantly present in hydrophytes) in which gases for exchange are present.

Cell Surface Respiration: It is exchange of gases directly between cells and the environment across the cell surface. In plants and primitive animals like Amoeba, Paramecium, Hydra, the body organisation is very simple, their body tissues are more or less directly in contact with the surrounding environment. So, they take oxygen directly and respire. But in animals which have organ level of body organisation, the tissues are not in direct contact with the atmosphere. In them, the oxygen should be first transported to the body tissues before respiration could occur. So they develop an extra mechanism to take in oxygen and then it is transported to the lungs from where it reaches tissues with the help of the haemoglobin pigment of blood.

Cutaneous Respiration: Skin functions as respiratory surface, e.g., earthworm, leech, frog. For Cutaneous respiration, the skin is thin, moist and vascular. The whole skin is involved as in earthworm and frog. Cutaneous respiration is the only mode of respiration during hibernation.

Tracheal Respiration: It occurs in insects and myriapods. The system consists of network of white shining tubes called **trachea.** Relaxation of abdominal muscules allow expansion of abdomen and entry of air from outside into tracheal system (inspiration). Gaesous exchange occurs between tracheal air and tissue fluid. The contraction of abdominal muscles pushes out the air (expiration). In tracheal system, expiration is active while in pulomonary system inspiration is active. In insects, blood does not have any respiratory pigments.

Branchial Respiration: It is exchange of gases with the help of **gills.** Gills occur in many arthropods (e.g., Prawn), molluscs, fishes, amphibian tadpoles and some adult amphibians. In fishes the water enters through mouth, passes through pharynx and then gill chambers from where it comes out through one or more openings. Fishes die outside water due to asphyxiation or nonavailability of air because the spaces in between lamellae collapse outside water. In fishes, *gills* are the organs of respiration as they live in water medium. Gills are richly supplied with blood and can readily absorb oxygen dissolved in water, the surace of gills is increased by the presence of filaments. The oxygen absorbed by the gills is



taken by blood and the CO_2 is given out in the aquatic animals. Gills are the organs of respiration in water only.

Pulmonary Respiration: It occurs with the help of lungs and a respiratory tract. The Lungs are the organs of respiration in man and other terrestrial organisms. The oxygen enters the lungs through nasal cavity, naso-pharynx, larynx, trachea, bronchi, and bronchioles. Lungs in man are present in thoracic or pleural cavities which serve as air tight compartments. The final ending of the bronchioles are the alveoli from where the oxygen is taken by the blood and carbon dioxide is given out.

TYPES OF RESPIRATION

The classification depends upon the availability of oxygen and thus it has been divided into two categories.

(a) **Aerobic Respiration:** It takes place in presence of oxygen and the stored food (respiratory substrata) gets completely oxidised into carbon dioxide and water as end products. i.e. $C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O + 686$ KCal.

(b) **Anaerobic-respiration:** It takes place in absence of oxygen and stored food is incompletely oxidised and instead of carbon dioxide and water certain other compounds are also formed. This type of respiration is of rare occurrence but common among micro organisms like yeasts and can be represented by $C_6H_{12}O_6 = 2C_2H_5OH + 2CO_2 + 56$ KCal.

Differences Between Aerobic And Anaerobic Respiration

Aerobic Respiration.	Anaerobic Respiration.
• It takes place in the presence of oxygen.	• It takes place in the absence of oxygen.
• Complete breakdown of glucose yields carbon dioxide, Water and energy. $C_6H_{12}O_6 + 6O_2$ $6CO_2 + 6H_2O$ + Energy	• Incomplete break down of glucose yields ethyl alcohol and carbon dioxide $C_6H_{12}O_6 \longrightarrow$ $2C_2H_5OH + 2CO_2$ +
• 38 ATPs are formed from 1 gm of glucose.	• 2 ATPs are formed 1 gm of glucose.
• It takes place in cytoplasm and mitrochondria.	• It takes place in cy toplasm only.

In the human body during muscular exercise energy demand is in excess than that is supplied by respiration. There is insufficient supply of oxygen from lungs through blood vessles and through cells membranes into cell. Muscle cells carry on anaerobic respiration temporarily. Under these conditions lactic acid is accumulated which is slowly removed in the blood stream or reoxidised during the resting period.

MAMMALIAN RESPIRATION

It consists of a respiratory tract, a pair of lungs and structures involved in ventillation. Respiratory tract consists of external nares, nasal cavity, internal nares, nasopharynx, larynx, trachea, bronchi and bronchioles.

External Nares (***Nostrils***): They are a pair of slit-like openings present on the lower end of nose.

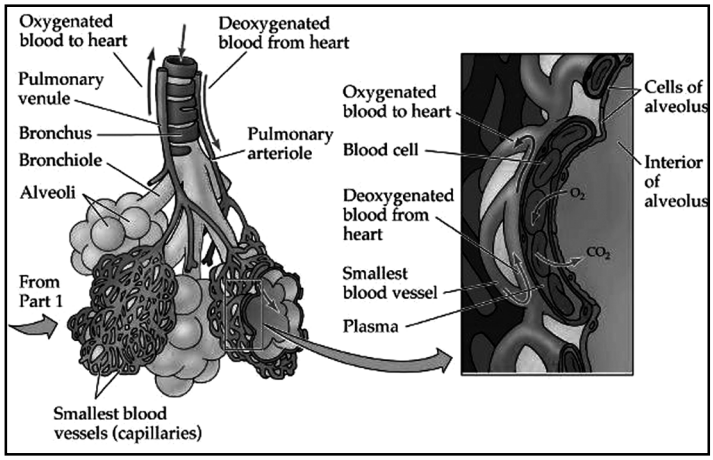
Nasal Cavity: It is situated between palate and cranium. Nasal cavity is divisible into two nasal chambers by a nasal septum. Each nasal chamber has three parts.

1. **Vestibule:** It is lower small part just above the external nares which is lined by skin and bears hair as well as oil glands. Hair help in filtering out dust particles from incoming air.
2. **Conditioner** (***Respiratory Region***): It is the middle part of nasal chamber. There are three bony projections called nasal conchae or turbinates (superior, middle and inferior) and some sinuses (maxillary, frontal, sphenoid and ethrnoid). The inhaled air is moistened, warmed and cleaned.
3. **Olfactory Region**: Upper part of nasal chamber and superior nasal concha are yellowish brown. They are covered by olfactory epithelium which perceives sensation of smell.

Internal Nares (***Choanae***): The two nasal chambers open into nasopharynx through internal nares or choanae.

→ **Pharynx:** Nasopharynx occurs at the base of skull and has a lining of ciliated epithelium. Nasopharynx leads to oropharynx or common pathway of respiratory and digestive systems or opharynse passes into laryngeopnarynse which contains epiglottis and passes into larynx.

Larynx: Larynx—or voice box opens into largeo-pharynx through a slit like glottis which can be widened by intrinsic muscles. Glottis can be closed by a muscular cartilaginous flap called **epiglottis.** Larynx has C-shaped **thyroid** cartilage (on sides and in front where it can be felt as **Adam's Apple).** Internally larynx has ciliated mucous epithelium and a pair of **vocal cords**. Vocal cords become thickened in adult males. Voice is produced by passage of air between vocal cords and modulations created by tongue, teeth, lips and nasal cavity.



Approx % of Gases in Human Respiration		
Gas	*Inhaled air (%)*	*Exhaled air (%)*
O_2	21	16
CO_2	.03	4
N_2	79	79
water vapour	---	1

Trachea (Wind Pipe): It is 10-12 cm long tube with 2-3 cm diameter which arises from larynx and passes up to the middle of thorax.

Bronchi: Trachea divides into right and left primary bronchi. Right bronchus almost directly enters the right lung. Inflection of right lung is more common due to this. Inside the lung, the primary bronchus divides into secondary bronchi, secondary bronchi into segmental bronchi and the latter into bronchioles. Bronchioles divide into terminal bronchioles, respiratory bronchioles, alveolar ducts, air sacs and alveoli. Muscus secreting cells are absent from terminal bronchioles and their branches.

Lung: A pair of conical spongy elastic lungs of pinkish to salty grey colour occur inside air tight thoracic cavity. Left lung is slightly narrower and longer than the right one. Right lung has three lobes, left lung has two lobes. Each lobe is divided internally into segments and segments into lobules. A lobule receives a terminal bronchiole. Terminal bronchiole produces a few respiratory bronchioles. A respiratory bronchiole give rise to 2-11 alveolar ducts, each of which ends in an alveolar sac. The latter has a number of small pouches named **alveoli** or **air sac.** Blood capillaries occur on the surface of alveoli for gaseous exchange.

Diaphragm: It is a membranouus musculo-tendinous partition between thorax and abdomen. Phrenic muscles attach diaphragm to ribs and vertebral column. Contraction of muscles straighten the diaphragm to increase thoracic cavity. There are two sets of **Intercostal Muscles:** (i) external intercostal for normal inspiration and expiration (ii) internal intercostal for forceful expiration.

Oxygen Transport

Most of the oxygen is transported by Haemoglobin, a respiratory pigment present in erythrocytes. Most of the CO_2 on the other hand is transported by the plasma in the form of soluble bicarbonates. Haemoglobin is a cojugated protein. It consists of the protein globin united to an iron containing porphyrin Haem. The iron in the haem is in ferrous state (Fe++). Human blood normally contains about 14.5g Hb/100 ml and 13.5g Hb/100 ml of blood in males and females respectively. As one atom of iron combines with one molecule of oxygen, on molecule of haemoglobin containing four atoms of iron will therefore, combine with four molecules of oxygen. Total amount of oxygen carried in 100 ml of blood will be approximately 20 volumes per cent. This is called the total respiratory capacity of the blood.

Mechanism of Respiration

Respiration is a cellular process. It consists of numerous sequential chemical reactions and all of them are enzymatically controlled. The overall process of respiration is summarised in the following equation.

$$C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O + 686 \text{ KCal}$$

This equation represents the oxidation of hexose sugar namely, glucose in the presence of oxygen from the air. The equation just indicates the two reacting substances sugar and oxygen and the two end products CO_2 and H_2O but this does not indicate the complete reaction sequence or the pool of intermediate substances of the process. This breakdown of sugar into carbon dioxide requires more oxygen than is contained in the glucose molecule. So oxygen has to be supplied from the atmosphre.

During the process of respiration glucose first undergoes a series of changes. The atmospheric oxygen does not enter into these initial reactions in which some intermediate compounds are formed and small amount of energy is released. This series of early reactions is known as glycolysis, which takes place outside the mitochondria in the cytoplasm. In these 3 steps a series of reactions takes place each catalysed by a particular enzyme.

(a) Phosphorylation: In respiration the glucose molecule is activated by its attachment with phosphate to form glucose phosphate.

(b) Sugar cleavage: Later the 6 carbon molecule of glucose phosphate is split into two 3 carbon molecules which are still combined with phosphorus.

Pyruvic acid formation: In a series of reactions the sugar fragments containing phosphorus lose their phosphorus, and some of their hydrogen atoms resulting in the formation of the 3 carbon intermediate compound called pyruvic acid.

So far the oxidation of the sugar has occurred through a rearrangement of the atoms within the molcule and removal of some of its hydrogen NAD (Nicotinamine Adenine Dinucleotide); a coenzyme molecule, serves as the universal hydrogen carrier in respiratory reactions. In this way $NADH_2$ is oxidised and the energy it contans is used in the formation of ATP from ADP and inorganic phosphate.

The fate of pyruvic acid now depends upon the

BIOLUMINESCENCE

Light is emitted by almost all major groups of organisms but in certain cases it is quite prominent. Bioluminescence means production of light by the living organisms i.e. energy appears in the form of light. Among plants it is found in many cases of fungi and bacteria. This mechanism consists of at least six components i.e. water, inorganic ions oxygen, ATP and two groups of substances, Luciferins and enzyme Luciferases. The last two are principal light generating elements and light generation is an oxygen requiring ATP dependent process. The emitted light may be of various colours seen as red, yellow, green or blue colour appearing to the human eye the actual wavelength of the emission is determined by the particular chemical made up of Luciferin.

VOICE BOX

At the top of your windpipe it is a hollow, tubular structure about 3-4 cm across which create sounds and prevent food from entering your airways.

Your voice box, or larynx, is a hollow tubular structure made of cartilage. It is connected to the top of your windpipe.

Inside your voice box are two bands of tissue that form your vocal cords. When you speak or sing, muscles pull these cords together. The air passing through the cords makes them vibrate. You can hear these vibrations as sounds.

The shorter your vocal cords are and the faster they vibrate, the higher the sound you produce. In both girls and boys the voice box and vocal cords grow during puberty and cause their voices to deepen. In girls, this change may be hardly noticeable with their voices dropping by just a couple of tones. But boys' voice boxes grow considerably. They also tilt to a different angle in the neck and can start to stick out as a prominent 'Adam's Apple'. Boys' voices can drop by as much as an octave.

On the upper part of your voice box there is a flap called the epiglottis. When you swallow, your voice box rises and your epiglottis forms a lid over its opening. This blocks the passageway to your respiratory tract and prevents food and other foreign substances from entering your airways. This is why your epiglottis is sometimes called the 'guardian of the airways'.

If anything other than air enters your voice box, you automatically cough to clear your airways.

availability of oxygen. The pyruvic acid is the key intermediate compound of both aerobic and anaerobic respiration.

In the presence of oxygen pyruvic acid becomes further oxidised by dehydrogenation to CO_2 and water through the reactions of oxidative cycle. The cells usually obtain their energy requirements in bulk through aerobic respiration. These reactions occur within small structures that are present in the cytoplasm known as mitochondria. These structures are generally considered as the power plants of the cell. A series of cyclic reactions take place in the mitochondria and is known as Kreb's cycle (TCA Cycle) The greatest energy turnover occur during the terminal stages of oxidation of pyruvic acid to CO_2 and water.

RESPIRATORY DISORDERS

1. **Tuberculosis:** Bacterial disease caused by *Mycobacterium tuberculosis.* In fection of several parts but common of lungs. Vaccination with B.C.G. (Bacillus-Calmette-Guerin).
2. **Pleurisy:** Inflammation of pleura or accumulation of pleural fluid.
3. **Emphysema:** Reduction in alveolar spaces due to collapsing of alveolar walls or obstruction of bronchioles. Due to infection or smoking. Short breath.
4. **Asphyxia:** Paralysis of respiratory centre due to excessive carbon dioxide. Commonly due to irreversible combination of carbon monoxide with haemoglobin to form **carboxyheamoglobin.** It results in death. Common in closed rooms with coal burning, kerosine lamp or several persons / animals.
5. **Pneumonia:** Collection of mucus and lymph in alveoli due to infection by *Diplococcus pneumoniae.* Gaseous exchange is impaired.
6. **Hypoxia (Anoxia):** Shortage of oxygen supply to the body due to (a) Normal shortage in air as on high mountains (**mountain sickness)** (b) Anemia (c) Histotoxicity or poisoning of electron transport system.
7. **Hiccough** (Hiccup): Respiratory spasm caused by sudden contraction of diaphragm accompanied by loud closure of glottis.
8. **Cough:** Violent expiration for expulsion of mucus and particles.
9. **Whooping Cough** (Pertussis): Cough with respiratory whoop caused by *Bordetella (= Haemophilus) pertussis.*
10. **Asthma:** Due to narrowing of bronchi and spasms in bronchial muscles.

TRIVIA

- **Tidal Volume** (T.V.): Volume of air inspired or expired in relaxed or resting position — 500 ml. It consists of 150 ml of dead space volume and 350 ml of alveolar volume.
- **Dead Space:** Part of respiratory tract not involved in

DIFFERENCES BETWEEN PHOTOSYNTHESIS AND RESPIRATION

Photosysnthesis	Respiration
● *It is an anabolic process which results in the synthesis of glucose (Carbohydrate)*	● *It is a catabolic process which results in the break down of glucose to CO_2 and H_2O*
● *There is an increases in weight after photosynthesis*	● *Weight decreases after respiration*
● *Carbon dioxide is used in photosysnthesis as raw material*	● *CO_2 is produced alongwith energy*
● *It stores chemical energy in the form of organic compounds (glucose)*	● *It releases energy of organic compound (glucose)*
● *Site of photosynthesis is chloroplast*	● *Site of respiration is cytoplasm and mitochondria*
● *It takes place during day in sunlight*	● *It takes place both during day and night*
● *Plants can live for many days without phosysnthesis*	● *Plants cannot live without respiration*

gaseous exchange. (Nose to terminal bronchi, vol. 150 ml).

- **Total Lung Capacity** (T.I.C.). Maximum amount of air the lungs can hold after forceful inspiration. 4.5 – 6.0 litres.
- **Residual Volume** (R.V.): Air left in lungs and dead space after forceful expiration 1.5 litres.
- **Vital Capacity** (V.C.): Maximum amount of air which can be breathed out through forceful expiration after a forceful inspiration 3.5 — 4.5 litres. Higher in athletes (than nonatheletes), mountain dwellers (than plain dwellers), nonsmoker (than smokers).
- **Inspiratory Reserve Volume** (I.R.V.): Volume of air in excess of tidal volume which can be inhaled due to forceful inspiration 2.0—2.5 litres.
- **Expiratory Reserve Volume** (E.R.V.): Volume of air in excess of tidal volume which can be exhaled due to forceful expiration. 1.0—1.5 litres.
- **Mouth Breathing vs Nasal Breathing:** Mouth breathing is harmful as uncleaned (no filtration of dust particles), unsterilised (no separation and killing of microbes) and unconditioned (no moisture and temperature regulation) air is inhaled.
- **Oxyheaemoglobin:** Hb_4O_8 (each haemoglobin molecule has four iron atoms, each of which can combine with a molecule of oxygen present in the lungs).
- **Haemoglobin.** Iron-protein reddish pigment inside RBCs in vertebrates and dissolved in plasma in invertebrates (e.g., annelids, crustaceans, some molluscs like *Planorbis).*
- **Myoglobin/Myohaemoglobin:** Similar to haemoglobin taking part in oxygen transport and oxgyen storage in muscles.
- **Erythrocruorin:** Haemoglobin dissolved in plasma as in invertebrates.
- **Haeomocyanin:** Blue-coloured copper containing respiratory pigment in the plasma of certain arthropods (e.g., Prawn, Daphnia) and molluscs (e.g., Pila, Helix, Octopus).
- **Altitude and Breathing:** Rate of breathing increases with altitude. Hill poeple have more RBCs.
- **Abdominal vs Thoricle Breathing:** In human males 75% breathing is through movements of diaphragm (abdominal breathing) and 25% through movement of ribs and sternium (thoracic breathing). The latter becomes major breathing in pregnant women.
- **Carrying Capacity of Blood:** 20 ml of oxygen / 100ml of blood and 37 ml of CO_2 / 100 ml of blood.
- **Co-affinity for Haemoglobin:** It is 200 times more than oxygen. At 0–5 partial pressure, CO combines with 50% of haemoglobin. It produces a stable compound (nondissociable) called carboxyhaemoglobin.
- **Respiratory Centre:** Respiratory centre is located in medulla oblongata and pons.
- Human's right lung has 3 lobes while the left lungs has only 2 lobes.
- Lungs tissues are elastic, porous and spongy, so float in water.
- ***Diaphragm*** is not the part of respiratory system but help in expansion and contraction of the lungs.
- ***Vagus,*** the 10th cranial nerve, control the blood vessels and bronchi of lungs.
- ***Normal Breathing*** follows Inspiration, Expiration and Pause.
- ***Inverse Breathing*** follows Inspiration, Pause and Expiration.
- Rate of respiration is ¼ of the heart beat but in new born it is high (40) at the age of 1 year it is 30 / mt., 2 to 5 years it is 24-mt. and in adult 18 / mt. ■■

CIRCULATORY SYSTEM

The complex structural organisation of multicellular organisms require a mechanism to transport materials throughout the body. In simple multicellular organisms like Hydra and in unicellular organisms like Amoeba, Paramoecium Chlamydomonas and other algae, this is achieved by diffusion. The transport in more complex animals is carried out through the circulatory system. In higher plants the transport within the body is carried out through the conducting tissues like xylem and phloem and through the intercellular spaces.

In higher and multi cellular organism cells no longer remain in direct contact with the exterior. So there is a need to transport various substances like digested food materials to provide energy to perform physical activities of the body and for growth of the body. Hormones and enzymes from the site of their secretion to the site of their action, metabolic wastes (e.g. CO_2, NH_3 and Urea) to the site of the excretion and useful substances (e.g. O_2, food particles) from the site of absorption to the site of utilization. For the transportation of these substances there is present a circulatory system in all the organisms.

- In **annelids** (earthworm) a closed type of well developed circulatory system is present. It consists of various blood vessels and capillaries that ramify to all the tissues of the body. Circulatory system in earthworm consists of blood, blood vessles, eroetic arches which fundtion like a human heart and blood glands.
- In **insect** (cockroach), an open type of circulatory system is present, as the blood (haemolymph) comes in direct contact with the body cavity or (hemocoel). The hemolymph is colourless as there is no respiratory pigment, so the blood of cockroach does all the functions except the transport of respiratory gases.
- In **vertebrates** there is a closed type of circulatory system. There are various blood vessles (arteries and veins) which carry and bring blood from various parts of the body. There is a central pumping organ called heart.
- In **fishes** the heart is a two chambered structure (an auricle and a ventricle). In *amphibians*, it is three chambered structure (two auricles and a ventricle) and in *birds* and *mammals* the heart becomes a four chambered structure (two auricles and two ventricles).

TRANSPORT SYSTEM IN PLANTS

Plants utilise simple inorganic substances like carbon dioxide, oxygen, water and mineral salts for all their metabolic activities. Sugars are manufactured in the leaf by the process of photosynthesis and are translocated from the leaves into the stem. All these movements of substances from the region of synthesis or plentiful availability to the region of utilisation (sink) is called translocation.

Transportation in plants takes place through **xylem** and **pholem** tissue. The xylem consists of thick walled tubes of dead cells. Water is transported through the xylem from the root to the leaves. Where it is partly utilised and the bulk of it is evaported from the leaf surfaces. Minerals dissolved in water are absorbed from the soil and are moved upwords to the leaves mainly through the xylem. So xylem forms the 'pipeline' for conducting water. On the otherhand the synthesised foods are conducted from the leaves to the roots and to the shoot tips through phloem tissue which consists of living cells. These cells are joined end to end. Their end walls are sieve like and perforated. These are called **sieve tubes**.

The loss of water in the form of water vapours from the internal tissues and organs of the plant body through the aerial parts such as leaves, green shoots, etc. is known as transpiration. The stomatal transpiration is the main way of water loss (about 80-90%) and is much more than cuticular transpiration under ordinary conditions of light, temperature and humidity. The loss of water in the form of liquid drops is known as **guttation** or **exudation**.

Guttation is very common among plants such as Rose, Grapevine, Balsam, Water lettuce, Sun Flower, Grasses and Chrysanthemum, etc. In them small droplets of water are seen at the tip or margins of leaves in the early morning hours. This loss of water in the form of liquid occurs through specialized structures known as **hydathodes**.

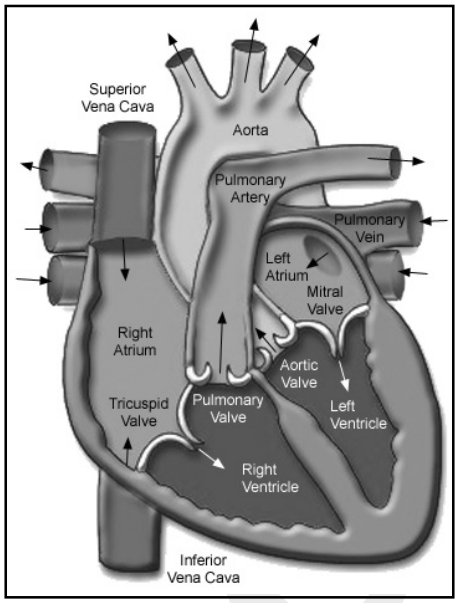
MAMMALIAN HEART

The heart of mammals, conical in shape, is completely enclosed in a membrane called '**Pericardium**'. It is 4-chambered. (Reptiles-Heart begins to show a division into four chambers, Amphibia 3-chambered Heart) of the 4-chambers 2 Auricles & 2 Ventricles. The 2 auricles are separated by an inter-auricular septum and the 2 ventricles by 2 ventricular septum. The right auricle receives venous blood (blood through vein) from all parts of the body, except the lungs. Left auricle receives oxygenated blood from the lungs through Pulmonary veins.

Right auricle leads into the right ventricle by an opening guarded by **Tricuspid valve**; this valve allows the flow of blood in one direction only i.e. from auricle to ventricle. Similarly, the left auricle which receives oxygenated blood coming from lungs, opens into left ventricle by an opening guarded by a valve called **Bicuspid valve** or **Mitral valve**. The valves between auricles and ventricles are membranous in mammals whereas in frog, they are muscular.

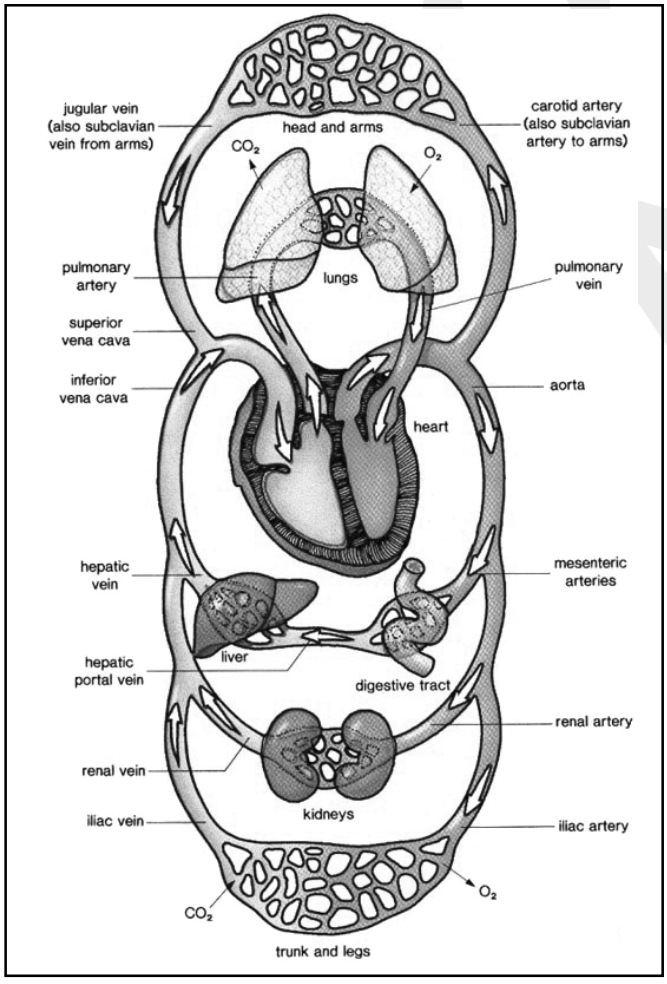
For the pumping action of Heart, the wave of contraction originates from a 'Pacemaker' or 'Contraction centre' called the '**Sinuauricullar node'**. Though the contraction originates in the node but its frequency is controlled by the nerves.

Any interference in the conducting system of the wave of contraction from the '**pacemaker**', either by mechanical obstruction or degeneration due to a disease affects the heart beat. The defect is called **Heart block**. It can be set right temporarily for a period of a few years by means of a transistorised device. The device is implanted in the chest muscles. The electrodes from the device (called Pacemaker) are inserted into the conducting system. Electrical stimulations from the device feed the conducting system which begins to function normally.



HUMAN CIRCULATORY SYSTEM

It consists of heart, arteries, veins & capillaries. Mammals, birds and crocodiles have a double circulation made up of the pulmonary circulation between the heart and the lungs, and the systemic between all other parts of the body. In humans the heart pumps blood into arteries. Arteries divide and sub-divide into narrower ducts called capillaries. Eventually capillaries join together forming small veins called venules and these leads into larger and larger veins which carry blood back to the heart. The aorta is the longest and largest artery in the body. It receives blood from the left ventricle of the heart, and branches from it lead to all organs and tissues except the lungs. The pulmonary artery carries blood from the right ventricle to the lungs. The pulmonary vein carries blood from the lungs to the left auricle. All veins except the pulmonary veins carry de-oxygenated blood.



The heart-beat consists of 2 phases systole and diastole. In systole the ventricles contracts and force blood along the aorta and pulmonary artery. Meanwhile the auricles begin to fill with blood. In diastole the ventricles relax and expand as blood flows into them from the auricles. The auricles contract at this stage. In human adult at rest, the heart beats at the rate of about 72 times per minute. Blood in the arteries of the average adult exerts a pressure equal to a column of mercury about 120 mm. high in a glass tube during systole of the ventricles, and 80 mm. high during their diastole. This is expressed as B.P. of 120/80. It should be noted that the blood pressure fluctuates considerably during each heart beat. The difference between the systolic and diastolic pressure is called 'pulse pressure.'

HUMAN BLOOD

It is red, sticky, salty fluid. In adult man normally 5.6 Lt.. of blood is found. In humans, blood is used as transport vehicle for any compound within the body. It has pH of 7.4. In fact blood is a mixture of RBC, WBC and Platelets, all floating in plasma.

- **RBC/Erythrocytes:** In the vertebrates other than mammals, the RBC are large oval cells with a bulging biconvex nucleus. In mammals including human RBC are

NORMAL BLOOD PHYSIOLOGICAL VALUES

	Unit	Man	Woman
Haemoglobin (Hb)	gm/100 ml	16+2	14+2
Packed cell volume (PCV)	%	47±5	42±5
RBC	Million/mm^2	5.4±0.8	4.8±0.6
WBC (TLC)	/mm^2	4300	10800
DLC			
Neutrophil	%	34-75	34-75
Lymphocytes	%	20-40	20-40
Monocytes	%	3-15	3-15
Eosinophils	%	1-3	1-3
Basophils	%	0-1	0-1
ESR*	mm fall	0-9	3-20
Coagulation time	min	3-6	3-6
Heart Rate	1 min	72	
Blood Pressure (syst/diast)	mm Hg	120/80	120/80

Note: * Erythrocyte Sedimentation Rate

round, biconcave and non-nucleated. There are 4 to 6 million erythrocytes / cubic ml. of human blood. The life of RBC is 120 days. RBC are made in the embryo by the liver or spleen but after birth they are formed in red bone marrow of short bones, mostly in sternum (breast bones), ribs etc.. They are destroyed in liver and spleen. Erythrocytes contain a protein called **Haemoglobin** which gives them red colour.

● **WBC/Leucocytes:** WBC are nucleated cells, irregular in shape, semitransparent and much less numerous than RBC (RBC:WBC::1:400 / 500). They have independent powers of amoeboid locomotion by preudopodia. They can engulf bacteria and so called '**Phagocytic**'. The life span of WBC is less than 2 weeks. But they are constantly manufactured in red bone marrow, spleen, thymus and lymph nodes. The main functions of WBC are to transport substance, remove dead cells and decaying tissues, fight bacteria and act as guardians of the circulatory system. Some WBC may be destroyed and along with fragment of tissues it forms '**Pus**'. There are five basic types of bucocytes:

1. **Neutrophils :** Most numerous (65-70% of total WBC); when germs attack they begin to destroy the tissue by poisoning them and engulf the bacteria and other antigen and destroy them.
2. **Lymphocytes:** After neutrophils in number (20-25%); produced in the spleen of a frog and lymph nodes of human; useful in healing process.
3. **Basophils:** Non-phagocytic; secrete anticoagulant called **Heparin.**
4. **Eosinophils:** Non-phagocytic; constitute 0.5% of total WBC; extra production causes asthma.
5. **Monocytes :** Phagocytic and are produced in spleen or lymph nodes; defend against tuberculosis, malaria, typhoid, etc.

● **Plasma:** It is the liquid part of blood; 50-60% of total human blood; contain 90% water and less than 10% of various substances in solution like plasma protein, organic substance, inorganic salts, potassium, calcium, iron, etc.. It also contain fibrinogen, hormones, digestive foods, Gama-globulin, etc. Gama-globulin is converted into anti-bodies. Bi-product of protein break down like urea, uric acid etc. are also found here. Serum (plasma- fibrinogen) provide passive immunity and so as antibodies in the treatment of tetanus, snake-bite etc. Gama-globulin acts as antibodies in case of measles, polio etc.

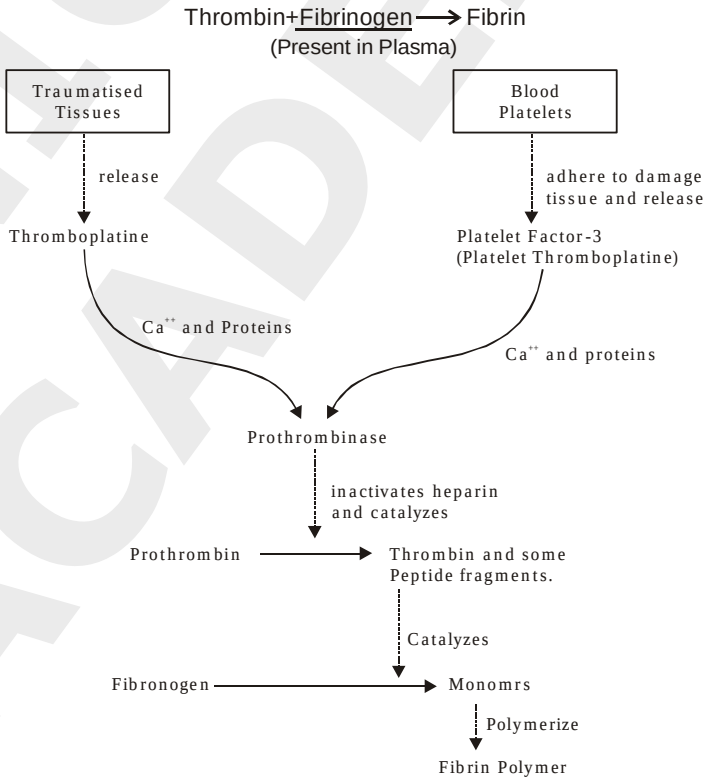
● **Platelets:** They are non-nucleated, colourless, smallest of all blood components, tiny circular or oval discs like. They are derived from giant cells of **megakaryocytes** of bone marrow. Their life-span is only of few hours. Platelets disintegrate and produce **Thrombokinase/thromboplastin**, vital in blood cloting.

BLOOD CLOTTING

The blood contains an inactive enzyme known as **Prothrombin** which is kept in check by another substance in blood called **Antiprophrombin** or **Heparin**. Thus, the blood flowing normally in blood vessels does not coagulate due to the presence of **heparin.**

When an injury occurs, blood begins to escape from it but the injured tissue cells and disintegrating blood platelets or thrombocytes on contact with wet and rough surface release the granules of a substance called 'Platelet factor 3'. This combines with several blood proteins and convert them into Prothromboplastin which immediately changes into Thromboplastin after reacting with Ca^{++}. Thromboplastin reacts with inactive Prothrombin in the presence of Ca^{++} to form active Thrombin. Thrombin acts on fibrinogen (Sol State) converting it into fibrin (gel state). The fibrin becomes a network of fine fibres which entangle corpuscles to form a clot at the site of injury.

Thus, clotting depends upon the presence of Prothrombin, Thromboplastin and calcium ions and absence of any of these will prevent coagulation. Three minutes is the normal time for blood to clot. However, average coagulation time varies from 2 to 6 minutes depending upon the amount of blood.



BLOOD TYPES

'Landsteiner' and his co-workers divided the entire human population into four major groups according to the reaction of their blood when mixed together. The four types of blood are named A, B, AB and O depending upon the presence of antigen in R.B.C. Each letter refers to a kind of antigen, or protein, on the surface of red blood cells. For example, the surface of red blood cells in Type A blood has antigens known as A-antigens.

Rh Factor: Rh in fact is first 2 letters of the monkey Rhesus in which first of all it was discovered. Rh is an antigen present in the RBC of a large majority of people. Such people who have this antigen are called Rh positive (Rh+) and the person who have not, are called Rh negative (Rh–). In India about 97% people are Rh positive. If an Rh

BLOOD PRESSURE LEVEL (MM HG)

Category	*Systolic*	*Diastolic*
PNormal	*< 120*	*< 80*
Prehypertension	*120–139*	*80–89*
High blood pressure		
Stage 1 hypertension	*140–159*	*90–99*
Stage 2 hypertension	*>=160*	*>=100*

NOTE: < means less than; >= means greater than or equal to.

negative person is given a transfusion of Rh positive blood, he will develop antibodies which may kill the person. A more serious situation result if an Rh positive male marries a Rh negative female, their offspring will be Rh positive and will produce the antigen, some of this antigen will pass from the embryo into the blood of the mother, in the mother the antigen will produce antibodies which will then enter the foetus and destroy its RBC, cause anaemia and death of new born babies. This is the situation of **'erythroblastosis faetalis"**. In some people the blood group is ABO, this type of blood kills the foetus during early development, this occurs when the mother is of the blood group O, and the foetus of the group A, B or AB. There is also an incompatibility when the mother is of group B and the foetus of the group A. It is now known that ABO incompatibility is responsible for deaths of unborn children, and this is often the cause why married couples do not have children.

Blood Transfusion: In a blood transfusion, a patient must receive a blood type that is compatible with his or her own blood type—that is, the donated blood must be accepted by the patient's own blood. If the blood types are not compatible, red blood cells will clump together, making clots that can block blood vessels and cause death.

Type O– blood is considered the "**universal donor**" because it can be donated to people of any blood type. Type AB+ blood is considered the "**universal recipient**" because people with this type can receive any blood type.

Blood type	**Who can receive this type**
O+	O+, A+, B+, AB+
O–	All blood types
A+	A+, AB+
A–	A+, A–, AB+, AB–
B+	B+, AB+
B–	B+, B–, AB+, AB–
AB+	AB+
AB–	AB+, AB–

Antigen and Antibody: An antigen is a macromolecular compound generally a protein which when administered to mammals stimulate the synthesis of a specifc compound. This compound combines with the antigen and is called an antibody. The antibodies are proteins. When it combines with its specific antibody it causes agglutination.

- Certain blood types are more common in certain countries. In China, over 99% of the population has Rh+ blood.
- Different kinds of animals have different kinds of blood. Dogs have 4 blood types; cats have 11; cows have about 800.
- Some people think blood type tells about personality. Legend has it that Type A is calm and trustworthy; Type B is creative and excitable; Type AB is thoughtful and emotional; and Type O is a confident leader.
- The approximate distribution of blood groups among Hindus in India is as follows. A-24%, B-38%, AB-8% and O-30%. A very interesting example of blood groups of human population are natives of Peru. They are cent-percent of group 'O'.

BLUE BABY

Blue baby is infant born with a congenital heart defect that causes a bluish coloration of the skin as a result of cyanosis (deoxygenated blood). The cyanotic condition occurs when a large portion of the venous blood bypasses the lungs. Normally, deoxygenated blood from the veins is pumped from the right side of the heart to the lungs, where it is oxygenated. In some blue babies, the pulmonary artery is too narrow to allow sufficient blood to pass into the lungs for oxygenation. Surgical correction of the defect is usually required and is usually successful.

LYMPHATIC SYSTEM

The RBC never leave the blood vessels, but the plasma and leucocytes escape from blood capillaries into the tissues. This colourless portion of blood without its RBC and heavy blood proteins is called '**Lymph**.'

The lymph carries food and oxygen to cells of the body, and it takes substances from tissues to re-enter blood by means of Lymphatic vessels though some lymph enter the venous capillaries by osmosis. Thin walled anastomosing lymph capillaries form a network in every organ (except nervous system), they start from minute knob like blind ends. Lymph capillaries join to from ''**Lymph vessels**" on lymphatics which have thick wall and contain valves in pairs.

In mammals, at several places along the lymph vessels are lymph nodes which are masses of lymphatic tissue and connective tissue containing lymphocytes and many lymph capillaries. In man, lymph nodes occur in the head neck, arms, pit, knee, groins and near large vessels, they also form the tonsils and Peyer's patches on the intestine.

There are no lymph hearts in mammal, the slow moving lymph is propelled through the lymph vessels and nodes by body muscles and by pressure in smaller vessels due to osmosis and by absorption of tissue fluids.

The lymphatic system differ from the blood vascular system in being an 'open system' because it has lymph spaces between tissue cells, moreover, lymph flows in only one direction, i.e. from the tissues towards the heart, hence its capillaries and lymph vessels are equivalent to veins, thus it does not make a complete circuit, as the blood vascular

system does, because lymph goes from tissue cells to the veins of the blood system.

BLOOD PRESSURE

Blood pressure is the force of blood against the walls of arteries. Blood pressure is recorded as two numbers—the systolic pressure (as the heart beats) over the diastolic pressure (as the heart relaxes between beats). The measurement is written one above or before the other, with the systolic number on top and the diastolic number on the bottom. Normal blood pressure is less than 120 mm Hg systolic and less than 80 mm Hg diastolic.

HUMAN HEART

Between our lungs heart is grapefruit-sized and cone-shaped which pump oxygen-rich blood throughout our body and oxygen-poor blood to our lungs. Your heart is divided into four hollow chambers. The upper two chambers are called atria. They are joined to two lower chambers called ventricles. These are the pumps of your heart.

One-way valves between the chambers keep blood flowing through your heart in the right direction. As blood flows through a valve from one chamber into another the valve closes, preventing blood flowing backwards. As the valves snap shut, they make a thumping, 'heart beat' noise.

- Blood carries oxygen and many other substances around our body. Oxygen from our blood reacts with sugar in your cells to make energy. The waste product of this process, carbon dioxide, is carried away from your cells in your blood.
- Our heart is a single organ, but it acts as a double pump. The first pump carries oxygen-poor blood to our lungs, where it unloads carbon dioxide and picks up oxygen. It then delivers oxygen-rich blood back to our heart. The second pump delivers oxygen-rich blood to every part of our body. Blood needing more oxygen is sent back to the heart to begin the cycle again. In one day our heart transports all your blood around your body about 1000 times.
- Our right ventricle pumps blood to our lungs and our left ventricle pumps blood all around our body.
- The muscular walls of the left ventricle are thicker than those of the right ventricle, making it a much more powerful pump. For this reason, it is easiest to feel your heart beating on the left side of your chest.
- **Cardiac muscle:** Our heart is an incredibly powerful organ. It works constantly without ever pausing to rest. It is made of cardiac muscles, which only exists in the heart. Unlike other types of muscles, cardiac muscles never gets tired.
- **Pacemaker:** Unlike skeletal muscle cells that need to be stimulated by nerve impulses to contract, cardiac muscle cells can contract all by themselves. However, if left to their own devices, cardiac muscle cells in different areas of our heart would beat at different rates. Muscle cells in our ventricles would beat more slowly than those in our atria. Without some kind of unifying function, our heart would be an inefficient, uncoordinated pump. So, our heart has a tiny group of cells known as the **sinoatrial node** that is responsible for coordinating heart beat rate across our heart. It starts each heartbeat and sets the heartbeat pace for the whole heart. Damage to the sinoatrial node can result in a slower heart rate. When this is a problem, an operation is often performed to install an artificial pacemaker, which takes over the role of the sinoatrial node.
- **Heart rate:** Without nervous system control, our heart would beat around 100 times per minute. However, when we are relaxed, our parasympathetic nervous system sets a resting heart beat rate of about 70 beats per minute, (resting heart rate is usually between 72-80 beats per minute in women and 64-72 beats per minute in men).
- When you exercise or feel anxious your heart beats more quickly, increasing the flow of oxygenated blood to your muscles. This is triggered by your sympathetic nervous system. Your heart rate also increases in response to hormones like adrenalin.
- On an average, your maximum heart rate is 220 beats per minute minus your age. So a 40 year old would have a maximum heart rate of 180 beats per minute.
- Although your heart is continually filled with blood, this blood doesn't provide your heart with oxygen. The blood supply that provides oxygen and nutrients to your heart is provided by blood vessels that wrap around the outside of your heart.

HEALTHY HEART I.Q.

- High blood pressure, smoking, and high blood cholesterol are the three most important risk factors for heart disease. Obesity increases the likelihood of developing high blood cholesterol and high blood pressure, which increase your risk of heart disease.
- A blood pressure of 140/90 mm Hg or greater is generally classified as high blood pressure. If the diastolic pressure, the second or lower number, is between 85–89, a person is at an increased risk for heart disease or stroke and should have his/her blood pressure checked at least once a year by a health professional.
- A total blood cholesterol of under 200 mg/dL is desirable and usually puts you at a lower risk for heart disease. A blood cholesterol level of 240 mg/dL or above is high and increases your risk of heart disease. If your cholesterol level is high, your doctor will want to check your levels of LDL-cholesterol ("bad" cholesterol) and HDL-cholesterol ("good" cholesterol).
- Eating foods low in saturated fat is the most effective dietary way to lower blood cholesterol levels, along with eating less total fat and cholesterol. Choose low-saturated

fat foods, such as grains, fruits, and vegetables; low-fat or skim milk and milk products; lean cuts of meat, fish, and chicken.

- For the first time, the doctor recommends a target for salt intake: no more than 1 teaspoon of salt a day. Too much salt can cause high blood pressure.
- Fat should make upto 35% or less of your daily calorie intake. Try to avoid eating trans fats. These types of fat are often listed as "partially hydrogenated" oils in the list of ingredients.

SPLEEN

It is a part of lymphatic (infection fighting system which lies on left hand side of your body, between your stomach and diaphragm. It cleans your blood, destroy old red blood cells and fight infection.

- **Filtering blood:** Your spleen acts as a filter for your blood, cleansing it of bacteria, viruses and other debris. When blood flows through your spleen, white blood cells attack and remove any foreign invaders. This keeps your blood clean and helps protect you against infection.
- **Destroying old red-blood cells:** Red blood cells have a lifespan of around 120 days, after which your spleen breaks them down. The red blood cell remains are transported elsewhere in your body where they are excreted or recycled to manufacture new red blood cells.
- **Making blood cells:** Before birth, foetuses produce red and white blood cells in their spleens. Shortly before birth the spleen loses its ability to make red blood cells and bone marrow takes over this job. The spleen continues producing infection-fighting white blood cells throughout our lives. ■■

NERVOUS SYSTEM

CHRONICLE IAS ACADEMY
A CIVIL SERVICES CHRONICLE INITIATIVE

Nervous system is a system of neurons / nerve cells, nerves and nervous organs that coordinate and control the activities of different parts of an animal body by receiving and sending nerve impulses. Nervous system performs a number of functions :

(i) Making the animal aware of environment.

(ii) Receiving information about the changes in the environment.

(iii) Memory of past experiences and impressions.

(iv) Interpretation of external changes with the help of memory.

(v) Producing sensations like pain, pleasure, smell, taste, vision, hearing etc. with the help of special sense organs.

(vi) Linking different body parts and coordinating their functions.

(vii) Controlling activities of muscles and glands.

(viii) Knowing changes or disturbances in the interior of body.

(ix) Helping maintain homeostasis in internal environment.

(x) Taking immediate remedial action for harmful sensations without consulting will of the animals.

Diffused Nervous System: It is the most primitive form of nervous system and is developed only in lower invertebrates like **Jelly fish** and **Hydra.** Here there is no brain and the nerve cells are distributed throughout the organism in a netlike pattern.

Centralised Nervous System: Here some part of the system has the dominant role and have a more complex central nervous system, like among **annelids** (earthworm, leeches), **arthopods** (insects, crustaceans). They have definite brain and ventral nerve cord. In vertebrates brain and dorsal nerve cord (spinal cord) are found.

In Mammals the nervous system is more complex and have basic three parts (a) Central Nervous System (brain and spinal cord) (b) Peripheral Nervous System (nerves between central nervous system and different parts of the body) (c) Autonomic Nervous System (controlling voluntary activities like heart beat, peristalsis of intestine, etc.)

NEURONS

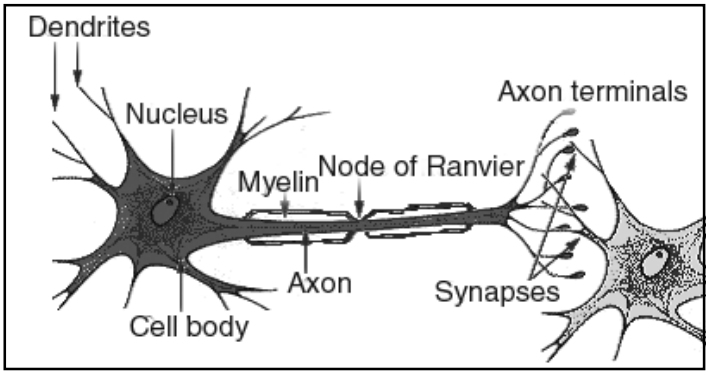
They are structural and functional units of nervous system. Over 30 billion neurons occur in human body, 98% in brain out of which 9 to 10 billion are found in cerebral cortex alone. Neurons are the largest cell in the body, up to 90 cm. Neurons conduct **electrochemical impulses**. **Dendrites** are fibres that generate nerve impulses in response to stimulation from a sense receptor or from other neuron. **Axon** are fibres that transmits an impulse away from the cell body. Carrying it to another neuron or to an effector muscle / gland. Neurons may be of 3 types-

(i) Sensory Nerves: They are nerves which contain only afferent or sensory nerve fibres that bring impulses from diferent body parts, including the sense organs to the central nervous system. Amongst cranial nerves, only three are sensory — olfactory, optic and auditory.

(ii) Motor Nerves: They are nerves which contain only efferent or motor neurons that carry impulses from central nervous system to effector organs for particular function like muscle contraction or glandular secretion. Five cranial nerves (oculomotor, trochlear, abducens, spinal accessory and hypoglossal) and nerves of autonomic system are motor in nature.

(iii) Mixed Nerves: The nerves contain both afferent (sensory) and efferent (motor) nerve fibres. All spinal nerves and four cranial nerves (trigeminal, facial, glossopharyngeal and vagus) are mixed.

- **Nerve impulse:** It is wave of bioelectric or electrochemical disturbance that passes along a nerve / neuron during conduction of an excitation.
- **Stimulus:** Stimulus is the change in internal or external environment which brings about excitation in a nerve / muscle / organ / organism. It can be mechanical, physical (heat, cold, humidity, visual), chemical or electrical.
- **Neurotransmitters:** They are chemicals secreted by axon terminals for transmitting impulse to the next neuron. The most common neurotransmitter is *acetylcholine***.** Other neurotransmitters include *gama aminobutyric acid, dopamine, glycine, glutamic acid* and *adrenaline*. **Synapse** is the junction between two neurons.



In mammals all body activities are either directly or indirectly under the control of the Nervous System. Direct control is exercised by supplying nerves to the various organs and tissues, while indirect control is exercised through the endocrine glands and the circulatory system. The nervous system receives a variety of stimuli from the various parts of the body. Depending on the nature of the stimuli, it sends out appropriate order to the concerned organs. Both exterior (eg. pressure, pain, heat, etc, which are caused due to changes in the external conditions) and proprioceptive *sensations* (sensations which convey the physical state of the body, eg. functioning of the internal organs) are brought to the brain and spinal cord through sensory nerves. Orders which are carried out in response to these sensations are conveyed to the appropriate organs through motor nerves.

HUMAN NERVOUS SYSTEM

The human brain shows a great advance over that of any other animal in the size of the cerebral hemisphere as well as the midbrain, cerebellum, medulla oblongata, etc. It weighs between 1250 to 1350 gms. Brain is safely protected in the cranium and is covered by three layers of membranes.

Central Nervous System

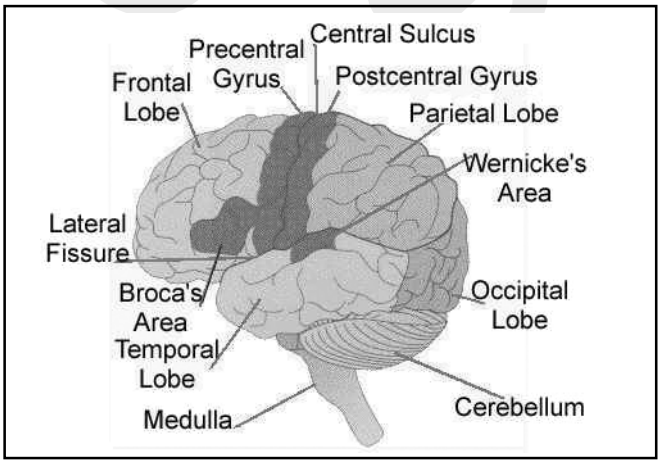
It consists of brain and spinal cord, covered by thin membrane **meninges** which protect them from infection. If it is infected by anyway causes **meningitis.** Central nervous system is made of neurons which will die if oxygen and glucose supply is restricted for 3 to 4 minutes. Neurons cannot be replaced or regenerated. Neurons has two parts: (a) **Grey matter,** responsible for the highest intellectual capacity and (b) **White matter,** which connects two or more grey matters. Central nervous system function on the basis of **Reflex Actions.** Brain has 3 regions –

(a) Fore brain (Olfactory lobes, Cerebral hemisphere and Diencephalon),

(b) Mid brain (Optic lobes and Crura cerebri), and

(c) Hind brain (Cerebellum and Medulla Oblongata).

Olfactory Lobes: They are a pair of solid club shaped structures present on the inferior surface of cerebrum having an olfactory bulb and an olfactory tract for relaying sense of smell to temporal lobes.



NERVES IN COMMAND

Cranial Nerves	Distribution	Functions
Olfactory	Mucus membrane of nose	Smell
Optic	Retina	Vision
Oculomotor	4 out of six eye muscles	Movement of eye
Trochlear	Eye muscles	Movement of eye
Trigeminal	Mucus membrane of head and Skin	Collection of stimuli from these regions
Abducen	Eye muscles	Movement of eye
Facial	Various parts of the face like neck, salivary gland, taste buds etc.	Movement of neck, perceiving taste, salivation.
Auditory	Internal ear	Hearing and balancing
Glossopharyngeal	Tongue, Pharynx	Swallowing taste and salivation
Vagus	Wind pipe, thoracic and visceral organs	Visceral reflexes
Accessory	Visceral organs	Visceral reflexes
Hypoglossal	Tongue	Movement of the tongue.

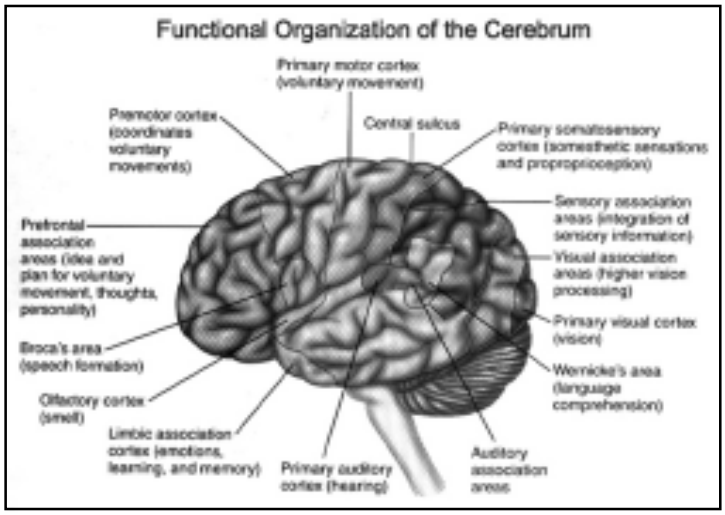
Cerebrum: It constitutes 80% of brain that overlies all other parts. Cerebrum is formed of two closely appresed cerebral hemispheres connected at the inferior region by a thick curved band known as **corpus callosum.** Three deep and wide fissures demarcate four lobes — anterior frontal, middle parietal, posterior occipital and lateral temporal.

- **Frontal Lobes -** (voluntary movements) higher centre for involuntary movements and autonomous nervous system, coordination of sensation and movements, speech intelligence.
- **Parietal Lobes -** General sensations (like pain, touch, pressure, temperature), taste (gustatory area) speech.
- **Temporal Lobes -** Smell, hearing, speech, memory.
- **Occipital Lobes -** Mainly sight.

Silent areas are those areas of cerebrum which regulate intellect, memory, fore-sight, imagination, moods, emotions, etc. Cerebral cortex exhibits rhythmic electric charges which can be recorded by electroencephalogram. The recording graph is called electroencephalograph (EEG). It depicts working and defect of different parts of brain.

Diencephalon: Hypothalamus is the floor of diencephalon. It consists of masses of grey matter scattered in white matter. Hypothalamus possesses higher nerve centres for controlling emotional reactions, sweating, fatigue sleep, thirst, hunger and body temperature. It also secretes neurohormones. Hypothalamus secretes twelve neurohoromnes — ten of them control the secretory pituitary gland while 2 of them (oxytocin and ADH) directly function as hormones of posterior lobe of pituitary (neurohypophysis).

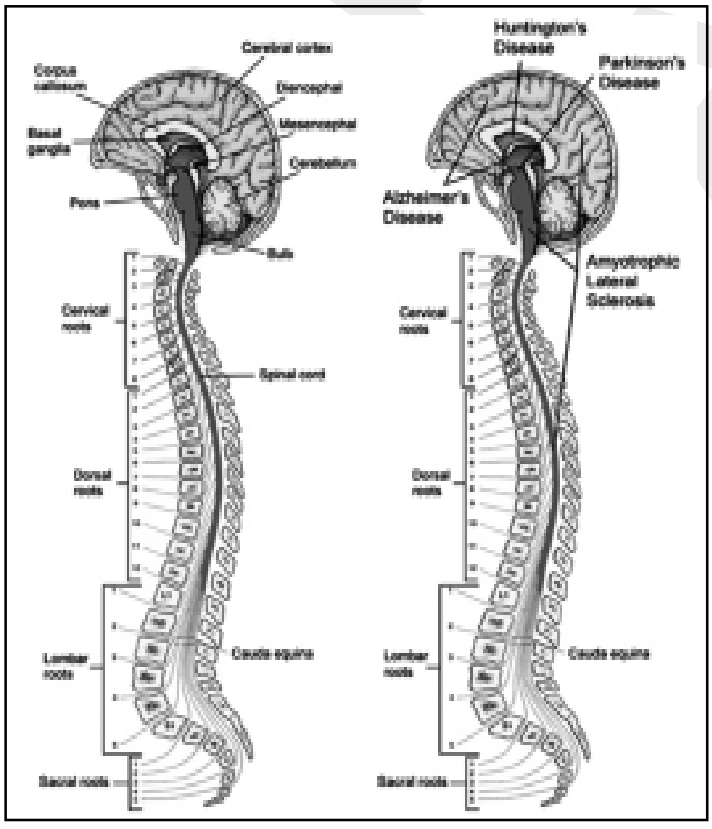
Midbrain: The nerve cells are involved in controlling



muscles tone and modifying some motor activities. There are two thick fibrous tracts called crura cerebri/cerebral peduncles on the inferior surface for connecting fore brain with hind brain and relaying impulses (both sensory and motor). The sides contain four swellings or corpora quadrigemina, two larger superior corpora or colliculi (sight reflexes) and two smaller inferior corpora or colliculi (auditory reflexes).

Cerebellum: It lies behind the cerebrum and above medulla oblongato. Cerebellum is second largest part which is very well developed in humans. Cerebellum is connected with both cerebrum and medulla oblongata and controls (i) Equilibrium of body (ii) Moderation of voluntary movements (iii) Maintenance of muscle tone.

Pons Varolli (Pons): It is a broad cross-wise band of fibres found on the inferior broad side of medulla oblongata that connects cerebrum, cerebellum, medulla and spinal cord



for functioning as relay centre amongst different parts and sides of brain.

Medulla Oblongata: It is cylindrical conical hindermost part of brain. Medulla oblongata is believed to cause change of nervous tracts from left to right and *vice versa.* Medulla oblongata has (i) Respiratory centre (ii) Cardiac centre (iii) Reflex centres for swallowing, vomitting, peristalsis, secretion and activity of alimentary canal, salivation, coughing, sneezing etc. (iv) vasomotor centre (diameter of blood vessels).

Brain Stem : It is a part of the brain that is continuous with spinal cord as medulla oblongata, pons varolli and midbrain.

Cerebrospinal fluid (CSF) : It is a clear, colourless, slightly alkaline (7.33 pH) fluid of 1.005 specific gravity that occurs in the ventricles of brain, central canal of spinal cord and subarachnoid space. It is filtered out of blood in the region of choroid plexus and passes back into it. CSF supplies food and oxygen to different parts of CNS. It picks up CO_2, urea and other waste products from CNS. Protection of CNS from shock. Maintenance of a constant internal pressure. Keeps CNS moist.

Spinal Cord : It is 42— 45 cm long (weight 30— 35 gm) cord-like nearly cylindrical lower part of CNS which lies inside the neural canal of vertebral column. It begins in the atlas and tapers to a point, **conus medullaris,** in the first or second lumbar vertebra. The short size of the spinal cord is due to elongation of vertebral column. Spinal cord is:

(a) centre for many reflexes (spinal reflexes)

(b) Providing nervous connection to a large number of body parts.

(c) Conduction of sensory and motor impulses to and from brain.

Spinal Nerves : They constitute peripheral nervous system (PNS) developing from spinal cord. There are 31 pairs of spinal nerves — 8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal. The nerves come out of vertebral column through intervertebral foramina, the first pair of cervicals coming out between skull and atlas.

Cranial Nerves : They constitute peripheral nervous system (PNS) that develops from brain. There are 212 pairs of cranial nerves.

Autonomic Nervous System

It lies outside the central nervous system and works independently of the central nervous system. It controls the survival mechanism of the body and all involuntary actions like heart beat, digestion, etc. Autonomous nervous system innervate various organs and glands of the body to stimulate, accelerate, slow down or inhibit their functions without directly consulting the will.

It is considered as the oldest part of the nervous system and is found in all animals except ***star fish***. The major sub-components of this system are:

(a) Thalmus: It directs or provide the link between cerebral cortex and spinal cord.

(b) Hypothalmus: Found in large brain; thermostat of the body as it regulates the body temperature, thirst, hunger, breathing and emotions.

(c) Medulla Oblongata : It is the lowest part of the brain, merging with spinal cord. It is concerned with unconscious processes, including the regulation of blood-pressure, body temperature, heart-beat rate, breathing, etc. It performs these tasks through connection with autonomic nervous system.

- ANS is involuntary so that brain is not taxed.
- Coordination of various body organs.
- The system through its two divisions is adopted to accelerate, moderate, slow down or inhibit an activity.
- It can help meet emergencies and emotional stress. ANS is made of two opposing divisions, sympathetic and parasympathetic.

Peripheral Nervous System

All the nerves and nerve cells outside our central nervous system make up peripheral nervous system. Its task is to relay information from our brain and spinal cord to the rest of body and from our body to brain and spinal cord. Peripheral nervous system consists of 12 pairs of cranial nerves, which emerge from our brain and mainly serve our head and neck. It also contains 31 pairs of spinal nerves, which branch off from our spinal cord and supply the rest of the body.

Voluntary and involuntary actions: With the help of our peripheral nerves, we are able to carry out voluntary and involuntary actions. If we pick up a mug, clap our hands or lift weights in the gym, we are performing voluntary actions. In contrast, our heart beats and our intestines digest without conscious control. Involuntary actions such as these are regulated by our autonomic nervous system. The autonomic part of our peripheral nervous system ensures that all our internal organs and glands function smoothly.

Our autonomic nervous system has two parts: the sympathetic and the parasympathetic. Both supply essentially the same organs but cause opposite effects. This is because their activating chemicals, or neurotransmitters, are different.

Fight or flight: Often referred to as our 'fight-or-flight' system, Our sympathetic nervous system prepares our body for emergencies. It shunts our blood to our muscles and increases our blood pressure, heart rate and breathing rate, enabling to cope with stressful situations.

FUNCTIONS OF VARIOUS PART OF BRAIN

1. Cerebrum
- ***Seat of mental abilities, controls thinking, memory, reasoning, perception controls, emotionals, speech.***
- ***Interprets sensations and response to cold, heat, pain and pressure.***

2. Diencephalon
- ***Relay centre for sensory impulse, such as pain, temperature, light, etc.***
- ***Reflex centre for muscular activities***
- ***Centre for certain emotions such as anger.***
- ***Contains centre for water balance, blood pressure, body temperature, sleep and hunger.***
- ***The hypothalamus controls hypophysis, or the pituitary gland, which function as master gland.***

3. Mid brain

It relays motors impulses from the cerebral cortex to the pons and spinal cord and relays sensory impulses from the spinal cord to the thalamus.

4. Cerebellum
- ***Maintains posture, equilibrium and muscle tone.***
- ***Coordinates voluntary movements initiated by cerebrum.***

5. Pons
- ***Transmits impulses from one side of cerebellum to the other and together with medulla it controls breathing.***

6 Medulla
- ***Contains centre for Cardiac, respiratory and vasomotor activities.***
- ***Coordinates reflexes such as for swelling, coughing, sneezing and vomiting.***

Rest and digest: Our parasympathetic nervous system maintains and restores our energy. It directs blood to our digestive tract and makes sure we actively digest food. It also maintains our blood pressure, heart rate and breathing rate at a low level. That's why it is sometimes called our 'rest and digest' system.

REFLEX ACTION

It is a nerve medicated spontaneous, automatic and involuntary response to a stimulus acting on a specific receptor without consulting the will of the animal. Reflex action was discovered by Marshal Hall (1833). Depending upon the part of CNS connected with reflex action, it can be **spinal reflex** or **cerebral reflex.**

Unconditioned Reflex: Reflexes present in an individual right from birth are called unconditioned / inborn / inherited reflex**.** The unconditioned reflexes are specific, predictable, purposeful and have survival value. They will be the same in all individuals. The stimulus for an unconditioned response is called unconditioned stimulus**.** Some examples of unconditioned reflexes are

(i) Withdrawal of hand or foot on being pricked.

(ii) Sweating.

(iii) Closing of eyes on being approached by an object.

(iv) Wider opening of pupil in dim light and constriction in strong light.

(v) Salivation on tasting the food.

(vi) Opening of mouth on hearing a loud sound.

(vii) Coughing during swallowing.

(viii) Persistalsis.

(ix) Discharge of bile.

(x) Breathing.

(xi) Jerking of knee when hit below knee cap.

Conditioned/acquired reflexes: They are those reflex actions that are not present at birth but develop later in life through learning, habit, experience or regular association of an indifferent stimulus (without any effect) with uncondition stimulus. Later on indifferent stimulus becomes conditioned stimulus. However, conditioned reflexes are liable to change, disappear or reappear. They reduce burden on doing the work, e.g., pedalling, driving a vehicle, playing musical instrument, writing, reading, daily chores, knitting without looking, salivation at sight or smell of food. Pavlov (1906) found that a dog salivated at the sight of food. He would sound a gong every time the dog was given food. After some days, the dog would salivate on hearing the bell even without food.

Reflex Arc: It is the pathway taken by nerve impulses generated at the receptor due to stimulus to reach the effector organ during a reflex action. It has five parts :

(i) Receptor — A tissue/organ/cell which reeives an external or internal stimulus, e.g., skin eye, ear.

(ii) **Sensory/Afferent Nerve Fibres —** They take the sensory impulsed generated by the receptor to the central nervous system.

(iii) **Part of Central Nervous System —** It can be spinal cord or brain. The sensory impulse is transferred here to motor nerves fibres either direclty or through interneurons.

(iv) **Motor/Efferent Nerve Fibres —** They carry the motor impulse generated in the CNS to the specific effectors. In case of motor nerve fibres pass through anterior/ventral root.

(v) Effector Organ — It may be organ/muscle/gland which on being activated by a motor impulse produces work or substance to suitably deal with the stimulus.

Importance. (i) It controls a number of body activities. (ii) Response to harmful stimulus is quick as to reduce harm. (iii) The response is always accurate, useful/purposeful. (iv) It avoids overtaxing of brain. (v) Coordination of body activities.

IMMUNE SYSTEM

Immune system is only developed in the vertebrates. Here the organisms have the capacity to develop anti-bodies against foreign body or microbes. It may be natural or artificial.

Natural Immunity : It means the ability of an organism to counteract a particular disease and certain microbes cannot take organism as a host. For example fish have natural immunity against measles, horses are not affected by polio and human can not be counteracted by hog cholera.

Artificial Immunity : It develops either by previous attack of the disease or by vaccination. Unlike natural immunity, it is brought about by the production of anti-bodies by the body.

Active Immunity : Here the body itself learns to manufacture the anti-bodies against a particular disease, even within very short period. Vaccine contains killed or attenuated microbes (disease causing virus or bacteria) which causes a mild form of the disease in the human body. After vaccination the body learns to produce antibody within 15 days.

Passive Immunity : Here the antibodies are borrowed from outside and they provide very short term immunity, generally last for about 6 months. For example the tetanus vaccine of the mother can protect the new born only for 6 months.

- Antigens are foreign bodies or microbes which enter the body like dust, pollen, etc. Without antigen the body cannot produce antibody.
- Antibody is highly specific protein which kills the antigens or neutralize the toxic substance produced by the microbes. Antibody produced by the body can affect only against a specific antigen of that particular disease and so are highly specialised.
- The first vaccine was invented for Smallpox by ***Edward Jenner*** in 1798
- ***Lues Pasteur*** propounded the Germ Theory of disease and scientifically explained the B-vaccination (anti-rabies vaccine). ■■

SENSORY ORGANS

Sense organ / receptor is a specialised body structure having specialised cells which can pick up an external or internal stimulus and transmit the same to the central nervous system as nerve impulse. Only brain can perceive sensations. Sense organs are avenues for receiving stimuli. The sense of taste, smell, sight and hearing are called **special senses** because their receptors occur in specific organs. The sense of touch / pressure / pain is called **general senses** as its receptor cells lie scattered in skin and various body parts.

According to Type of Stimulus.

(1) Mechanoreceptors —Sensitive to mechanical stimuli like pressure, gravity, pain, current, sound, touch.

(2) Chemoreceptors —Sensitive to chemicals or their concentration as in taste, smell, gases, humidity, etc.

(3) Photoreceptors —Sensitive to intensity and wave length of light, image formation.

(4) Thermoreceptors —Sensitive to temperature changes, including heat and cold.

SENSE OF TOUCH – SKIN

Our skin is the largest organ. It covers our entire body and has a surface area of around 2 square metres. Its thickness varies from 0.5mm on our eyelids to 4mm or more on the palms of our hands and the soles of our feet. In total, it accounts for around 16 per cent of our body weight.

ToughPhysical Barrier: Skin consists of two main layers: the outer epidermis and the inner dermis. Cells in the deepest layer of our epidermis divide constantly to make new cells. The new cells are pushed towards the surface of our skin. They eventually die and become filled with keratin, an exceptionally tough protein. Keratin provides our body with a durable overcoat, which protects deeper cells from damage, infection and drying out. Cells on the surface of our skin rub and flake off steadily and are continuously replaced with new ones. About every 30 days, our body produces a totally new epidermis. Inner dermis consists of strong collagen and elastic fibres pierced by blood vessels. It also contains touch, pressure and pain sensors and is packed with hair follicles, sweat and oil glands. The oil glands produce a lubricant that keeps our skin soft and prevents our hair from becoming brittle.

Temperature control: Our skin's blood vessels, sweat glands and hairs play a crucial role in regulating our body temperature. When we need to cool down:

1. blood vessels widen and allow heat to escape through our skin.
2. we start sweating, and as our sweat dries, it uses heat from our skin and cools us down.
3. our hairs lie flat to make sure little warm air doesn't get trapped between our skin and our hairs.

Skin Layers: Skin is the largest organ of the body (18 ft^2.). It regulates body temperature and acts as the organ of touch. It protects the inner organs from infection & injuries.

I. Epidermis

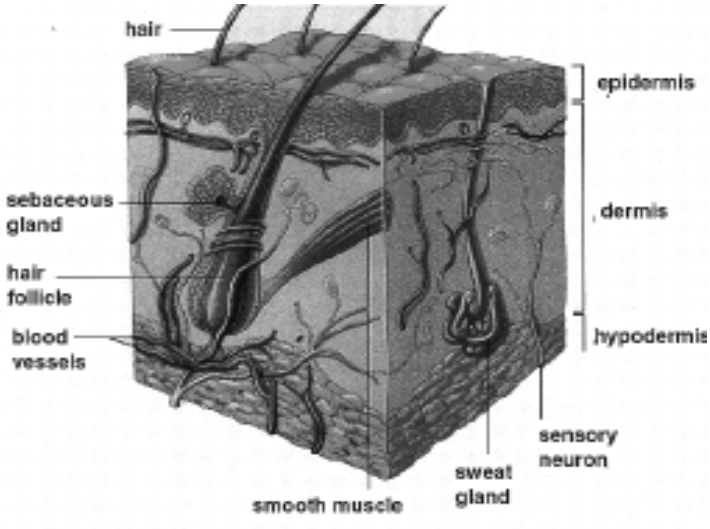
(i) Cornified layer : have dead cells; to cut the loss of water from evaporation & to prevent from microbes.

(ii) Malpighian layer : colour, contain malpighism cells which secrete 'Melanin' which protect the inner cells from ultra-violet radiations. When more melanin is secreted, the skin colour becomes 'tan'. White-men have more possibility of skin cancer. Skin cancer may be of two types: (a) Localised Skin Cancer- can be treated, not fatal, less harmful (b) Melonoma- most serious, known as skin cancer, fatal, pigment cell are affected, most common in Southern Hemisphere due to erosion of ozone layer.

II. Dermis (inner layer)

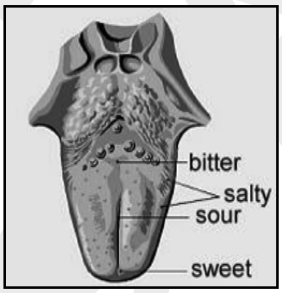
It is more thicker, true skin, regulates the body temperature through capillary vassels & sweat glands, have millions of capillary blood vessels, sweat glands, nerve endings, sebaceous glands and hair follicles. If temperature increases the capillary vessels expand & sweat glands help in evaporation; air conditioner of the body; sweat glands also remove the waste products; sebaceous glands- kills bacteria & keeps the skins soft & the body hair lustrous; found at the root of the hair follicles.

- When we need to retain heat, the opposite happens, our blood vessels narrow, we produce less sweat and our hairs stand up on end to trap warm air around our body.



- **Skin colour:** Our skin contains specialised cells called melanocytes. They produce melanin, a brown substance, which absorbs some of the Sun's harmful ultraviolet rays. Fair-skinned people only have melanin in the lower layers of their epidermis. People with dark skin have larger amounts of melanin in all layers. Freckles and moles are nothing else but small patches of skin with more melanin than in the surrounding area.
- **Wrinkles:** As we age, the number of collagen and elastic fibres in our dermis decreases. Additionally, we lose fat from the tissue under our skin. As a result, our skin becomes less elastic and begins to sag and wrinkle.
- **Skin Receptors :** Pressure, Pain, Touch/Tactile, Temperature Receptors.
- **Meissner's Corpuscles** (Tactile Corpuscles)**:** Low frequency vibrations and movements of objects, also pain.
- **Free Nerve Endings:** Touch, pressure and pain.
- **Hair End Organs** (Basket Nerve Endings)**:** Touch and movement of objects.
- **Merkel's Corpuscles** (Merkel's Discs)**:** Tactile receptors, constant touch.
- **Pacinian Corpuscles:** Pressure, tension and tissue vibrations.
- **Golgi-Mazzoni Organs** (Organs of Golgi)**:** Heavy touch, pressure, joint rotation.
- **End Bulbs of Krause/Krause's Corpuscles:** Cold.
- **Ruffini's Organs or Corpuscles:** Warmth
- Maximum number of tactile corpuscles occur in figner tips and lips.
- Cold sensation is more developed in fore-head region.

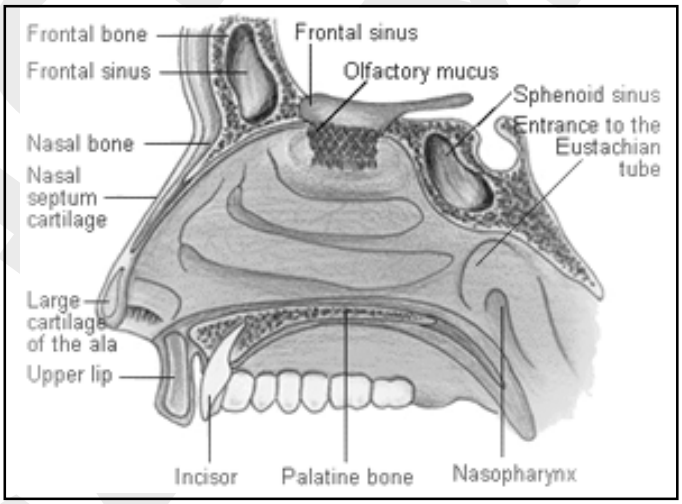
SENSE OF TASTES –TONGUE



Taste is a sense connected with feeling about food taken in mouth. It determines selection of food, its palatability and stimulation of reflexes for secretion of saliva, gastric juices and pancreatic juices. There are four basic tastes — sweet (sugars, glycerol), saltish (sodium), sour (acidic substance) and bitter (e.g., quinine, nicotine). Chillies and pepper give burning sensation. Gustatorceptros are chemoreceptors. They are located on the tongue, a few on palate, pharynx and tonsillar pillars. Organs of taste are **taste buds.** Some 10,000 of them occur on tongue in or around papillae with a papilla having 1 to 100 taste buds. Though a taste bud can be sensitive to two or more basic tastes, it is specialised for one only. The taste buds for sweet taste are located at tip and anterior surface of tongue, saltish antero-laterally, sour on sides and bitter towards base (posterior side).

- Sensation of taste is collected by facial (VII cranial, glossopharynegeal (IX cranial and vagues (X cranial taken to brain stem and then taste centre in temporal lobes of cerebrum for interpretation. However, the sense of taste is imparied in bad cold (when the sense of olfaction or smell is lost) indicating that most of our taste is actually related to smell.
- **Metallic Taste** spreads all over the tongue; tastes are in the form of chemical impulses; for tastes, tongue must be moist; well developed in man.
- Our sense of taste also helps us maintain a consistent chemical balance in our body. Like sugar and salt for example, satisfies our body's need for carbohydrates and minerals, similarly, eating sour foods such as oranges and lemons supplies our body with essential vitamins like vitamin C.

SENSE OF SMELL – NOSE



Sense of smell is the ability to perceive chemicals diffusing through air. It is well developed in mammals and in humans too who can distinguish many odours. Dogs, cats, rats and rabbits have very well developed olfactoreceptors. The olfactory sense is useful in search of food, selection of food, detection of enemies, preys, predators and mates. Nose is the organ of olfaction or smell. There are some 100 million olfactory cells which are actually bipolar neurons.

Mucus present over olfactory epithelium picks up particles and molecules present in the inhaled air. An impulse is generated in the nerve-fibre which is taken by olfactory nerve to olfactory bulb of fore-brain and then transmitted to olfactory area of temporal lobe of cerebrum for interpretation. However, continuous perception of a smell does not occur. Olfactory centre of brain gets fatigued of a smell within 2.5 –10/0 minutes. This is helpful to human beings in living and working in premises having odorous chemicals. The ability to condition one self in an odorous environment is known as olfactory adaptation. Perfume sprayed over one's clothes will stop smelling to that person after some time while other persons will be able to smell the same.

- Our sense of smell warns of dangers such as smoke and poisonous gases. It also helps appreciate the full flavours of food and drink.
- Our sense of smell is 10,000 times more sensitive than the sense of taste.
- When our olfactory receptors are stimulated, they

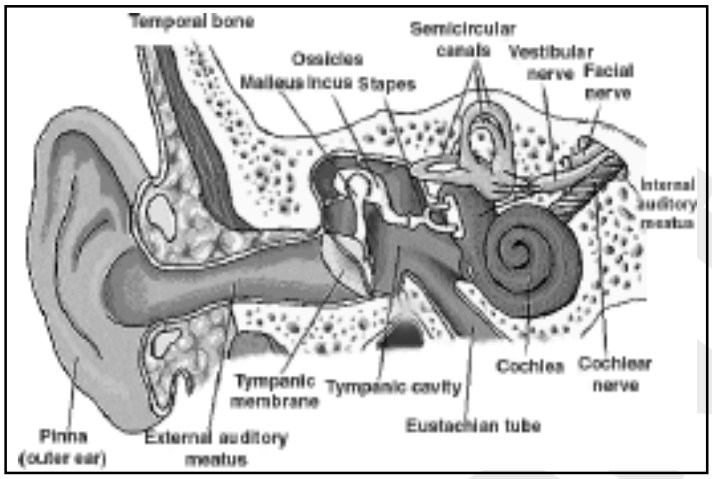
transmit impulses to our brain. This pathway is directly connected to our limbic system, the part of our brain that deals with emotions.

SENSE OF SOUND –EAR

Organ of hearing; organ of maintenance of equilibrium of body; audible range of human- 20 to 20000 fr / sec. (hertz). An ear has three parts — external, middle and inner.

1. **External Ear.** It consists of pinna, external auditory canal and tympanum.

(a) Pinna: It is the funnel-shaped oval projecting part which



consists of elastic cartilage covered by skin and having muscles (not functional in humans). It is meant for collecting sound waves.

(b) External Auditory Canal/Meatus: The canal is oblique S-shaped irregular passage from outside to tympanum. External auditory meatus is covered by skin having **hair** in the outer part and **ceruminous** or **wax glands** in the inner part. Secretion of ceruminous glands is called creumen or ear wax. Hair and ear wax trap dust particles and microbes. Ear wax also lubricates tympanum.

(c) Tympanum (Ear Drum): It is an oval, bluish grey, tight, stretchable membrane capable of vibrating, that lies at the end of external auditory canal. Tympanum is made of fibrous connecting tissue covered by stratified epithelium on external side and mucous membrane on the inner side.

2. **Middle Ear:** It has an irregular air-filled **tympanic cavity** lined by mucous membrane and enclosed inside temporal bone of skull. Tympanic cavity leads to Eustachian tube that opens into pharynx through a valve for equalising air pressure. A ligament supported chain of three bones or **ear ossicles** occurs between tympanum and oval window — outer hammer shaped **malleus** (in contact with tympanum,) middle anvil-shaped **incus** and inner stirrup-shaped **stapes** (in contact with oval window). The ear ossicles are meant for transmitting as well as amplifying vibrations received from ear drum.

2. **Internal Ear:** It is an irregular endolymph filled organ called **membraneous labyrinth** that occurs inside a **perilymph** filled **bony labyrinth.** Membranous labyrinth is differentiated into three parts — vestibule, semicircular canals and cochlear duct.

- **Vestibule** consists of an epithelium having sensory cells and supporting cells.
- **Semicircular Canals** are three semicircular ducts borne over the utriculus at right angles to one another. One end of each semicircular canal is swollen to form ampulla having a sensory spot known as **crista.**
- **Cristae** maintain dynamic equilibrium of the body.
- **Cochlear Duct** is a spirally coiled tube of 21 / 2 turns. The coils of cochlear duct are held by ligaments. Cochlear duct lies in a coiled part of bony labyrinth called cochlear bone. The two are collectively called cochlea. They have receptor organ for hearing called organ of Corti. There are some eight types of sensory cells specialised to perceive different sound vibrations. The sensory cells or organ of Corti are also called phonoreceptors.

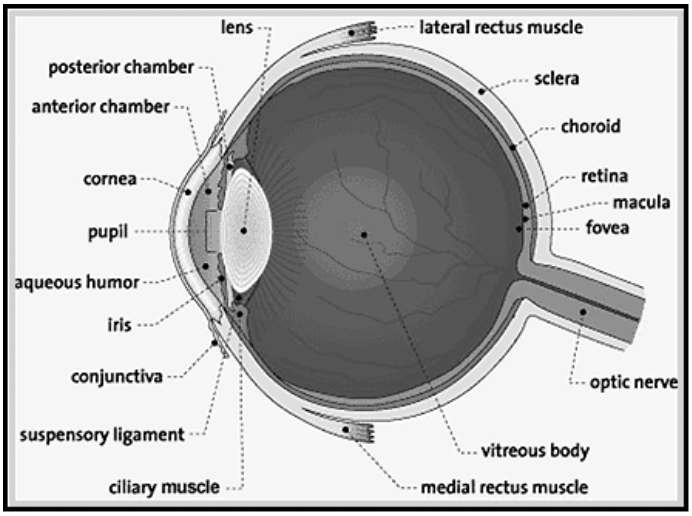
Our ear flap funnels sound waves into our outer ear canal. The waves travel along this passage until they hit our eardrum and cause it to vibrate. As a result, our ossicles start moving. They, in turn, pass on vibrations to a thin layer of tissues at the entrance of our inner ear called the oval window. The movement of the oval window then sets off wave-like motions in the fluid in our cochlea.

Our organ of hearing, the spiral organ of Corti, runs through the inside of our cochlea. It consists of thousands of sensory hair cells, attached to a membrane. Tiny sensory hairs emerge from each sensory hair cell and pierce into a second, gel-like membrane above. Whenever the fluids in our cochlea are in motion, the first membrane vibrates and squashes the sensory hairs against the second membrane. The movement of our sensory hairs is then translated into nerve impulses, which travel along our cochlear nerve to our brain.

Because we have two ears, we are able to locate the source of a sound. If a sound comes from the right, for instance, it will reach our right ear slightly sooner than our left ear. Or it will be slightly louder in our right ear. As a result, we will recognise the sound as coming from our right.

SENSE OF SIGHT–EYE

Organs of sight are a pair of eyes lodged in eyes sockets or **orbits** of skull having cushion of fat for frictionless movement and protection from shock. Each eye is rounded and called **eye ball.** It is 2–5 cm in diameter . It can move in the orbit by six strap– shaped occular muscles: Eyes are protected by eye lids and tear glands. **Eye brows** are supra-orbital arched eminences bearing obliquely projecting hair. They can be brought down to protect the eye ball from dust, sweat and rain. **Eye lids** are a pair of movable skin folds supported by stiff connective tissue plates which lie above and below the 'eye' and cover the same at intervals by coming together in the process of blinking, closing of eyes during sleep or rest. Eye lids bear stiff hair or **eye lashes** at the edges. They are lubricated by **glands of Moll.** Margins of eye lids posses **Meibomian** or **tarsal glands** (modified sebaceous glands).



The inner surface of eye lids is lined by mucous membrane called **palpebral conjuncntiva.** Secretion of Meibomian glands helps in frictionless blinking and holding tears over the exposed part of eye ball. Eye lashes and blinking are protective against dust particles, flies, rain, etc. A small reddish patch on the inner corner of eye is called **plica semilunaris** (may be vestigial third eye lid or nictitating membrane). **Tear gland** (**lacrimal** = **lacrymal** = **lachrymal gland**) is an almond shaped racemose gland lying in the upper part of orbit that secretes a watery fluid or tear having antibacterial **lysozyme** (water + sugar + amino acid + proteins + minerals + salt + urea). It is poured over the exposed part of eye ball by 6 — 10 tear ducts. The lacrimal secretion or tear moistens and cleanses the eye ball and eye lids, provides protection from microbes and nourishes the cornea.

Wall of eye ball has three concentric layers — fibrous tunic, uvea and retina. Out of these only fibrous tunic is complete.

Fibrous Tunic (Sclerotic): It is the outermost covering of eye ball. The coat is made of fibroelastic connective tissue. 5/6th of it is opaque and bluish white, largely hidden but a part present in front as white of eye. It is called **sclera,** has blood vessels and provides attachment to eye muscles. The front part (1/6th) of fibrous tunic is thicker, transparent, bulged out **cornea** which is devoid of blood vessels. Cornea is nourished by aqueous humour and partly by lacrimal secretion. Cornea and the exposed sclera is covered by a transparent membranous epidermis called **conjunctiva** (bulbar conjuctiva). It provides protection and lubrication. Cornea admits light and helps in rough focussing.

Uvea (Choroid): It is middle pigmented and vascular coat which is differentiated into three parts — choroid, ciliary body and iris.

(i) **Choroid :** It lines the sclera. Because of its pigmented nature, choroid prevents internal reflection. It provides nourishment and oxygen to retina.

(ii) **Ciliary Body :** It is ring-shaped thick muscular structure occuring at the junction of choroid and iris. Its epithelium secretes aqueous humor.

(iii) **Iris :** It is an opaque muscular pigmented and perforated diaphragm having radial (dilator) and circular (sphincter) smooth muscles which are operated by sympathetic and parasympathetic nerves respectively. The iris provides colour to eyes. It can be blue (only at the back), grey, brown (dark, light) or black (depending upon layers having pigment). The central perforation of iris is called **pupil.** Its size is controlled by radial (contraction dilates pupil) and circular (contraction constricts pupils) muscles in response to dim and strong light respectively.

Lens: It is transparent, elastic, biconvex structure which is suspended in the cavity of eye ball behind the pupil by means of suspensory ligaments. Lens is made of layers of non-nucleated elongated cells and intercellular proteins. It is covered by a thin transparent membrane called **lens capsule.** The convexity of lens is slightly more on the back as compared to the front. Stretching and relaxation of suspensory ligaments changes the focal length of the lens for accomodation.

Cavity of Eye Ball: Lens and suspensory ligaments divide the cavity of eye ball into anterior **aqueous chamber** and posterior **vitreous chamber.** Aqueous chamber is filled with clear watery fluid or aqueous humor secreted by ciliary body. It nourishes lens and cornea. Aqueous humor also maintains shape and pressure in the front part of eye. The posterior vitreous chamber (between lens and posterior part of eye ball) contains a non-replaceable jelly-like transparent substance called **vitreous humor/**vitreous body. It maintains shape of eye ball and provides pressure for keeping the lens in position. Vitreous chamber contains a lymphoid hyaloid canal from lens to blind spot.

Retina: It is the delicate inner non-vascular light sensitive coat of the eye ball . It is sensory and differentiated into two parts, outer **pigmented part** and inner **nervous part.** The pigmented part is made of cuboidal cells with dark brown granules and fringe-like protoplasmic processes. It continues beyond ora serrata. The inner nervous part is transparent and made of three layers —

(i) Outer photosensitive layer of visual / photoreceptor cells called rods and cones.

(ii) Middle layer of bipolar nerve cells.

(iii) Inner layer of ganglion cells that form nerve fibres.

Glowing of eyes in cats and dogs is **due** to presence of reflecting layer of **tapetum** behind the retina. The area of retina where optic nerve and blood vessels enter and leave the eye ball is called **blind spot** (optic disc) as it does not contain visual cells. An area lateral to blind spot is the spot of image formation. It is called **yellow area** or **muscular lutea.** A depression in the yellow area is called **yellow spot** or **fovea centralis.** It lies on optical axis, has maximum density of cone cells and forms the sharpes vision.

- Human eye has about 120 million rod cells and 7 million cone cells. Cone cells are more abundant in the yellow area. Yellow spot has exclusively cone cells.The animals which can see in dark have very high number of rod cells (e.g., Owl, Bat).
- A **rod cell** has an outer pigment part drawn out as a rod, the inner end contains a nucleus. The pigment present in rod cells is called **visual purple** or **rhodopsin**. It consists

of protein and vitamin A. Rods produce a blurred grey white image in dim light. In twilight a coloured flower will appear only black due to rod-mediated vision. Rhodopsin is bleached in strong light but is reformed in dim-light with the help of vitamin. A. Deficiency of Vitamin A leads to **night blindess** (no vision in dim light) because of little rhodopsin.

- A **cone cell** has a conical outer pigmented part and a branched inner part. The pigment is known as **visual violet** or **iodospin**. It is actually of three types corresponding to three basic colours — green sensitive **chlorolabe,** blue sensitive **cyanolabe** and red sensitive **erythrolabe.** Cone cells produce sharp, coloured image is bright light. Alongwith humans, colour vision is present in paes, monkeys, birds, lizards, snakes, fresh water fishes, cray fishes, etc. Other animals have black-white vision. In humans colom blindness is caused by a defect in the colom sensitive cells (Cones).

- **Working:** Eye, like photographic (camera, has to parts — diopteric or focussing and sensory / receptor

(a) **Focussing —** It is carried out by cornea (rough focussing) and lens (fine focussing) so that image is formed on fovea centralis or yellow spot. Aqueous and vitreous humors help in keeping the light rays on proper path. For focussing at nearer objects, the ciliary muscles contract, the suspensory ligaments are loosened and the lens becomes more convex. Human beings have **binocular** (monocular in Frog) and **ssterescopic** (3-dimensional) **vision,** because both the eyes are focussing an the same object with very slight variation of angle. It gives clearer image with better idea of distance.

(b) **Reception —** An inverted but real image is formed over the retina. A black and white blurred image is formed in dim light due to perception by rods. A sharp coloured image is produced in day light due to perception by conces in the area of fovea centralis. The stimulus perceived by rods and cones is converted into impulses which are transferred to bipolar ganglion cells and then nerve fibres of optic nerve to be carried to visual area of occipital lobe of cerebrum for interpretation.

Common Refractive Eye Defects

1. **Myopia** (Short Sightedness). Common in young persons / students due to either higher convexity of lens or longer eye ball which results in image of distant objects (writing on black board, bird on a tree) being formed in front of the retina. It is corrected by wearing (spectacles with) concave or convergent lenses.

2. **Hypermetropia** (Far or Long Sightedness). The image of nearer objects (words in a book) is blurred due to its being formed beyond retina due to eye ball being short or lens being flattened (with low convexity). It is corrected by wearing (spectacles with) convex or divergent lenses.

3. **Astigmatism**. Cornea or lens is curved unequally in different regions so as to produce a blurred image (foccusing at different points in different regions). Complementary lenses (cylindrical lenses) are prepared to correct astigmatism.

4. **Presbyopia.** It is old age (after 40 years) far sightedness due to loss of elasticity in the eye lens so that near objects (e.g., written or printed words) are not correctly visible. Convex / bifocal lenses correct the vision.

5. **Cataract.** In older persons (60 years and above) the eye lens becomes opaque reducing visibility. Cataract can be nuclear (central portion capacity) or cortical (peripheral opacity). Cataract is corrected by (i) Removing or opaque lens and wearing special spectacles. (ii) Replacing opaque lens with artifical infraocular lens. (iii) Laser treatment of opacity.

TRIVIA

- **Koths, Butterfiles:** Chemoreceptors occur on antennae.
- **Chillies:** Not bitter taste but produce burning pain.
- **Vibrations to which Human Ear is Most Sensitive:** 1000 cycles / sec.
- **Pinna:** Absent in certain mammals like Platypus,. and many aquatic forms like Whale, Seal, Sirenian.
- **Colour Blindness:** Sex linked recessive. Three types — protanope (red), tritanope (blue) and deuteranope (green).
- **Glaucoma:** It is an eye defect in which intra-ocular pressure becomes different in the two chambers causing acute pain leading to damaged retina and hence blindness.
- **Squint/Strabismus, Diplopia** or two images: Correct surgically.
- **Binocular Vision:** Found in mammals and some birds.
- **Stereoscopic/Three Dimensional Vision:** Occurs in primates.
- **Cones:** Absent in Owis, Shrews, Moles, Hedge Hogs, Bats, etc. Pure cone retina occurs in squirrels.
- **Harderian Glands:** Present at the angle of eye, secrete lubricant for nictitating membrane in animals where the latter is present.
- **Eye Size:** Diameter at birth is about 17.5 mm and at puberty 20-21 mm. In relation to body size, Deer possess the largest eyes.
- **Colour Vision:** Occurs in bees, reptiles, birds, monkeys, apes and humans. Absent in most domesticated animals.
- **Eye-Lids:** Absent in snakes and fishes. ■■

EXCRETION & OSMOREGULATION

CHRONICLE IAS ACADEMY
A CIVIL SERVICES CHRONICLE INITIATIVE

Excretion is the process by which the metabolic waste products formed as a result of anabolism and catabolism are eliminated from the body. An important requisite for the continuation of life therefore is the removal of metabolic waste products such as ammonia, urea, uric acid, bile pigments, excess salts and water. The organs concerned with this function are called excretory organs. In addition to the kidney, the skin, lung, intestine and liver also eliminate metabolic waste products directly or indirectly. The removal of carbon dioxide from the lungs is also an excretory process. Nitrogenous wastes i.e. ammonia, urea and uric acid are derived from catabolism of dietary proteins. Major metabolic waste products are:

1. **Nitrogenous Waste:** They are formed during metabolism of excess proteins, amino acids, nucleic acids, alkaloids, etc. Nitrogen waste products include ammonia, urea, uric acid, creatine, creatinine, hippuric acid, amino acids and allantoin. Depending upon the major nitrogen excretory product, animals are aminotelic, ammonotelic, ureotelic and ureotelic and uricotelic.
2. **Non-nitrogenous Waste :** Oxalic acid, lactic acid.
3. **Excess Chemicals:** Sodium, Calcium, Magnesium, Lead, Chloride, Phosphate, Iodine, pigments, drugs, chloesterol, hormones, vitamins, wax, etc.
4. **Bile Pigments:** Bilirubin, biliverdin and urochrome are breakdown products of haemoglobin formed by liver.
5. **Carbon-dioxide**
6. **Excess water**

AMMONOTELISM

It is the elimination of nitrogenous wastes mainly in the form of ammonia. Ammonia is highly toxic and water soluble. Ammonotelism is found in aquatic invertebrates like annelids, aquatic crustaceans, aquatic molluscs, bony fishes, aquatic amphibians, aquatic larvae of amphibians, lungfishes and *Xenopus* toad inside water, earthworm in water saturated soil, etc. Animals without an excretory system are ammonotelic. Most protozoan protists are also ammonotelic.

UREOTELISM

It is elimination of nitrogenous wastes mostly in the form of urea. Urea is less toxic than ammonia. It is water soluble but can be concentrated to some extent (100 times in humans, several hundred times in camels, sharks and Kangaroo Rat). It is the most common condition e.g., Earthworm, Snail, Prawns, cartilaginous (elasmobranch) fishes, adult amphibians, aquatic reptiles, mammals, etc.

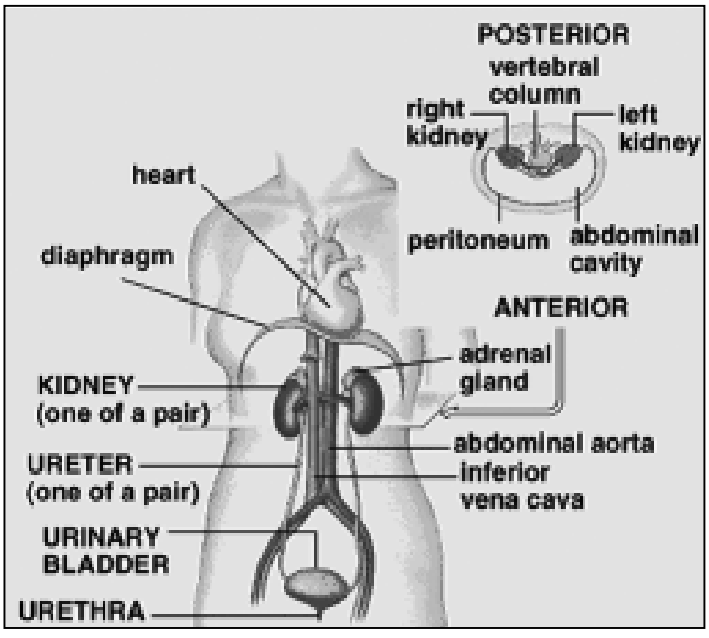
Uricotelism: It is the elimination of uric acid and urates as the main nitrogenous wastes. Uric acid is little toxic and least soluble in water though it can be suspended in the same. Very little water is required for elimination of uric acid. Uricotelism occurs in birds, lizards, snakes, land snails, terrestrial crustaceans and insects. Droppings of birds and lizards have whitish patch of uric acid on one side.

EXCRETORY MECHANISM IN PLANTS

During the process of respiration, CO_2 is given back to environment through stomata of the leaves. Some plants produce insoluble solid waste product like tannin, alkaloids such as quinine or morphine. These waste products are stored in leafs, fruits or bark cells and are removed when a leaf or fruit falls or when the bark peels off. The excess of salts are deposited in the form of insoluble crystals within the tissues and cells, so these crystals are formed as a product of excretion. Some of the excretory products of roots act as a solvent by which the complex materials in the soil are broken down before being absorbed by the root.

EXCRETORY ORGANS OF INVERTEBRATES

- **Unicellular Organisms:** They mostly live in water. Excretory organs are absent. Contractile vacuoles may occur (e.g., *Amoeba, Paramecium*) for excretion and

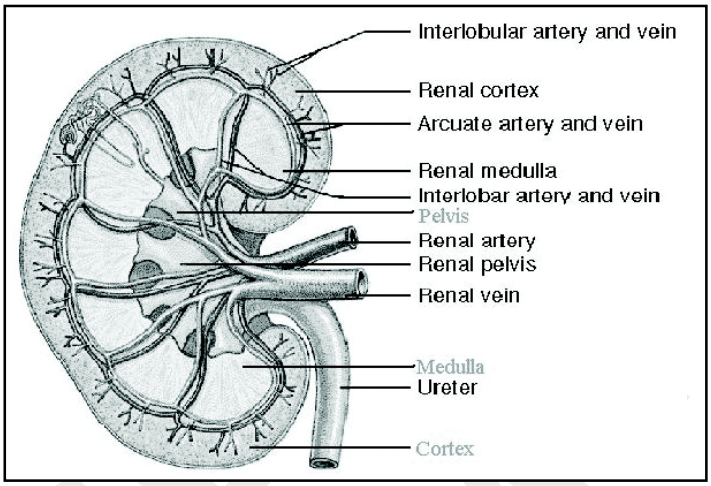


ORGANS & METABOLIC WASTES

	Organ	Metabolic Wastes or By-products
1	Kidney	Water, urea, uric acid, salts of sodium, calcium, magnesium, potassium creatinine, excess of glucose and certain vitamins.
2	Liver	Bile pigments, toxins, urea.
3	Skin	Sweat containing water, urea, uric acid, sodium chloride, ammoniacal salts, heat.
4	Lungs	Carbon dioxide, water vapours, heat.

osmoregulation. Main excretory product is ammonia, rarely amino acids. It passes out through diffusion.

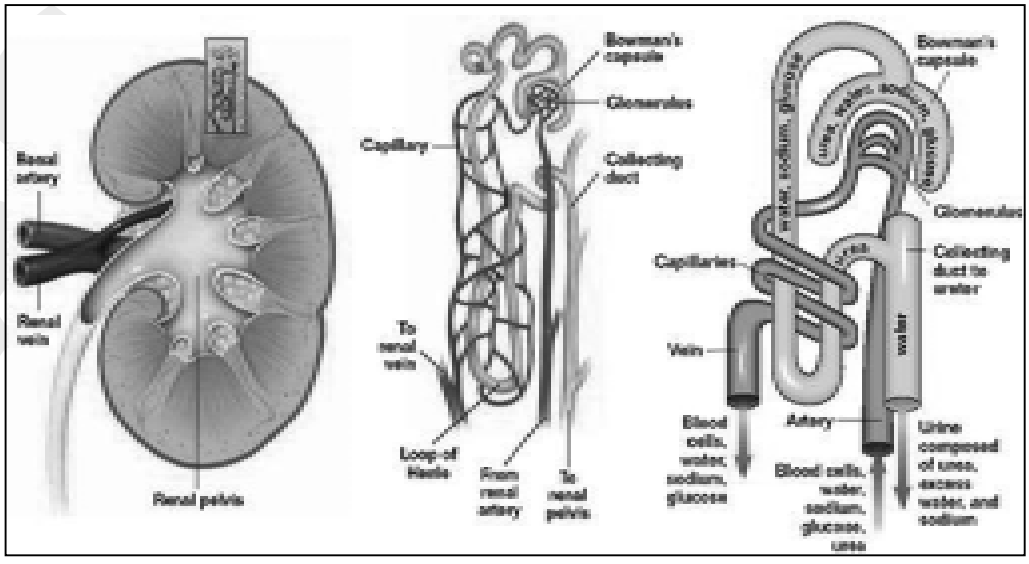
- **Sponges:** Ammonia formed by individual cells diffuses out into water present on the outside canals and spongocoel.
- **Coelenterates** (e.g., *Hydra*)**:** Ammonia passes out of cells through diffusion into water present on the outside.
- **Platyhelminthes** (e.g. *Planaria,* Liver Fluke, Tapeworm) **:** They have an excretory system with excretory pores, excretory capillaries. They create a current for flow of excretory fluids.
- **Annelids** (e.g., Earthworm, *Neries*/Sandworm, Leech)**:** Their excretory organs are **nephridia.** Each nephridium has a nephrostome, nephridial body/tubule and nephridial pore. They body tubule of the nephridium is coiled and surrounded by blood capillaries. Nephrostome is funnel shaped ciliated pore which can pick up materials from body cavity. Blood capillaries selectively secrete waste products into tubule and selectively absorb useful substances from its interior.
- **Crustaceans** (e.g., Prawan)**:** The excretory organs are a pair of **green glands** situated at the base of second antennae and a median renal sac that lies over the stomach and reaching upto gonads. The renal sac has excretory cells that extract waste products from outside. Renal sac is connected to the bladder of each green gland by a lateral duct. A small duct or ureter takes urine to a **renal pore** opening on a small papilla on the inner side of coxa.
- **Insects, Centipedes and Millipedes:** The excretory organs are **malpighian tubules.** Scorpions and spiders have malpighian tubules, green glands or both. Urine consists of uric acid, urates, guanine, salts and water.
- **Echinoderms:** Excretory organs are absent. Amino acids, ammonia and other waste materials diffuse out.
- **Molluses:** One or two kidneys take part in extracting waste products and discharging the same into mantle cavity.



EXCRETORY ORGANS OF VERTEBRATES

Urinary system of a vertebrate consists of two kidneys, two ureters, a urinary bladder (absent in birds) and urethra (present only in mammals).

- **Kidney:** They are a pair of reddish brown slightly flattened, bean shaped organs present in the lumbar region along the dorsal wall, one on either side of vertebral column. Weight is 150—170 gm. Size is 10 cm length, 5 — 6 cm breadth and 4 cm thickness. Left kidney occurs at a slightly higher level than the right one. Internally, the kidney has two parts, granular outer darker **renal cortex** and striated inner pale **renal medulla.** A kidney has 1.2 million **uriniferous tubules** or **nephrons** embedded in a connective tissue. Nephrons are structural and functional units of kidneys. Each has a length of 4—5 cm and is differentiated into H Bowman's capsule, neck, promximal convoluted tubule (PCT), loop of Henle, distal convoluted tubules (DCT) and collecting tubule.
- **Bowman's capsule** is blind cup-shaped end of uriniferous tubule which has a double wall of thin-walled flattened cells supported over basement membrane, lobed with a narrow lumen. The hollow of Bowman's capsule contains a globular bunch of fine



EXCRETORY PRODUCTS OF ANIMALS

Ammonotelic:	***Which release NH_3 (Ammonia) ex : Lower organisms (ceoleutrates, protozoa, sponges) aquatic amphibians, fresh water fishes.***
Uricotelic:	***Which release uric acid.***
	example : In Reptiles, Birds and egg laying mammals (Platypus, anteater)
Ureotelic:	***Which releases urea.***
	example : Land amphibious, mammals, earthworm, round worm
Ammonitic:	***Which release amino acids.***
	example: some molasses.

blood vessels (= capillaries) called **glomerulus.** Glomerulus is maintained in position by connective tissue. Bowman's capsule, glomerulus and its connective tissue are together called **malpighian capsule/ malpighian body** or **renal capsule.** Glomerulus obtains blood from an **afferent arteriole** and is drained out to form an **efferent arteriole.** Since this filtration is very fine and is caused by pressure, it is known as **ultrafiltration.** About one-fifth of blood plasma flowing through kidneys is filtered out as **glomerular** or **nephric filtrate.** Its volume is 125 ml/min. The reaction is alkaline. Filtrate contains urea, amino acids, creatinine, hormones, vitamins, salts/ions, glucose, etc, i.e., all small sized molecules. Bowman's capsules and glomeruli are absent in marine fishes and desert amphibians.

- The hormone helps in absorption of water from the nephric filtrate and pass out hypertonic urine. In the absence of hormone, water is not absorbed by the tissue fluid and hence hypotonic or dilute urine passes out. This is a mechanism to regulate water balance in the body.
- Birds cannot make urine as hypertonic as mammals can do. Reptiles produce only hypotonic urine. The urine of both groups contain uric acid. Dilute urine is stored in cloaca where water is reabsorbed and only semisolid urine is passed out alongwith faeces.
- **Ureters:** They are a pair of narrow, whitish muscular and distensible tubes of about 30 cm in humans. Ureters undergo peristalsis to pass urine from kidneys to urinary bladder.
- **Urinary Bladder:** It is a median pyriform bag that occurs in the pelvic part of abdominal cavity. Bladder is capable of considerable stretching with a capacity of 300— 800 ml of urine.
- **Urethra:** It is a tube that connects urinary bladder with external opening of urinary tract.

URINE

It is transparent amber-coloured (due to **urochrome**), often hypertonic fluid formed by urinary system as excretory product which is released at intervals. An adult human produces 1.0 — 1.8 litres of urine/day. Reaction is acidic but becomes alkaline on standing. Urea is changed to ammonia on standing.

Composition of urine: Water 95%, Urea 2%, Uric acid 0.05%. Amount of urine secreted per day is 1.5 to 2 liters approximately. It depends upon the water intake, diet, climate, mental state and physiological condition. Tea, Coffee, Alcohol and other beverages increase the formation of urine.

- **Abnormal constituents of Urine:**

1. **Glucose** - In diabetes mellitus
2. **Blood** - In case of bleeding, tumour or infection in the kidneys.
3. **Excessive water in urine** - In diabetes insipidus.
4. **Acetone and auto acetic acid** - During fasting or starvation. In such a case proteins are used as a source of energy.

- **Urine Tests:** Urine is tested for-

(i) **Albuminuria:** Loss of proteins.

(ii) **Pus.** Presence of pus cells, casts and haemoglobin indicate destructive changes in kidneys or a severe urinary tract infection (UTI)

(iii) **Haematuria:** Occurrence of blood due to kidney stones, lesions in kidneys or urinary tract.

(iv) **Calculi:** Small stones.

(v) **Bile Pigments:** Jaundice.

(vi) **Glucosuria:** Presence of glucose due to diabetes.

(vii) **Ketonuria:** Presence of ketones due to metabolism of fatty acids instead of glucose during diabetes, starvation and pregnancy.

(viii) **HCG:** Occurrence of human chorionic gonadotropin indicates pregnancy (Pregnancy test).

OTHER ORGANS OF EXCRETION IN HUMAN

There are four other major organs besides kidney which are involved in excretion. These are skin, lungs, intestine and liver.

(a) **Skin:** The skin acts as an organ of excretion with the help of the sweat glands present in it. These glands remove water, urea and some salts from blood and excrete them on the surface of the skin. The excretion of water by sweat glands aids in regulating the body temperature.

(b) **Lungs:** The lungs are the chief organs of respiration, they absorb oxygen and eliminate CO_2. The loss of water vapour during breathing is an unavoidable consequence. The alveoli of lungs must remain moist if they are to remain in an active state. The rate of respiration is regulated by the nerves.

(c) **Intestine:** The intestine plays a minor role in excretion. It has a lining of epithelial cells. These cells excrete certain salts for example those of calcium and iron.

(d) **Liver:** It may be considered as an accessory excretory organ because it plays only a minor role in excreting waste products directly from the body. *Urea*, the chief nitrogenous waste material in the human body is formed in the liver. The breakdown of amino acids which takes place in it, results in the accumulation of nitrogenous wastes. These nitrogenous wastes breakdown further into ammonia. The liver converts the ammonia along with carbon dioxide into urea with the help of specific enzymes, urea is removed by the kidneys eventually. The haemoglobin of the dead red blood cells is broken down in the liver. In this process the liver manufactures bile pigments through the bile ducts. The bile pigments pass into the intestine and are thrown out along with the faces.

Osmoregulation or Homeostasis : Kidneys maintain osmotic pressure of the blood by regulating its percentage of water and salts while removing wastes like urea from the blood. This is called osmoregulation. If the concentration of blood is higher than that of the body cells, water will be drawn out from them and they will shrink and if the blood has lower concentration, the cells will absorb water from the blood and will swell. Hence, the need to maintain the right concentration of blood plasma.

Artificial kidney: An artificual kidney is used to replace the non-functional or damaged kidney in its excretory functions. It works on the principle of dialysis. The blood of these patients is pumped into a cellophane tube suspended in a salt solution of same ion concentration as plasma. As blood flows through this tube mineral ions and nitrogenous wastes may diffuse out like ammonia and urea freely from the blood to the surrounding solvent because cellophin membrane has pores large enough to allow free passage. Thus the excess of those mineral and nitrogenous products are removed from blood but plasma proteins are retained in the blood because the pores of the cellophin are too small to allow passage of those large solute molecule.

- **Aminotelic Animals:** Animals excreting amino acids, e.g., some molluses (Pila, Unio) and some echinoderms (Starfish, *Holothuria).*
- **Marine Teleosys:** Excretory product is **trimethylamine oxide** (T.M.O.)
- **Spiders.** Excretory product is guanine.
- **Kidney Stones:** Two types (i) Oxalate crystals (ii) Urice acid crystals. Uric acid crystals can accumulate in other places in the body as well.
- **Uremia:** When blood urea content is above 0.05%. However, in elasmobranch fishes, blood urea content is 2.0 — 2.5% . The excess is used for osmoregulation.
- **Urochrome:** A yellowish pigment which provides colouration to urine and is believed to be derived from brochrome chemicals of haemoglobin.
- **Amount of Nephric Filtrate:** 160 — 180 litres / day with a later concentration of 99% so that only one precent liquid is excreted as urine.
- **Polyuria:** Production of unusually excessive amount of urine.
- **Diuresis:** Increased secretion of urine. The chemicals stimulating diuresis are called **diuretic** e.g., disodium citrate, glucose, caffein.
- **Dysuria:** Painful urination.
- **Oligouria:** Less urine.

  Anuria: Absence of urine.
- **Diabetes Insipidus:** Hypotonic polyuria, several times a day due to deficiency of ADH vasopression. Thirst and dehydration occur.
- In 24 hours, our kidneys filter around 150 litres of blood and produce roughly 1.5 litres of urine.
- When our kidneys detect that our blood pressure is dropping, they secrete an enzyme called **renin**. This enzyme triggers a chain of events that makes our kidneys reabsorb more salt and water, leading to an increase in blood pressure.
- People can live healthily with one functioning kidney. However, when about 90% of kidney function has been lost, a person can only survive by having **dialysis**. Dialysis works by using a machine that replicates the blood-cleaning function of healthy kidneys. In the most extreme cases of kidney failure, survival depends on the person receiving a donor organ.

TRIVIA

- **Haemodialysis/Dialysis/Artificial Kidney:** It is employed in case of uremia or excessive concentration of urea in the blood due to renal damage. Artificial kidney performs dialysis (separation of micromolecules and ions from colloids / macromolecules) of blood or haemodialysis of waste products (urea, uric acid, creatinine, phosphate, sulphate, etc.) so as to prevent toxicity that may lead to death. Blood from an artery (recently from a vein with pumping mechanism) is mixed with heparin, cooled to 0°C and passed through

cellophane tubes when waste products pass into dialysing fluid. Purified blood is warmed, mixed with antiheparin and passed into a vein.

- **Camels** excrete a highly concentrated urine in order to conserve water. They do not sweat till body temperature rises above 55° – 60°C. Camels can also tolerate desiccation upto 40% cellular water content.
- **Gout :** Non-elimination of uric acid from human body due to excessive formation or reduced tubular secretion results in deposition of urates in cartilages, kidneys, joints and soft tissues resulting in various type of disorders and joint pains. Swollen and painful big toe is quite common.
- **Guana :** Faecal deposition of birds (especially marine) having uric acid can be used as fertilizer due to being rich in nitrogen and phosphorus. ■■

ENDOCRINE SYSTEM

Endocrine System is a system of isolate glands that pour their secretions directly into venous blood or lymph for passage to different body organs in order to control their functioning, metabolism, cell permeability, growth, differentiation and stress conditions. Endocrine system comprises endocrine glands and their hormones. It is therefore, also called hormonal system**.** The branch of science that is connected with the study of endocrine glands, hormones and their effect is known as **endocrinology.**

TYPE OF GLANDS

Gland is an organ, tissue or cell that secretes a chemical for performing a particular function outside.

- **Exocrine Gland:** It is a gland that pours its secretion on the surface or into a particular region by means of ducts for performing a metabolic activity, e.g., sebaceous glands, sweat glands salivary glands, gastric glands, intestinal glands.
- **Endocrine Gland:** It is an isolated gland which secretes informational molecules or hormones that are poured into venous blood or lymph for reaching the target organ because the gland is not connected with the target organ by any duct. Endocrine gland is, therefore, also called **ductless gland.**
- **Heterocrine Gland** (Mixed Gland)**:** It is a gland that has both exocrine and endocrine tissue, the former pouring their secretion through ducts while the latter pour their secretion directly into blood/lymph. Mixed organ is an organ which has both an endocrine activity and a metabolic function, e.g., gonads.

HORMONES

In 1905, the term hormone was proposed by Hardy The hormones are formed by certain aggregates of cells referred to as endocrine glands. The role of the hormones is to direct, regulate and coordinate the activities of the various organs. There are certain other endogenous (originating from within) substances called *tissue factor* or *autocoids* produced by specialized group of cells. These are different from hormones as they produce their effects without entering the blood stream. Their release is controlled by hormones metabolic products, cell enzymes etc.

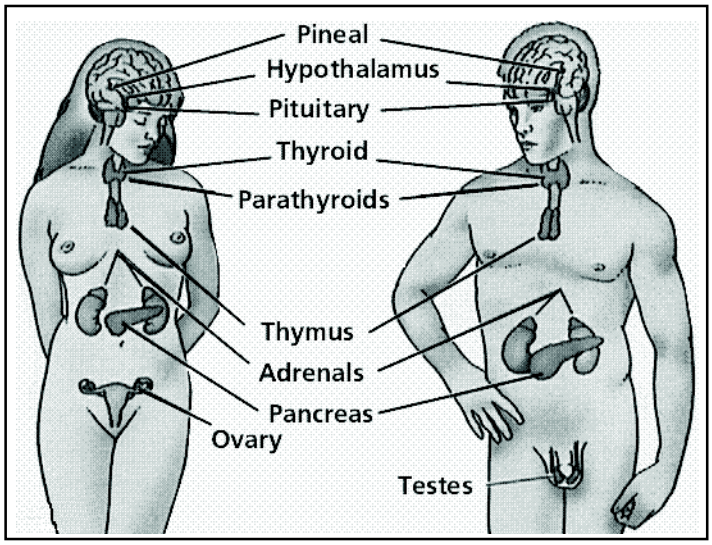
The action of a hormone on a cell in the target organ and its effect are mediated by stimulation or the synthesis of specific proteins or other products. Specific recognition sites for a particular hormone are present in the cytoplasm and nucleus and are involved in the expression of hormonal action. The functions of various glands like thyroid, adrenal, ovary and testes are regulated by hormones secreted by the pituitary gland. The secretion of pituitary gland hormones are regulated by hypothalamus. Hormones are effective in very low concentration, e.g., 0.003 ppm in case of adrenaline.

Chemically there are different kinds of hormones. These are:

1. **Biogenic Amines:** Hormones of pineal gland (melatonin) and adrenal medulla (catecholamines, viz, adrenaline, noradrenaline).
2. **Modified Amino Acids:** Hormones of thyroid are iondinated tyrosine, e.g,, thyroxine.
3. **Peptides:** Hormones of hypothalamus (ARH, TRH, GRH, GIH), intermediate (MSH) and posterior lobes of pituitary (ADH, oxytocin). ACTH of anterior pituitary and calcitonin of thyroid belong to this category. They may further be differentiated into short peptides (e.g, oxytocin, ADH) and **long peptides** (e.g., calcitonin, ACTH).
4. **Proteins:** Hormones of pancreas (e.g., insuling, glucagon), gastrointestinal tract, some female hormones (e.g., relaxin of ovary and hCG of placenta), parathormone (PTH) and most hormones of anterior pituitary except ACTH (e.g, TSH, FSH, LA, LTH, GH) are proteinaceous.
5. **Steroids:** Hormones are derived from cholesterol and other steroids, e.g., aldosterionie, cortisol, sex corticoids (adrenal cortex), testosterone, estradiol, progesterone (gonads except relaxin, placenta except hCG).

Characteristics of Hormones:

- They are regulatory chemicals that control and coordinate functions of different body organs.
- Hormones are formed by ductless or endocrine glands.
- Hormones are poured into circulatory system in which they are soluble and carried to target cells.
- They function as chemical messengers or information molecules.
- Hormones generally function away from the area of their formation.
- They are effective in very low concentration of pico-grams or micrograms.
- Hormone molecules are small in size.



- They belong to diverse categories of proteins, peptides, amino acids derivatives, amines, steroids, etc.
- Hormone molecules get attached to the membranes of target cells at specific points having receptors for inward passage or reaction.
- They inhibit or stimulate specific processes in the target cells.
- Hormones do not provide raw materials or energy. They simply start certain reactions and are consumed in the process.
- Hormones are formed in response to specific stimuli.
- They may be formed in the inactive state e.g., **pro-Insulin.**
- Hormones control most activities like membrane permeability, cell division, cell growth, cell differentiation, regeneration, reporductive activity, production of enzymes and metabolism, ion and water balance of the body, adaptations and emergencies, etc.

Pineal Gland

It is a stalked small rounded gland found behind the anterior choroid plexus on the epithalamus. Calcification occurs in middle age. The gland secretes two biogenic amine hormones:

1. **Serotinin**: Also by disintegrating blood cells. Constricts (vasoconstriction) blood vessel at the place of injury.
2. **Melatonin**: The hormone develops pale skin colour in amphibians. Its concentration is maximum at midnight and minimum during noon. The hormone delays puberty, opposes FSH and LH hormone (hence antigonadotrophic).

Hypothalamus

It is found below thalamus and connected to Pituitary at the base of brain. They are peptide in nature.

1. **Thyrotropin Releasing Hormone** (TRH or TSH-RH): Stimulates anterior pituitary to secrete thyrotropin or thyroid stimulating hormone.
2. **Adrenocorticotropin Releasing Hormone** (ARH or ACTH-RH): Stimulates anterior pituitary to secrete adrenocorticotropin or adrenocorticotrophic hormone.
3. **Gonadotropin Releasing Hormone** (GRH): Stimulates secretion of gonadotropins by adenohypophysis which are of two types, FSH and LH. There may be two distinct releasing hormones, FSH-RH and LH-RH in female and ICSH-RH in males.
4. **Somatrotropin Releasing Hormone or Growth Hormone Releasing Hormone** (SRH or GH-RH): Stimulates production fo growth hormone or somatotrophic hormone by antrior pituitary.
5. **Somatostatin or Growth Inhibiting Hormone** (GIH): It inhibits adenohypophysis to secrete growth hormone.
6. **Prolactin Releasing Homone or Luteotrophic or Lactogenic Hormone Releasing Hormone** (PRH, LTH-RH): The anterior pituitary is stimulated to secrete prolactin or LTH.
7. **Prolactin Inhibiting Hormone or Luteotrophic or Lactogenic Hormone Inhibiting Hormone** (PIH, LTH-IH): The hypothalmic hormone stops synthesis of LTH by anterior pituitary.
8. **Melanocyte Stimulating Hormone Releasing Hormone** (MSH-RH or MRH): The releasing hormone induces intermediate pituitary to secrete MSH.
9. **Melanocyte Stimulating Hormone Inhibiting Hormone** (MSH-IH or MIH): The inhibiting hormone or factor stops synthesis of MSH.

Pituitary Gland

Below hypothalamus at the base of brain, it has three parts — anterior lobe, intermediate lobe and posterior lobe. Pituitary gland is also called **master endocrine gland** because many of its hormones control the functioning of other endocrine glands, (viz, TSH, ACTH, FSH, LH). Actually hypothalamus should be called master or super-master endocrine gland.

- **Anterior Lobe of Pituitary:**

1. **Thyroid Stimulating Hormone** (TSH): Proteinaceous hormone that controls structure and functioning of thyroid inclnding synthesis and release of its hormones.
2. **Lipotropin or Adipokinetic Hormone**: The hormone stimulates liberation of fatty acids from stored body fats.
3. **Adrenocorticotrophic Hormone** (ACTH, Corticotropin or Corticotrophic Hormone): The petide hormone controls structure and functioning of adrenal cortex especially secretion of glucocorticoids and sex-corticoids.
4. **Growth Hormone/Somatotropin or Somatotrophic Hormone**: Proteinaceous hormone that brings about body growth by retention of proteins/amino acids,

deposition of proteins in tissues, retention of calcium and growth of long bones as well as other parts of skeleton, growth of muscles, growth of visceral organs, control of metabolism, etc. Hypersecretion produces **dwarfism** and **acromicria** while hypersecretion gives rise to **gigantism** and **acromegaly.**

5. **Follicle Stimulating Hormone** (FSH, Gametokinetic Factor)**:** It is a proteinaceous gonadotrophic hormone which stimulates spermatogenesis in testes, maturation of Graafian/ovarian follicles and secretion of estrogens in ovaries.

6. **Luteinising Hormone/Interstitial Cell Stimulating Hormone** (L.H. ICSH)**:** It is a proteinaceous gonadotrophic hormone. LH stimulates ovulation, development of corpus luteum and secretion of progesterone in females. ICSH activates interstitial or Leydig's cells of tests to secrete testosterone and other androgens.

7. **Prolactin/Lactogenic or Luteotrophic Hormone (LTH)**: Proteinaceous hormone (often included under gonadotrophins) that stimulates development of mammary glands during pregnancy and lactation after child birth.

- **Intermediate Lobe of Pituitary:** It stimulates synthesis and dispersal of melanin pigment in skin of fishes, amphibians and some reptiles. In human beings it may be connected with pigment maintenance in hair, Addison disease and pregnancy releated skin pigmentation (hyperpigmentation in excess).

- **Posterior Lobe or Pituitary.**

1. **Oxytocin**(Pitocin)**:** It is known as birth hormone because it stimulates uterine contractions during child birth. Oxytocin is also termed as **milk ejection hromone** because it stimulates ejection of milk secreted by mammary glands under control of protactin or LTH.

2. **Vasopression or Antidiuretic Hormone (ADH)/ Pitressin:** The hormone is essential for reabsorption of water from nephric filtrate in distal convoluted tubules and collecting tubes so that urine is hypertonic and water loss from body is minimised. ADH has pressor effect, can cause arteriole consetriction, raise blood pressure and cause contraction of several smooth muscles like those of intestine, gall bladder, urinary bladder, etc. Deficiency causes **diabetes inspidus.**

Dwarfism: It is the condition of having smaller body size (1-1.3m) due to premature stoppage of body growth and reduced development of skeleton mainly because of undersecretion of growth hormone from the begining. Intelligence and alertness are normal.

Acromicria: The condition of normal body and intelligence but smaller hands, feet and face due to deficiency of growth hormone in later stage of develpment.

Gigantism: It is the condition of extra-oridinary growth in height caused by abnormal elongation of long bones in childhood before the fusion of epiphyses. Gigantism is due to excess secretion of growth hormone or somatotropin. Limbs are extraordinary long. Height is about 2.15 m (7').

Acromegaly: Acromegaly is the condition of abnormal growth of hands, feet, and face especially lower jaw in an otherwise normal sized individual due to oversecretion of growth hormone in an adult. The appearnace may be gorilla-like.

Diabetes Inspidus: It is hormonal abnormality of **polyuria** (excessive urine) or micturating dilute urine (hypotonic, surgar-free) several times a day. Diabetes inspidus is due to deficiency of ADH/vasopressin causing a loss of 5 litres or mroe of urine per day. Therefore, it is accompanied by excessive thirst (polydipsia) and dehydration.

Thyroid

It is the largest endocrine gland with weight of about 25 gm, at the upper end of trachea below larynx. It has some 3 million follicles, arranged in lobules. Follicles secrete iodinated amino acids tetraiodo-thyronine and triido-thyronine. Out fo these tetraiodothyronine is popular called thyroxine. Another hormone called calcitonin is secreted by interfollicular cells.

1. **Thyroxine** (Tetraoidothyronine)**:** The hormone is iodinated form of amino acids tyrosine which is stored in follicular colloid of thyroid gland and is released into blood when required. (i) Thyroxine controls basal metabolic rate or BMR. (ii) It regulates urine output. (iii) It maintains nervous and muscular tonus. (iv) Physical growth and mental faculties are controlled by thyroxine. (v) Hormone is required for tissue differentiation and metamorphosis. (vi) Thyroxine is a factor in reproduction. Deficiency of thyroxine or hypothyroidism results in **cretinism, myxedema** and iodine deficiency **goitre.** Excess of thyroxine or **hyperthyroidism** produces **exophthalmia** (= Grave's disease).

2. **Calcitonin (CT) or Thyrocalcitonin:**It is hypocalcemic and hypophosphatemic peptide hormone of which checks excess plasma Ca^{2+} and phosphate by decreasing mobilisation from bones. Deficiency of calcitonin results in **osteoporosis** or loss of bone density (due to dissolution by parathormone).

Cretinism: Hypothyroidism in infant and children results in the disorder called cretinism which is characterised by dwarfism, physical and mental deficiencies or under-development with a peculiar infantile facial expression, large head, thick legs, pot belly, pigeon chest, protruding tongue, swollen eye lids, short neck, dry skin and uncoordinated gait.

Myxedema (Myxoedema)**:** It is disorder found in adults due to hypothyroidism. The disorder is characterised by puffy appearance due to subcutaneous accumlation of fat, low basal metabolism, lower heartvate and body temperature, lack of alertness, retarded sexuality and raised blood cholesterol.

Goitre: It is disorder characterised by enlargement of thyroid which brings about a swelling in the neck region. It occurs in certain pockets in northern hilly areas where soil and ground water is deficient in iodine. Cretinism and myxedema may also occur. Enlargement of thyroid is a distress development by the body in order to rope in whatever iodne is available in the diet and produce more thyroxine.

Exophthalmia/Grave's Disease: It is result of **hyperthyroidism** or **thyrotoxicosis** which is accompanied by enlargement of thyroid gland as well as over-secretion of thyroxin probably due to failure of feedback system and hence higher production of TSH by pituitary. Besides swelling in the neck region, Grave's disease is characterised by protrusion of eyes or exophthalmia. Ohter traits are high BMR, accelerated oxidation of food, increased appetite, accompanied by leannes, increased heart beat, faster pulse, higher body temperature, excessive sweating restlessness, nervousness diszziness, little sleep and fine tremor in stretched hands.

Parathyroids

They are four oval, small endocrine glands situated close to the two lobes of thyroid, two on each side. The main secretion is a proteinaceous hormone **parathormone/PTH/ Collip's hormone**. Small quantity of **calcitonin** is also formed. Parathormone secretion is under **feedback** control operated by calcium level in blood passing through the parathyroid glands. PTH maintains optimum level of plasma calcium by (i) Mobilisation from bones (ii) Reduced urinary excretion. (iii) Increased absorption from intestine. The level of phosphorus is not allowed to remain high by stimulating its urinary excretion. Optimum Ca level blood plasma is essential for proper functioning of muscles, heart, nerves and membrane permeability. Hypoparathyroids result in **parathyroid tetany** while hyperparathyroidism leads to **osteitis fibrosa cystica.**

- **Parathyroid Tetany:** Decreased secretion of PTH decreases calcium level in blood plasma from 10 mg/ 100 ml to 5 mg/100 ml while phosphorus level rises from 5mg/100 ml. It causes muscular twitching, cramps and spasms especially of hands, feet, face and larynx-muscular hypersensitivity.
- **Osteitis Fibrosa Cystica:** The disorder is due to hyperparathyroidism or excessive secretion of PTH. The hormone mobilises excess of calcium from bones forming cavities in their interior, maing bones soft, liable to fracture and develop deformities. The excess of plasma calcium is deposited in various parts of body bringing about calcification of soft tissues. It produces stones in kidney and ureters causing renal insufficiency.

Thymus

It is a temporary gland, the endocrine nature of which is doubtful. The glands is present in children with maximum development at puberty after which it atrophies due to development of sex glands. The gland contains lymphoid tissue that forms lymphocytes. Three types of hormones are believed to be formed by thymus-thymosin, thymin I and thymin II. Thymosin believed to accelerate cell division, lymphocyte formation, development of resistance to infection and attainment of sexual maturity.

Adrenals/Suprarenals

They are a pair of glands lying over kidneys. They secrete over tenty hormones which are grouped under mineralocorticoids, glucocorticoids and sex corticoids.

1. **Mineralocorticoids:** They are steroid hormones which regulate electrolyte and water balance in body, sweat, bile, urine and saliva. Deficiency is one of the causal agents of **Addison's disease** while over-secretion causes **aldosteronism** or **Conn's syndronme.**
2. **Glucocorticoids:** Glucocorticoids are steroid hormones e.g., cortiosol, cortisterone. The hormones are invovled in metabolism of carbohydrates, proteins and fats. A major function is glucogenesis or synthesis of glucose from glycogen, breakdown of fat and proteins (formation of amino acids and their decamination). Cortisone/ cortisol is anti-inflamatory. Deficiency of glucocorticoids is one of causative reasons of Addison's disease. Overscecretion produces Cushing's syndrome.
3. **Sex Corticoids:** They are steroid androgen hormones. Their exact role seems to be elaboration of proteins. In males they have a role is development and maintenance of external sex characters. In excess they cause **adrenal virilism** in females.
4. **Adrenaline/Epinephrine:** It is an amine (biogenic amine or catecholamine) hormone secreted for meeting an emergency as in cold, injury, pain, emotional setress, anger, fear, grief, fall in blood sugar/blood presusre, etc. Hence emergency hormone or hormone for fight, fright and flight. Adrenaline increases blood supply to muscles and heart by constriction of spleen for pouring reserve blood and constriction of artieroles of skin and abdominal organs. It is bronchiodilator (dilates bronchioles) for higher rate of blood oxygenreaton. There is reduction in peristalsis, digestion (relaxation of smooth muslces) and urinary activity (relaxation of bladder muscles and contraction of sphincters). Pupil dilates. Cardiac output increases due to increased rate and force of heart beat. Blood pressure is raised. There is increased availability of blood to cardiac and skeletral muscles due to higher availability and dilation of arterial vessels supplying them. Glucose and oxygen supply is increased to skeletal muscles. Muscle fatigue is little. Arrector pili muscles beocme active.
5. **Noradrenaline/Norepinephrine:** It is a biogenic amine. It is tonus hormone for circulatory system. Noradrenaline raises systolic and diastolic pressure through consetricting small arteries without mobilising body reserves or raising function of skeletal/smooth muscles. Deficiency of adrenaline/noradrenaline does not

produce any marked physical / physiological deformity being emergency hormones.

Addison's Disease: It usually results due to destruction of adrenal cortex or deficient secretion of aldosteronice and cortisol. There is electrolyte upset with low plasma Na^+ through increased urinary elimination and high plasma K^+, reduced blood volume, lower pressure, marked anaemia, hypoglycaemia, great muscular weakness, nausea, vomitting, diarrhoea and bronze pigmentation.

Cushing's Syndrome: The syndrome is due to elevated level of plasma cortisol and related hormones due to carcinoma of adrenal cortex, excessive does noradrenaline secretion or dose of ACTH. It results in higher blood volume, higher blood pressure higher blood sugar or hyperglyceamia, glycosuria (sugar in urine), obesity, wasting of limb muscles, electrolyte imbalance with rise in Na^+ in plasma. A related but rare disease is **Cushing disease** due to excessive hormone stimulation in adrenal cortex by tumour / hyperplasia of anterior pituitary. It mainly cocurs in females and causes obesity, hyperglycaemia, hypertension, glycosuira and **virilism.**

Conn's Syndrome/Aldosteronism: Oversecretion of aldosterone due to adrenal cortical tumour causes Conn's syndrome — rise in blood volume and blood pressure but without oeema, muscular weakness, high plasma Na^+ due to renal excretion resulting kidney damage and polyuria, low Ca^{2+} level and msucular tetani.

Virilism/Adrenal Virilism/Androgenital Syndrome: Excessive secretion of sex corticoids caused by adrenal tumour results in virilism or appearance of male secondary characters in females like male voice, beard, moustaches, stoppage of menstruation and growth of clitoris.

Male Sex Hormones

Male sex hormones or **androgens** are produce by testes (mixed organs). They are secreted by **Leydig's cells** or **interstitial cells** found in the connective tissue around seminiferous tubules. Androgens are steroid hormones produced under control fo ICSH of anterior pituitry with maximum activity at puberty. Two common androgens are testosterone and androsterone. The time of puberty testosterone cause development of **male seecondary sex organs** (like seminal vesicles. prostate and other glands, scrotum, penis), **external/accessory male sex characters** (like beard, moustaches, masculine voice, body hair, comb and wattles in cock), growth in body tissue, broadening of shoulders, growth of muscles, higher metabolism, increased sebaceous gland activity, normal skin and formation of sperms though spermatogenesis is mainly due to FSH. Deficient androgen secretion causes eunuchoidism.

Eunuchoidism: Eunuchoidism is a hormonal disorder due to nonsecretion of testosterone in a genetically male individual. The secondary male sex organs are underdeveloped and nonfunctional (prostate gland, seminal vesicle, penis). The accessory male characters (beard, moustaches, masculine voice) fail to develop. Spermatozoa are not formed. **Castration** is artificial removal of testes. Secondary male characters / accessory male characters do not differentiate. Castrated human males are called **eunuchs** and oxen (instead of bulls) in case of cattle.

Female Sex Hormones

They belong to both steroid and protein categories. The hormones are secreted by growing graffian / ovarian follicles (esetrogesns = oestrogens), corpus luteum (progesterone, relaxin) and placenta (estrogen, progesterone, hCG).

1. **Estrogens:** They are steroid hormones secreted by growing ovarian follicles under instructions from anterior pituitary through FSH. At puberty the hormone is required for development of **female secondary sex organs** (like vagina, uterus, fallopian tubes, duct system of mammary glands), **external/accessory female sex characters** (like high pitch voice, breasts, development of female pattern of body hair), **body contour** (like broadening of pelvis, fat deposition in thighs) and **onset of menstrual cycle.**
2. **Progesterone:** It is steroid hormone secreted by **corpus luteum** (emptied enlarged Graahan follicel) under the influence of LH of anterior pituitary in the second half of menstrual cycle and hCG of placentia during pregnancy. Routinely progresterone cause temporary changes in endometrial lining of uterus (secretory phase) for receiving egg. During pregnancy it helps in attaching embryo to uterine wall, development of placenta, maintenance of pregnancy and growht of secretory alveoli in mammary glands.
3. **Relaxin:** The proteinaceous hormone is secreted by corpus luteum towards the close of gestation period for loosening of pelivic ligaments, softening and relaxing of uterus for decreasing discomfort of carriage and easy child birth.
4. **Human Chorionic Gonadotropin** (hCG): The proteinanceous hormone is secreted by placenta for maintaning corpus luteum (and hence continued secretion of progresterone), hCG in urine is an indication of pregnancy.

Pancreas

It is a heterocrine gland where exocrine glandular part occurs as acini. The endocrine part constitutes 2-3%^ and is represented by **Islets of Langerhans** or **pancreatic islets.** The islets have 5 types of endocrine cells secreting different hormones-**insulin** by *Bitta*-cells, glucagon by *Alpha*-cells, **gastrin** by *Gamma*-cells, **somatostatin** by *Delta*-cells and **panchreatic polypebtide** by F-cells. Somatostatin seems to be a local hrmoned that keeps a check on escessive secretion by *Bitta* and *Alpha* -cells. Polypeptide (pancreatic) may check secretory activity of digestive glands while gastrin in similar to the one produced by pyloric stomach.

1. **Insulin:** It is proteinanceous hormone secreted by *Bitta* - cells of islets of Langerhans as **proinsulin** whenever there is high glucose and amino acids content in blood. Insulin lower glucose content of blood by promoting its (a) Absorption by cells for respiration (b) Absorption by liver and muscles for **glycogenogenesis** or conversion to glycogen. (c) Helping in conversion of glucose to fatty acids. It reduces amino acids content of blood by promoting their absorption by individual cells and formation of proteins in them. Deficiency of insulin causes **diabetes mellitus.**

2. **Glucagon:** Proteinaceous hormone secreted by *Alpha*-cells of islets of Langerhans whenever there is decreased level of plasma glucose (hypoglycaemia). Glucagon promotes (a) Glycogenolysis or conversion of glycogen to glucose in liver cells and passage of latter into blood. (b) Diamination of amino acids and formation of glucose. Excess of glucagon may cause glycosuria.

Diabetes/Diabetes Mellitus: The disorder is causeed by deficient insulin production. It is characterised by (a) **Hyperglycaemia** or high level of blood glucose, 300-1200 mg / 100 ml from normal 90 mg / 100 ml due to regular supply from alimentary canal and failure of cells to absorb glucose. (b) **Glycosuria** or glucose in urince. (c) **Polyuria** or excessive urination due to increase in water content of urine. (d) **Polydispsia** or excessive thirst. (e) Dehydration. (f) Reduced storage of fat and protein synthesis. (g) Oxidation of fatty acids and amino acids for energy release. (h) Acidosis and ketone bodies. (i) Growth hormone becomes ineffective. (j) There is wasting of body tissues. Healing power is reduced. Injuries may result in gangrenes. (k) Diabetes may lead to coma or unconsiousness. The disorder is kept under control by administration of insulin and hypoglycemics.

Gastrointestinal Mucosa

Certain cells present in the lining of digestive tract have endocrine activity. All the gastrointestinal hormones are proteinanceous in nature.

1. **Gastrin:** It is produced by pyloric mucosa (small quantity by ?-cells in pancreas) in response to presence of food in stomach. Gastrin stimulates secretion of gastric juices and churning movements of stomach. Hypersecretion produces gastric ulcers and other gastric problems.

2. **Secretin:** Entry of HCL in duodenum stimulates secretion of secretin from duodenal mucosa. The hormone stimulates secretion of water and bicarbonate in bile and pancreatic juice. It inhibits stomach movements and secretion of gastric juice.

3. **Cholecystokinin:** It is produced by duodenum in response to pressure of food. Cholecystokinin stimulates flow of pancreatic enzymes and contraction fo gall bladder.

4. **Enterocrinin:** The hormone secreted by intestinal muscosa stimulates secretion of succus entericus or intestinal juice.

5. **Villikinin:** Intestinal hormone that stimulates movement of intestinal villi.

TRIVIA

- **Releasing and Inhibitory Hormoens:** Hormones of hypothalamus and kidney (renin) which control secretion fo trophic hormones.
- **Trophic Hormones:** Hormones controlling activity of other endocrine glands, e.g., anterior pituitary hormones like thyrotropin for thyroid.
- **Hormones Connected with Reproduction:** FSH, LH (ICSH), oxytocin, sex hormones.
- **Hormones Connected with Connected with Reproduction:** FSH, LH (ICSH), oxytocin, sex hormones.
- **Hormones Connected with Growth and Development: GH** (somato-trophin), thyroxine.
- **Hormones of Digestive System:** Gastrin, secretin, enterocrinin, etc.
- **Hormones Connected with Metabolism:** Insulin, glucagon, calcitonin, corticioids.
- **Pituitrin:** ADH + oxytocin of posterior pituitary.
- **Female Contraceptive Pills:** Generally contain oestrogen and progesteron.
- **Gravidex Test:** Test for pregnancy, e.g., hCG test.
- **Largest Endocrine Gland:** Thyroid.
- **Largest Endocrine Organ:** Gut.
- **Temporary Endocrine Gland:** Corpus luteum, placenta.
- **Receding Endocrine Gland:** Thymus, shrinks after puberty.
- **Smallest Endocrine Gland:** Pituitary (0.5-1.0 gm.)
- **Triple F. Glands:** Emergency glands or adrenals for flight, fight and fright.

■ ■ ■

REPRODUCTIVE SYSTEM

Reproduction is the formation of new similar young living organisms by the grown up individuals of a species or race. It is meant for perpetuation of the race/species because individuals are bound to die after a life span. Reproduction provides group immortality. Four processes are basic to reproduction— DNA replication, cells division, formation of reproductive units and development of a new individual. Animal reproduction is of two types, asexual and sexual.

Reproduction is the inherent property of the living organisms to continue their race Sby producing offsprings. Reproduction is of two types: (i) Asexual reproduction, (ii) Sexual reproduction

ASEXUAL REPRODUCTION

The development of new individuals without the fusion of the male and female gamates is known as asexual reproduction. The asexual reproduction usually includes miotic division of the body (somatic) cells. Therefore it is also known as somatogenic reproduction. The sexual reproduction is common only in lower plants and animals and it is of following types:

(i) **Binary fission:** In the binary fission, the body splits in such a way that two equal and identical halves are produced. It is most common in protozoans, bacteria and some lower metazoans.

(ii) **Budding:** In certain multicellular animals, e.g. hydra and fungi the body gives out a small outgrowth known as the bud, the bud is supported by the parent body and it ultimately develops into a new individual.

(iii) **Gemmule formation:** In certain metazoan animals, e.g. fresh water sponges and in some bryophytes such as Marchantia, the asexual reproduction is carried on by certain peculiar asexual bodies known as gemmules, which is composed of a group of undifferentiated cells which contain stored food material.

(iv) **Spore formation:** In many unicellular plants, fungi etc. the asexual reproduction by spore formation is very common under unfavourable conditions. In this process the condensation of protoplasm due to reduction in the water content results. These spores under favourable conditions abosorbs water and germinate to form a new plant.

(v) **Vegetative reproduction:** A fragment or part of the plant grows to produce new plants. Fragmentation is very common in algae and fungi. In higher plants the vegetative propagation takes place in many ways under the following ways:

- **Sucker** stem as in mint banana which run horizontally under ground can be separated and grown individually and each is able to develop into separate plant. The vegetative multiplication in the certain storage felshy leaf like Bryophyllum has also been found very useful.
- **Tubers** like potato, when cut into pieces with a bud in each piece and sown each grow into individual tuber plants.
- **Bulbs** are also propagated by separating the young bulb eg. Crinum or adventintious ends of the scale leaves eg. Urginea.

SEXUAL REPRODUCTION

It is a mode of multiplication in which the new individuals or young ones are formed through the process of formation and fusion of gametes. Haploid (gametes)-diploid (individual) attraction occurs. Gametogenesis involves meiosis. Fusion of gametes or fertilization restores the chromosome number. The offspring is produced by growth of the fusion product of gametes called zygote. Sexual reproduction is commonly bi-parental.

- **Exogamy:** Sexual reproduction involving gametes from different parents (bi-parental).
- **Unisexual:** Organism in which the two sexes occur in different individuals, e.g., humans, mammals, birds, lizards.
- **Bisexual/Hermaphrodite:** Organism in which the two

PARTHENOGENESIS

It is the development of a new individual from a single gamete (generally the egg/ovum) without involving fertilization. Parthenogenesis can be natural or artificial. Natural parthenogenesis may be obligatory or cyclic.

- ***Obligatory/Complete Parthenogenesis: Males are absent; females develop parthenogenetically, e.g., rotifers, Typhlina brahmina (small lizard, 15 cm long).***
- ***Cyclic/Incomplete Parthenogenesis: Both sexual and parthenogenetic individuals occur. In aphids several generations of parthenogenetic females develop followed by formation of both males and females to perform sexual reproduction. In Honey Bee, male or drone develops parthenogenetically (no meiosis at the time of spermatogenesis) while queen and workers develop from fertilized eggs. Also in wasps and ants.***
- ***Artificial Parthenogenesis: Sugar, salt, alkaloids and other chemicals, heat, cold, pricking and other stimuli can stimulate eggs to undergo cleavage and form parthenogenetic embryos. Being haploid, they generally do not survive.***

types of sex organs (mal and female) occur in the same individual, e.g., Earthworm.

1. Sexual reproduction in plants

This is very coommon type of reproduction in the angiospermic plants. Meiosis (reduction division) occurs in the male and female parts of a flower to form male (pollen grains) and female (ovum) gametes. In order to produce seeds (to reproduce) male and female gametes fuse together to form zygote that divides miotically and develops into a seed. The process of transference of pollen grains from the another of a flower to the stigma of the same or of different flower is called pollination. It is of two types:

(i) **Self-pollination:** If the pollen grains are transferred to the stigma of the same flower or between two flowers borne by the same parent then it is self pollination or autogamy.

(ii) **Cross-pollination:** If the pollen-grains are transferred to the stigma of a different flower borne by a different plant then it is called cross-pollination or allogamy.

All unisexual flowers are cross pollinated. However the bisexual flowers also show the following characteristics to favour cross-pollination.

2. Mammalian Reproduction

Primary Sex Organs: Gonads which form gametes are called primary sex organs — testis (plural testes) in males and ovary (plural ovaries) in females. Testis produces sperms and secretes testosterone (formation and maintenance of secondary sex organs, accessory male glands and external sex characters). Ovary produces ova. Maturing Graffian follicles secrete estrogens for development and maintenance of secondary sex organs, accessory or external sex characters and part of mensetrual cycles. Progesterone produced by ruptured Graffian follicles or corpus luteum controls a part of menstrual cycle, implantation and development of placenta.

Secondary Sex Organs: Sex organs, glands and ducts which do not produce gametes but are otherwise essential for sexual reproduction are known as secondary sex organs. In human male reproductive system, the secondary sex organs are vasa efferentia, epididymes, vasa deferentia, ejaculatory ducts, seminal vesicles, urethra, prostate glands, Cowper's glands and penisin. Secondary sex organs of a human female include fallopian tubes, uterus, vagina, external genitalia, Bartholin glands and mammary glands.

Species	Life-span (yrs)	Gestation Period (months)	Litter No.
Mare	*27*	*11½*	*1*
Cow	*18*	*9½*	*1*
Ass	*24*	*12*	*1*
Goat	*17*	*5*	*1-8*
Ewe	*13*	*5*	*1-3*
Sow	*14*	*4*	*4-6*
Bitch	*16*	*2*	*1-12*
Cat	*15*	*2*	*1-6*
Rabbit	*5*	*1*	*1-13*

Accessory/External Sex Characters: They are traits which do not have any direct role in reproduction but provide specific features and structures to the two sexes. The important external/accessory sex characters of human male are beard, moustaches, body hair on shoulder and chest, pubic hair on both lateral and vertical direcitons, comparatively more height with more muscular body, larynx apparent externally, voice low pitched with breathing more by means of diaphragm. The important accessory sex characters of human females are high pitched voice, breast, broader pelvis, lateral public hair, rounded body contous with more subcutaneous fat in thighs buttocks and face, and sternal breathing.

Puberty: Beginning of sexual maturity or ability to reproduce is known as puberty. Primary sex organs being functioning. Secondary sex organs develop fully under the influence of sex hormones produced by primary sex organs. Growth is rapid. It is accompanied by slow development of accessory/external sexual characters. Puberty occurs at the age of 10-14 years in girls and 13-15 years in boys.

Characteristics of Human Reproduction

(i) Human beigns are **nonseasonal breeders**.

(ii) There is no oestrus/heat.

(iii) In human females the ability to produce young ones begins at **menarche** (beginning of menses) and ends at **menopause** (stoppage of menses).

(iv) In human females the reproductive phase has 28 day repeated menstrual cycle.

(v) Fertilization is internal.

(vi) There is **vivipary.** i.e., giving birth to young ones.

(vii) Foetus develops inside uterus and is nourished by joint special structure called **placenta**.

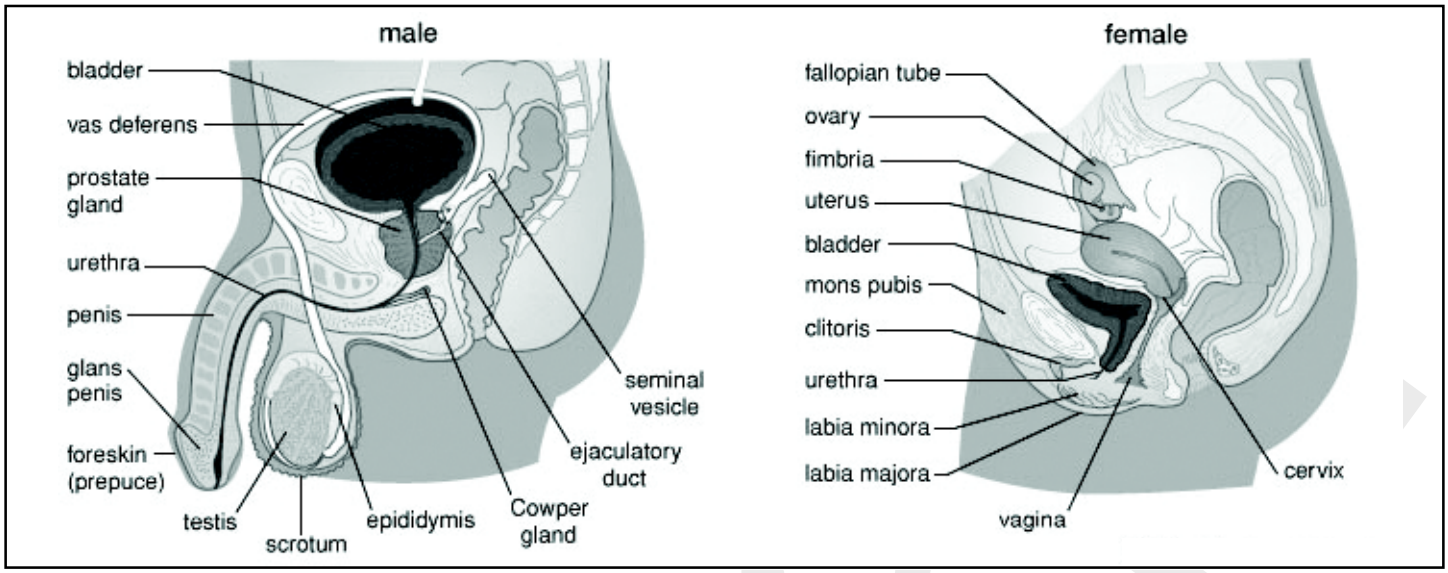
(viii) Infants can be fed on mother's milk.

(ix) Parental care is very well developed.

MALE GENITAL

Below the bladder and between the legs the plum sized testes and expandable sausage-like penis exist which make and deliver sperm into a woman.

- Sperm and male sex hormones are made in two plum sized glands called the **testes**.
- The testes lie in a sac called the **scrotum** that hangs outside the body, between the legs. This arrangement maintains sperm at a temperature slightly below body temperature, which is essential for the production of healthy sperm.
- Each testis has a long highly coiled tube attached to it known as an **epididymis**. Immature sperm pass out of



the testes into the epididymes. As sperm make their way through these tubes, they mature and learn to swim. Maturation takes between one and three weeks, after which they are either ejaculated out of the body or reabsorbed into the body.

- Every day a man makes between 50 and 500 million sperm.
- Sperm and urine both leave the body through a tube called the **urethra** that runs down the middle of the penis.
- **Semen** is a milky white, sticky mixture of sperm and fluid secretions. It provides nutrients to energise sperm and acts as a transport medium to carry sperm through the penis, out of the body and into a woman's vagina.
- During ejaculation, sperm are propelled from the epididymis along a duct called the **vas deferens**. This carries sperm upwards, out of the scrotum, towards the penis.
- En route, fluids from the **seminal vesicles** (the small red glands at the end of the vas deferens) and the **prostate gland** dilute the sperm. These fluids provide the optimal environment for sperm to swim and survive in the acidic conditions of the female reproductive tract.
- During ejaculation, a man produces between two and five millilitres of semen that contains between 50 and 130 million sperm per millilitre.
- The tiny **bulbourethral glands** secrete a thick, clear mucus that drains into the urethra. It clean the urethra before ejaculation and act as a lubricant during sex.

FEMALE GENITAL

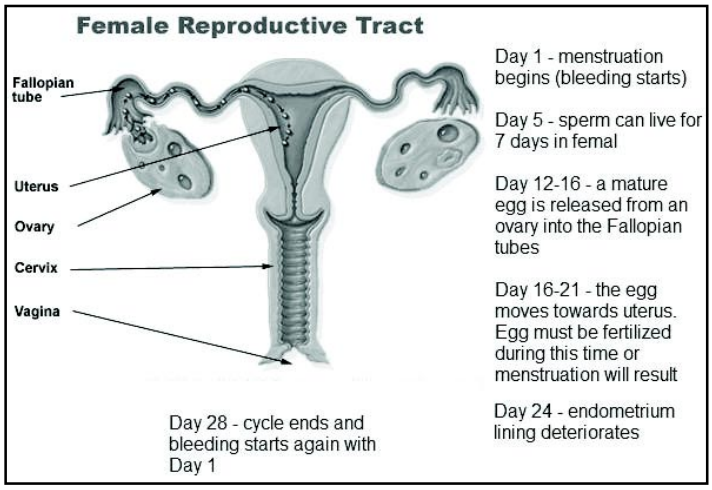
Behind the bladder there is uterus, or womb, the size of an upside-down pear which produce eggs, have sex, carry a developing baby and to give birth.

- The female genitals consist of two glands called **ovaries** that are responsible for producing eggs and female sex hormones.
- Once women reach sexual maturity, they experience a hormone regulated monthly fertility cycle known as a **menstrual cycle**. These hormones control the maturation and release of an egg from one of the ovaries every month, and they affect the lining of the womb making it ready to receive a fertilised egg.
- Mature eggs are released from the ovary and move along the fallopian tube to the uterus. If an egg is fertilised, it tries to embed itself in the uterus wall, ready to develop into a foetus. If no egg becomes implanted, the uterus lining is shed, and this results in a flow of menstrual blood, know as the **'period'**.
- When a baby girl is born, she already carries all the eggs that she will ever produce through her life. A boy, however, does not carry sperm at birth, and only begins to produce sperm when he reaches sexual maturity.

MENSTRUAL CYCLE

It is a series of cyclic changes that occur in the reproductive tract of human females and other primates with a periodicity of 28 days, right from menarche to menopause. It is characterised by menses or loss of blood for a few dyas. Menstrual cycles consists of the following phases.

1. **Menstrual Phase:** It is the pahse of menstrual flow menses which continues for 3-5 days and involves discharge of blood (a total of 50-100 ml). Mensetrual phase is also called funeral of unfertilised egg or shedding tears of lost ovum. First day of menstrual phase is also considered to be first day menstrual cycle.
2. **Post-Menstrual/Follicular Phase:** Anterior pituitary secretes FSH which stimulates follicular cells of Graafian follicle to secrete estrogen (a) **Recovery Phase.** It last for 2 days and brings about repiar of ruptured blood vessels and mucous lining or endometrium of reproductive tract. (b) **Proliferative Phas.e** The endomitrial lining begins to thicken, especially that of uterus. There is development of blood capillaries, elongation and coiling



of uterine glands, greater activity of uterine muscles thickening and development of more cilia in epithelial lining of fallopian tubes.

3. **Fertility Phase/Ovulation:** Production of FSH decreases while that of LH increases. Presence of both FSH and LH causes ovulation. The ovum is drawn into fallopian tube. It is viable for two days when fertilization can occur. Ovulation takes place between 10-14 days (fertility period 10-16 days of menstrual cycle).

4. **Pre-Menstruation/Luteal/Secretory Phase:** It operates under the influence of progesterone produced by corpus luteum (empty proliferated Graafian follicle and supervised by LH of anterior pituitary. Endomitrial lining thickens and its glands become secretory. Uterine movements are reduced. The stage is meant for receiving fertilized ovum. In the absence of fertilization, corpus lutem degeneretes. LH level falls. Progesterone level is reduced. Reduced level of both progesterone and estrogen causes menses.

Estrous Cycle: It is a series of cyclic changes that occur in the reproductive tract of nonprimate mammalian females with variable periodicity indifferent aniamls. There is a period of estrous or **heat** near the time of ovulation due to rising level of estrogen. It lasts for only 18 hours in cow. The female receives the male only during estrous or heat. There is generally specific period of oestrous (= estrous, except for domesticated mammals), may be two (spring and autumn for bitches), called **breeding seasons.** In case of no fertilization, the endometrial breakdown is not accompanied by rupturing of blood vessels. Hence, there is no bleeding.

TRIVIA

- **Androgenesis:** Development in which embryo has only paternal chromoscomes.
- **Gynogenesis:** Development in which embryo has only maternal chromosomes.
- **Amenorrhoea:** Non-occurrence of menses.
- **Human Ovum:** Maximum diameter (0-1 mm) in any human cell.
- **Birds:** In many birds (exception some birds of prey) only the left ovary and left oviduct and functional. The right ones are non-functional.
- **Inguinal Hernia:** Protrusion of intestinal loop into scrotum.
- **Seminiferous Tubules:** Structural and functional units of testes.
- **Cowper's Glands:** Homologous with Bartholin's glands of females.
- **Seminal Vesicle:** Also called uterus masculinu.s
- **Spontaneous/Reflex Ovulator:** Ovulation without any external induction.
- **Induced Ovulator:** Ovulation after copulation e.g., Rabbit.
- **Castration/Orchidectomy:** Removal to tests. It produce eunuchs. Castration changes aggressiveness of male into docile nature.
- **Hysterectomy:** Surgical removeal of uterus.
- **Gynaecomastia:** Development of breasts in males/ enlargement of males mammary glands due to hormonal disturbance. ■ ■ ■

HUMAN DISEASES

Disease is a condition of disturbed functioning of the body caused by infection, defective diet, heredity, environment or depraved condition of brain. Health is a state of complete physical, mental and social well being.

TYPES OF DISEASES

1. **Congenital Diseases:** Diseases contracted before birth due to defective heredity (chromosomal abnormalities and gene mutations), physiological disturbance or transplacental transmission, e.g. Hemophilia, Down's syndrome, colour blindness, hare-lip, transplacental syphilis.
2. **Acquired Diseases:** Disease contracted after birth due to infection, defective diet, hypersensitivity, injury, addition, degeneration, cancer, depression, etc.
3. **Infectious Diseases:** They are diseases due to pathogens that can be transferred from one individual to another, e.g. flu, malaria, typhoid.
4. **Deficiency Diseases:** Disease caused by absence or deficiency of an essential element, e.g., anaemia, goitre.
5. **Degenerative Diseases:** Disease caused by ageing resulting in malfunctioning or decreased efficiency.

CAUSES OF DISEASES/DISEASE AGENTS

Disease agent is organism, substance or force which causes disease due to its excessive presence, deficiency or absence.

- **Pathogens/Biological Agents:** They are biological entities which cause infectious diseases, e.g., viruses (mumps, chicken pox, small pox), mycoplasma (e.g, bronchitis, acute leukemia), chlamydia (e.g, trachoma), bacteria (e.g. cholera, tetanus), fungi (ringworm, thrush, moniliasis, pulmonary aspergillosis), protozoa (e.g. giardiasis, sleeping sickness), helminths (e.g., filariasis, ascariasis, taeniasis), other organisms (e.g., scabies).
- **Nutrient Agents:** Deficiency of vitamins (e.g., beriberi, scurvy, night blindness), minerals (e.g., anaemia, rickets), carbohydrates, fats and proteins (e.g., kwashiorkar, marasmus), or excess of food (e.g., obesity).
- **Chemical Agents:** Endogenous Agents- Excess presence of uric acid, reduced secretion of ADH (diabetes insipidus) or insulin (diabetes mellitus). Exogenous Agents- Pollutants (e.g., pneumoconiosis), allergens (allergy).
- **Physical Agents:** Heat (e.g., stroke), cold (frost bite), radiations, sound (impaired hearing), humidity, etc.
- **Mechanical Agents:** Fractures, sprains, dislocation, injury, chronic friction.
- **Genetic Agents:** Excess or deficiency of chromosomes, mutations, harmful alleles, e.g, colour blindness, albinism, haemophilia, Turner's syndrome.
- **Degeneration:** They include old age change like peptic ulcers, hypertension, atherosclerosis.

INFECTION

Infection is invasion, establishment and growth of pathogen in a host. Contamination is occurrence of harmful organisms or their products in articles of use, e.g., milk, food, water, garments. Infestation is occurrence of animal parasites on or inside the body of an individual.

Carrier is an animal or healthy human host which harbours the pathogen without being harmed (due to counter-balancing of its antigens with antibodies) and passes the same to another susceptible individual.

Transmission of Infectious Diseases :

1. **Direct Transmission:** An intermediate agent is absent.

- **Direct Contact With Infected Persons:** The disease are called contagious**,** e.g., ringworm, syphilis.
- **Droplet Infection:** Transmission is from an infected person to a healthy person in mist emitted from nose and mouth while sneezing, spitting, talking and coughing.
- **Contact with Soil:** Soil borne pathogens enter the host through injured or exposed parts, e.g. tetanus.
- **Animal Bite:** Rabies is spread through bite of dog/cat.
- **Transplacental Transmission:** Mother transfers virus of German measles and bacterium of syphilis through placenta.

2. **Indirect Transmission**: An intermediate agent is required.

- **Vectors:** Vectors are living agents for transferring pathogens, e.g, housefly, mosquito, tse-tse fly, sandfly. Mosquitoes are vectors of malaria, encephalitis, filaria, yellow fever, etc. Housefly is vector of cholera, dysentery, typhoid, diarrhoea, conjunctivitis, poliomyelitis, etc.

ABC of ALLERGY

Allergy is noninfectious unusual reaction or hypersensitivity of an individual to a foreign substance or agent that is harmless to other individuals. Allergen is a foreign substance or agent that produces hypersensitivity in an individual e.g., pollen, spores, dust, scent, woollen, silk or nylon, lotions, nail polish, lipstick, drug, egg white, fur, feathers, shell fish etc. The allergen on first contact functions as a mild antigen. The process is called sensitisation. It produces antibodies which remain attached to mast cells. Whenever, the allergen enters the body of a sensitised person, it causes antigen-antibody reaction and lysis of mast cells. This releases histamine which dilates arteries and causes fluid accumulation. Important allergic reactions are

- ***Sneezing,***
- ***Coughing,***
- ***Watering of Eyes,***
- ***Oedema or accumulation of tissue fluid below and difficulty in expiration,***
- ***Hay Fever: Allergic swelling and secretion of mucous membrane of nose, throat and conjunctiva in response to pollen and spores.***
- ***Urticaria: Allergic skin eruptions characterised by multiple, circumscribed raised pinkish itchy blisters persisting for a few days.***
- ***Eczema: A dermatitis started with reddening of skin, formation of vesicles, rupturing of vesicles and forming of scales.***
- ***Anaphylaxis (Anaphylactic Shock): It is a hypersensitive reaction of the body to a foreign substance like bee sting, penicillin, serum protein, etc. that results in shortness of breath and collapse due to marked dilation of arteries, very low blood pressure, collection of tissue fluid below skin, little supply of blood to brain and other vital organs which may prove fatal. Allergic reactions are countered by the administration of antihistamines like phenindamine, diphenhydramine and cyclizine.***

- **Vehicle Borne:** An article of food, water, ice, etc carries the pathogen for transmission e.g. cholera, typhoid, dysentery.
- **Air Borne:** Dust and air current spread disease like typhus in dried feces of lice.
- **Fomite Borne:** Articles handled or coming in contact with patients are a cause of disease transmission, e.g. door handles, taps, crockery, currency, garments.
- **Unclean Hands:** They transfer germs to healthy persons, food, utensils, etc.

Every pathogen has a specific portal of entry into the body. Invasiveness of a pathogen is its ability to gain entry into host and grow. Virulence is the ability of pathogen to produce disease. Toxigenicity is power of a pathogen to form toxins capable of damaging host cells. Host has three lines of defence against invasion by pathogens. There are nonspecific (external defence and nonspecific internal defence) and specific defence mechanisms.

1. **External Defence/First Line of Defence/Physical and Chemical Barrier:** It consists of physical barriers of skin, membranes, friendly microorganisms and chemical barriers.

- **Skin:** Keratinised dead outer cells do not allow entry to pathogens. Oil and sweat are inhibitory to growth of most pathogens.
- **Nostril Hair:** They filter out dust and microorganisms from inhaled air.
- **External Friendly Microorganisms/Friendly Bacteria:** Many friendly bacteria live on skin and secrete chemicals harmful to pathogens.
- **Mucous Membranes:** They line digestive, respiratory and urinogenital tracts so as to prevent entry of germs into body tissues.
- **Mucus and Cilia:** Mucous membrane of the nasal tract possesses cilia for pushing back dust and germs. It also secretes mucus for trapping and killing them.
- **Internal Friendly Microorganisms:** They occur in intestine and vagina.
- **Chemical Barriers:** (i) Sweat, oil and secretions of external friendly bacteria are acidic to prevent growth of many pathogens. (ii) Lysozyme or bacteriolytic enzyme is present in sweat, tears, saliva and mucus. (iii) HCL of gastric juice has germicidal properties. (iv) Bile does not allow growth of microorganisms.

2. **Nonspecific Internal Defence/Second Line of Defence:** A pathogen having entered body tissues/fluid is confronted with second line of defence consisting of phagocytosis and inflammatory response.

- **Phagocytosis:** Phagocytes present in blood come out of capillaries through diapedesis. Phagocytes of blood and macrophages present in tissues attack germs and engulf them. Pus may collect. Pus is a thick liquid formed in the region of wound and is composed of tissue fluid, damaged body cells, dead phagocytes, some leucocytes and microorganisms.
- **Inflammatory Response:** It is reaction of living tissues to injury, irritation or infection which is characterised by pain, swelling, redness and heat. It is

caused by release of an amine called histamine from body tissue and lymphocytes. Histamine dilates blood capillaries, makes them more permeable, lowers blood pressure, allows greater leakage of phagocytes and plasma so that tissue fluid accumulates. Toxins released by pathogens and pyrogens (substances capable of producing fever / pyrexia) produced by leucocytes raise body temperature to stimulate phagocytes and inhibit microorganisms. However, body temperature may rise too high when it is brought down by administration of antipyretic drugs (e.g. paracetamol, aspirin) and cold packs.

3. **Specific Internal Defence/Immune System/Third Line of Defence:** It is a system that provides resistance to infection. A constituent of pathogen behaves as antigen.

- **Antigen** (antibody generating) is any foreign substance like protein or polysaccharide present on external coating of pathogen, toxin of pathogen, white of egg, feathers, constituent of a vegetable, fruit, meat, drug, chemical, tissue or organ transplant which induces the immune system to produce antibodies.

- **Antibodies** are proteinaceous substances occurring naturally in blood plasma or produced by immune system in order to overcome the toxic effect of antigens. They are immunoglobulins / gammaglobulins like IgA, IgD, IgE, IgG and IgM. Each has a specific area (V-region) for binding with antigen. Immune system is capable of distinguishing body cells and their macromolecules from foreign cells and substances. The system consists of two parts — humoral and cell-mediated.

ANTIBODY MEDIATED IMMUNE SYSTEM

The immune system comprises antibodies present in body humors (blood, lymph). Cell Mediated Immune System (OMIS) comprises lymphocytes that defend the body against pathogens, cancers and foreign structures like tissue transplants.

Cells of Immune System : They are two types of lymphoctyes (B-lymphocytes and T-lymphocytes) which develop from stem cells or haemocytoblasts in liver of fetus and bone marrow thereafter. B-lymphocytes (after bursa Fabricii in birds) undergo early differentiation in bone marrow and later inside bursal lymphoid tissue (peyer's patches, appendix, tonsils). T-lymphocytes undergo differentiation in thymus. They then come to lie inside spleen, tonsils and lymph nodes.

Action of T-cells: T-cells are long lived cells (4-5 years, some through life) which develop antigen specificity through previous contact. They respond to an antigen by forming a clone of cells. The cells differentiate into four types :

(i) Killer T-cells: The cells reach the site of infection of agglutination, attract other cells and phagocytes to feed on antigen containing pathogens.

(ii) Helper T-cells : They activate B-lymphoctyes to produce antibodies.

(iii) Suppressor T-Cells: The cells protect the body tissues and chemicals from attack of phagocytes and their antibodies.

(iv) Memory T-Cells: They are sensitised T-cells which retain memory of antigen-specificity for future, sometimes life long. Killer, helper and suppressor T-cells are also called effector cells Action of B-cells. The antigen specific helper T-cells stimulate specific B-lymphocytes to multiply rapidly forming clone of plasma **cell.** In the presence of antigen the plasma cells form antibodies at the rate of 2000 molecules per cell / per second, a total of some 20 trillions per day.

- **Robert Koch** (1876): First to establish connection between disease and pathogen (anthrax disease of sheep due to *Bacillus anthracis*).

- **Pasteur** (1879): Development of vaccines through attenuation of pathogens (idea from cholera bacteria).

- **Father of Immunology:** Edward Jenner (1749-1823).

- **Antibodies/Immunoglobulins:**

(i) **IgA**: Main antibody is secretions attacking microorganisms and their toxins.

(ii) **IgG:** Main antibody in body fluids (in circulation) for attacking microorganisms and their toxins.

(iii) **IgD**: Membrane bound antibody.

(iv) **IgE:** Allergic reactions.

(v) **IgM:** Largest antibody, takes part in lysing microorganisms along with IgC (also as opsonin).

COMMON HUMAN COMMUNICABLE DISEASES

They are infectious diseases caused by pathogens which can spread from infected persons to healthy persons. Communicable diseases are grouped according to the type of pathogens, viz., viral, mycoplasmal, rickettsial, chlamydial, bacterial, protozoan, helminthetic, etc.

- **Influenza/Flu** : It is highly infectious viral disease which often spreads in epidemic / pandemic- (spreading throughout country / continent) form. It affects nose, throat, eyes and upper respiratory tract. The disease is accompanied by sneezing, coughing, headache, sore throat, body aches and fever for 4-5 days. The common flu virus is *Myxovirus influenza.* Incubation period is 2 — 3 days. Complications include development of bronchitis, ear infection and pneumonia. The disease spreads through direct contact, unclean hands and droplet method.

- **Small Pox :** It is an eruptive viral disease which has been completely eradicated through widespread

compulsory vaccination. The disease is caused by *Variola virus.* Incubation period is 12 days. The disease begins with headache, backache, chill, high fever, rashes appearing on third day of illness as reddish spots which change into vesicles, pustules and finally scabs in third week. The scabs fall down leaving permanent pox marks, especially over face. Complications, include blindness. Death could also occur. First vaccination developed by Edward Jenner (1796) was against small pox. Diseases used to spread through fomite transmission.

- **Chicken Pox :** It is a contagious and fomite transmitted eruptive viral disease which is more common but less severe in children upto 10yrs and severe but rare in adults. The disease is caused by virus *Varicella zoster* with incubation period of 14-16 days. Illness begins with slight fever, shivering and backache. There are then prodormal or transitory rashes with crops of pinkish centripetal spots appearing first on trunk, fore-head and face. Uneasiness, aches and high fever accompany. Spots turn into fluid filled vesicles and then scabs in five days. Scabs fall off without leaving any mark. Use of boric acid, calamine and benzyl benzoate reduces itching and tendency to scratch. No drug, no vaccine. Single attack gives life long immunity.

- **Measles:** It is a highly infectious eruptive viral disease of children below the age of five and caused by Rubella Virus / *Polynosa morbillorum.* Disease is transmitted by contact, fomite and droplet methods. Portal of entry is respiratory tract and conjunctiva. Incubation period is 10 — 14 days. In preruptive stage (3 — 4 days), there is hoarseness, cough, sneezing and running nose due to inflammation of respiratory tract, redness or watering of eyes, loss of appetite and fever. White Koplick's spots appear opposite molar teeth in buccal cavity on third day. Fourth day begins with skin rash, small raised red spots (rubella) in crescent shaped groups starting from back of ears, reaching fore head, face (bloated and blotchy) and then body. By 5-6th day and the rashes begin to subside. Vaccination is available which is given at the age of one. Prior to that the infant carries passive immunity from mother.

- **Mumps :** It is an acute infectious one time viral disease of school going children which is characterised by swollen parotid salivary gland, hence **infectious parotitis.** Adults without previous infection may catch the disease. The pathogen is *Paamyxo/*Mumps, *Virus.* It is transmitted by direct contact, droplet method and fomite method. Incubation period is 12 — 26 days. Due to mumps the patient has difficulty in swallowing and opening of mouth. There is high fever. In adults, mumps may cause damage to sex organs. Antibiotic are given to prevent secondary infection. Vaccination is available (MMR- mumps, measles and rubella a German measles).

- **Poliomyelitis/Polio/Infantile Paralysis :** It is highly infectious viral disease of infants and children (hence infantile paralysis) that may attack adults also. Causal agent is *Polio Virus.* Disease is transmitted through faces, urine and nasal secretions contaminating food, water, drinks, either directly of through flies with an incubation period of 5 — 17 days. During incubation period, the virus multiples in alimentary canal. Then it passes to lymph, blood and finally central nervous system in dorsal horn cells of spinal cord and brain stem. Preparalytic stage (1 — 4 days) is characterised by fever, sore throat, nausea, vomiting, diarrhoea, headache, stiff back, stiff neck, twitching and convulsions. During paralytic stage, motor nerves are affected resulting in atrophy of muscles, generally of arms and legs but may affect those of diaphragm (only iron lung can save), larynx and pharynx (fatal). Vaccine (Salk's vaccine), now oral also, is available for taking at the age of 6 weeks, 10 weeks, 14 weeks, booster (18 — 24 months).

- **Rabies/Hydrophobia :** It is a fatal viral disease (Rabies Virus) that is transmitted to human beings by biting / saliva of rabid dog or cat. Incubation period is 1 — 3 months. Multiplication occurs in neurons (nourotrophic). It leads to encephalitis, **fear of water,** severe headache, high fever, alternate excitement and depression, spasm of throat and chest leading to death. Bitten person should be immediately administered vaccine that develops antibodies before the virus becomes active. Dog should be watched for 10 days for the development of rabies symptoms (running a muck, change of voice, excessive salivation). Rabid dog should be killed. Stray dogs and cats must be eradicated while pets should compulsorily be immunised.

- **Hepatitis :** It is two types, A and B. Hepatitis A (**Epidemic jaundice**) is more common in children and young adults with incubation period of 15 — 50 days which is spread through faecal-oral route. There is high fever. Hepatitis B occurs at any age, has an incubation period of 50 — 160 days, carrier state of upto 5 yrs, with little fever. Mode of transmission is parenteral. Hepatitis is accompanied by loss appetite, nausea, whitish stool, but orange brown urine and jaundice., Personal cleanliness, boiled water, properly heated, cooked / cleaned food articles and control of flies are required in period of epidemic. Vaccine is available.

- **Trachoma :** It is an eye disease caused by *Chlamydai trachomatis* (primitive procaryote) with an incubation period of 5 — 12 days and characterised by granular outgrowths on eye-lids, cornea and conjunctiva. It is spread through direct or indirect contact with the patient. Trachoma can lead to visual impairment. Antibiotics are effective.

BACTERIAL DISEASES

- **Cholera** (Vischuchika of Ayurveda) : It is a highly communicable bacterial disease caused by *Vibrio cholerae (= V. cornmae)* which is transmitted through food, water, drinks (fomite transmission) and direct as vomits and stools of patient contain innumerable pathogens. Floods, fairs, wars, and other calamities often lead to epidemic

outbreak. Incubation period is a few hours to five days. There is acute diarrhoea with rice water stool (upto 40 per day), vomiting, muscular cramps, anuria and rapid dehydration. Oral dehydration (oral intake of sweetened and salted rice water or electrolyte solution), intravenous dehydration and antibiotics (e.g, chloramphenicol) can treat the disease. Chlorination (by chlorogen or tropical chloride of lime/TCL) or ozone treatment of water, boiled water, disinfected food are essential for prevention. If untreated, the disease leads to collapse marked by sunken eyes, hollow cheeks, bluish colour, subnormal temperature, washerman's hands and feet, shallow quick respiration which may lead to death or slow recovery.

- **Pneumonia :** Pneumonia is bacterial (*Diplococcus pneumoniae)* droplet transmitted disease of lungs with an incubation period of 1 — 3 days and characterised by accumulation of mucus/fluid in alveoli and bronchioles so that respiration becomes difficult. If untreated, pneumonia leads to death.

- **Plague/Bubonic Plague** : It is essentially a bacterial disease (*Pasteurealla/Yersinea pestis)* of rats which is spread by rat flea (*Xenopsylla cheopis).* The disease kills the rats. Rat fleas leave the dead rats and attack humans. Incubation period is 2 — 6 days. The disease is characterised by high fever, lung infection and painful enlargement of groins/armpits (bubo). It spreads in epidemic form. If untreated (effective antibiotic is tetracycline), the disease proves fatal. Anti-plague vaccine, spray of insecticides, killing of rats, nose caps and high cots are some preventive measures.

- **Tuberculosis/TB :** It is a bacterial (*Mycobacterium tuberculosis)* disease where the pathogen destroys the infected tissue and releases toxin called **tuberculin** (test called Mantoux reaction is tuberculin specific), Lung tuberculosis is more common but other forms (intestinal, bone, skin, meningitis also occur. Disease is spread by direct contact and droplet method. Incubation period is from a few days to several months. The symptoms include evening-night fever, night sweating, loss of weight, cough, difficult breathing and haemoptysis (blood stained sputum) in case of pulmonary TB while there is acute pain in other cases. Meningitis leads to coma. Sputum, tuberculin, X-ray and gastric analysis are carried out to diagnose disease. Antitiuberculosis drugs are streptomycin, isoniazid. analysis are carried out to diagnose disease. Antituberculosis drugs are streptomycin, isoniazid, thiacetazone, PAS, ethambutol, pyrazinamide, kanamycin, rifamycin, etc. Surgery is required for removing infected lump. Vaccination with BCG (Bacillus Calmette Guerin) provides immunity.

- **Pertussis/Whooping Cough :** It is an infectious bacterial disease (*Bacillus Haemophilus pertussis)* of children which is characterised by attack of irritating cough accompanied by inspiratory whoop/gasp. The disease spreads through direct contact and droplet method. Incubation period is 10—15 days. There is inflammation of respiratory passage, cold, cough and mild fever in beginning, leading to accumulation of mucus and inspiratory whoop. Convulsions and pneumonia may occur. Antibiotic erythromycin is effective. Vaccination is available in form of DPT (diphtheria, pertussis, tetani) for thrice inoculation to infants at monthly intervals.

- **Diphtheria :** It is an acute infectious bacterial disease (*Corynebacterium diphtheria)* of mostly children which spreads through droplet method. Incubation period is 1/2-5 days. Portal of entry is upper respiratory tract though implanation may occur anywhere. Exotoxin produced by pathogen causes epithelial necrosis. In the beginning there is mild fever, sore throat, mild headache and lassitude. Later on semisolid material oozes out of throat where a grey false tough membrane may develop choking air passage. An offensive odour is produced. Antitoxin given within 12 hrs. may give relief. Antibiotics may also provide some relief. Membrane has to be removed surgically. Schick test can indicate susceptibility. Triple vaccine, DPT, is useful.

- **Typhoid :** It is an acute infectious bacterial disease (*Salmonella typhi)* which spreads through food, milk and water contaminated with sewage, flies or faulty personal hygiene. Incubation period is 1 — 3 weeks. The pathogen causes lesions in the intestinal wall. There is high fever in steps with perfuse pea soup diarrhoea which may become haemorrhagic. A rose coloured rash may occur on upper abdomen at the end of first week. Lately, resistance typhoid has appeared. Vaccine provides immunity for 1 — 3 years. Antibiotics are available. Typhoid is diagnosed by Vidal test.

- **Salmonellosis.** It is caused by *Salmonella enteridis* and *S. typhimurium*. The bacterium often contaminates meat and other proteinanceous food articles. The pathogen causes diarrohea, vomiting, nausea, headache and paratyphoid fever. Antibiotics are helpful in curing. Oral or intravenous rehydration is required.

- **Shigellosis.** It is due to bacterium *Shigella shigae. S, flexneri* and other species. The disease spreads through contaminated food. Shigellosis is characterised by frequent passage of stool with mucus, blood and abdominal cramps. Effective antibiotics are available. Oral or intravenous rehydration is required.

- **Tetanus/Lock Jaw** (Dhanustamba) : It is an incurable bacterial disease (*Clostridium tetani*) characterised by painful muscular contraction of jaw. It causes mortality in infants and mothers. The bacterium occurs in intestine of horse and other animals from where they pass out as spores (viability 60 yrs) in their excreta that mixes in street dust and contaminates various articles including rusted iron. Wounds and cuts, surgical instruments coming in contact with road dust may cause entry of bacteria into body. Incubation period is 3 — 28 days. Injection of ATS within 24 hours of injury gives passive immunity while tetanus toxoid gives active immunity. Children are immunised at the age of 6 weeks, 10 weeks,

14 weeks, 11/2 yrs. and 4 yrs. 2 — 3 vaccinations are given during pregnancy. Disease begins with headache, chill, irritability followed by back pain, stiff neck and spasm of jaw.Ultimately there is lock jaw, spasm of chest, abdomen and spine leading to death due to heart failure, suffocation and exhaustion.

- **Leprosy :** Leprosy is contagious chronic bacterial (*Mycobacterium leprae*) of warmer climates which is contracted on prolonged closer contact through skin lesions, nasal and throat discharge. Incubation period is 2 — 5 yrs. Infection begins with appearance of hypopigmented skin patches with little sensation, thickening of peripheral nerves, numbness in some body parts, pain in some other, unexplained fever, finally appearance of ulcers, nodules, lesions, scalyscabs, followed by deformities in fingers, toes and wasting of body parts. Surgery along with drugs (diaminodiphenyl sulphone, alepol, chaulmoogra oil) can cure the disease. However, the disease carries a social stigma.

VENEREAL DISEASE (V.D.)/SEXUALLY TRANSMITTED DISEASE (S.T.D)

- **Gonorrhoea:** It is a venereal bacterial disease (*Neisseria gonorrhoeae*) which is spread through sexual contact, common toilets and under clothes with incubation period of 2 — 5 days. The bacterium lives in genital tubes, produces pus-containing discharge, pain around genitalia and burning sensation during urination. It may lead to arthritis and eye infection in children of gonorrhoea afflicted mothers. Disease can be cured through use of appropriate antibiotics.
- **Syphills:** It is highly infectious venereal bacterial disease (*Treponema pallidum)* with incubation period of 4-5 weeks. Transmission is through sexual contact and from mother to children. In the first stage there is indurated infectious and painless ulcer or chancre on the genitals and swelling of local lymph glands. In the second stage, chancre is healed and there are skin lesions, rashes, hair loss, swollen joints and flu-like illness occasionally. In the tertiary stage chronic ulcers (gummata) appear on palate, nose and lower leg. There can be paralysis, brain damage, blindness, heart trouble and aorotic impairment. The disease is curable through appropriate antibiotics.

PROTOZOAN DISEASES

- **Malaria:** It is a communicable protozoan disease of tropical and subtropical areas which is caused by species of *Plasmodium* and spread through female *Anopheles.* The disease was known to Charaka and Surata. It is characterised by recurring rigors (consisting of chill, shivering, rise in temperature upto 106°F, perspiration and gradual fall of temperature), anaemia, toxaemia and splenomegaly (enlarged spleen). (i) *P.vixax*. Benign tertiary fever, incubation period 10—15 days. (ii) *P.malariae.* Quartan fever, incubation period 28— 30 days, persistent subchemical malaria. (iii) *Plasmodium.* Irregular, daily or tertian, malignant, may develop into cerebral malaria, P. falciprsum. Irregular, daily or tertian, malignant, may develop into cerebral malaria, incubation period 6 — 12 days, (iv) *P. ovale.* Benign tertian (S. America, W. Africa), incubation period 10—15 days.
- **Amoebiasis :** The disease is characterised by abdominal pain, alternating diving worms (e.g., male fern oil, chenopodium oil) but solices have to be removed surgically, diarrhoca and constipation, stool with blood mucus and mucous membrane pieces. The disease can be cured by drugs like metronidazole, stremetine and emetine. It can be prevented through sanitary disposal of human excreta, safe drinking water, proper washing of vegetables and salad.
- **Giardiasis/Backpacker's Disease :** The disease is characterised by mild diarrhoea involving passage of pale bulky and greasy stool.
- **Filaria/Filariasis/Elephantiasis** : The disease is known in India since sixth century. Affected body parts can be reconstructed through surgery. Drugs available are hetrazan, MSE and diethylcarbamazine.
- **Taeniasis :** Tapeworm infection can also occur in vegetarians through improperly washed raw vegetables. At times the embryos released from bladder worms pass on to different body parts and form **cystercerci.** They cause damage to different body parts, blindness (in eyes), epilepsy-like fits (in brain). The prevention requires proper washing of vegetables, checking pork for brownish spots and proper cooking. Drugs are available for removing worms (e.g., male fern oil, chenopodium oil) but solices have to be removed surgically.removing worms (e.g., male fern oil, chenopodium oil) but solices have to be removed surgically.

COMMON HUMAN NON-COMMUNICABLE DISEASE

They are diseases which develop in persons suffering from them. They are not transmitted to others.

- **Diabetes/Diabetes Mellitus**
- **Cardio-Vascular Disease:**

1. **Arteriosclerosis:** It is a degenerative disorder occuring in elderly persons where by the arteries lose their elasticity due to hardening and thickening of fibrous tissue.
2. **Atherosclerosis:** It is narrowing of arteries and arterioles due to insolubilisation and deposition of cholesterol inside and over the intima.
3. **Phypertension:** Prehypertension is in American classification for cases where a person's blood pressure is elevated above normal but not to the level co to he hypertension (high blood pressure).

4. **Hypotension:** Occurs when blood pressure during and after each heartbeat is much lower then usual.

5. **Rheumatic Heart Diseases** (R.H.D.): Rheumatic fever (due to streptococcal infection, also cox shake B-4 virus) produces toxins that causes inflammation of different body parts including joints and endocardium. Repeated fever causes damage to heart walls, heart muscles, scarring and malfunctioning of heart valves, especially atrio-ventricular ones. Heart functioning becomes irregular with age. It may give rise to low blood pressure and heart attack.

6. **Hypertensive Heart Disease:** Continuous hypertension leads to overwork by heart causing damage to its muscles and valves. It may lead to heart attack. Other complications are chronic nephritis (damage to renal arteries), blindness (damage to arteries supplying eyes) and brain stroke resulting in paralysis, loss of speech and other functions.

7. **Coronary Heart Disease:** Blood flow to heart walls may be reduced due to hardening and narrowing of coronary arteries and appearance of blood clot in a coronary artery that blocks blood supply to a part of heart. Coronary thrombosis is occlusion of a coronary vessel by a clot of blood, stoppage of blood supply to a part of heart wall leading to heart attack. Myocardial infarction is necrosis or death or a part of myocardium / middle layer of heart wall caused by reduced blood supply. Angina pectoris is a severe temporary cardiac pain radiating to arms due to myocardial ischaemia / deficient oxygen due to reduced blood supply at the time of physical activity causing heart to beat faster.

8. **Heart Attack:** Failure in the working of heart is heart attack. It may be caused by valvular obstruction or degeneration, degeneration of cardiac muscles, blood insufficiency or myocardial infarction. Symptoms of impending heart attack are (i) Irregular pulse. (ii) Pain in chest in the area of heart or chest pain moving to arms. (iii) Murmur. (iv) Constant low / high blood pressure. (v) Internal haemorrhage. (vi) Nausea, vomiting after exercise. The risk factors include (a) Continuing stress conditions. (b) Diabetes. (c) Obesity. (d) Raised cholesterol. (e) Smoking, (f) Sedentary habit. (g) Drug / alcohol addiction.

- **Stroke** (Cerebro-Vascular Accident or CVA)**:** It is brain damage due to stoppage of blood to a part caused by (i) Clot formation in an artery. (ii) Rupturing of an artery due to weakening of its wall and hypertension. (iii) Sustained contraction or spasm of an artery. The affected brain part does not receive oxygen and nutrients resulting in damage to nerve cells and their defunctioning. Such a stroke leads to paralysis, loss of consciousness, loss of speech, hearing or memory and even death.

- **Arthritis:** It is a disease / syndrome characterised by pain in joints.

1. **Rheumatoid Arthritis—**It is believed to be caused by bacterial infection that produces an antibody called rheumatoid factor. It results in inflamed synovial membranes followed by development of hard tissue over the cartilage causing stiffening of joint and painful movements. Bones may fuse. Rheumatoid arthritis is more common in women between 20—40 yrs. In certain cases subcutaneous nodules and painful swelling of smaller joints of hands and feet occur.

2. **Osteo-Arthritis —** It is a degenerative arthritis where secretion of synovial fluid decreases and bone heads develop excrescences that limit movements, causing joint fixation or ankylosis. Knuckles become swollen and knobby with bony outgrowths or Herden's nodes on the sides of phalangial joints. Articular cartilage and bone undergo slow degeneration.

- **Gout:** It is a diet related disease that is produced due to deposition of sodium biurate (uric acid) in superficial layer of articular cartilage, especially metatarso-phalanged joint of great toe, to a lesser extent fingers and knee. There is a sudden acute pain, especially in great toe accompanied by swelling, chill, fever, headache and tachycardia.

- **Cancer :** Cancer is a group of diseases characterised by uncontrolled proliferation of cells and ability of proliferated cells to invade other tissues / parts of body. Neoplasm is a new abnormal tissue that is capable of continued growth, formation of tumor, crowding and disrupting of normal cells. Tumors are of two types, benign and malignant. Benign tumor is a larger localised mass of abnormal tissue which presses other tissues but does not infiltrate adjacent tissues because it is encapsulated in connective tissue. Malignant tumor is a large mass of abnormal tissue which is not encapsulated, is capable of invading adjacent tissue and distant sites Metastasis is spread of cancerous cells from one part of the body to other parts through blood, lymph or formation of secondaries from a malignant tumor. ***Cancers are of three types:***

1. **Carcinoma—**It is cancer of epithelial / epidermal tissues and their derivatives like skin, mucous membrane, glands, lungs, breast, pancreas, stomach, etc.

2. **Sarcoma —** It is cancer of primitive mesodermal tissue like connective tissue, bone, muscle, lymph nodes.

3. **Leukemia —** It is malignancy where there is unwanted and uncontrolled increase in number of white blood corpuscles (200,000 - 1000,000 / mm^3) and immature or myeloid stem cells. In common type of leukemia, the white blood corpuscles infiltrate bone marrow, spleen, liver, lymph nodes and other organs causing damage and increasing their size. In myelocytic leukemia (9th and 22nd chromosomes bring their jumping genes together) erythroblastic tissue of bone marrow degenerates. There is bleeding at different places. Tonsils and cervical glands enlarge. The most common cancers in India are mouth-throat cancer in men and uterine-cervical cancer in women.

INCOMPATIBLE GENES

- **Rh-Factor Incompatibility.**
- **ABO Incompatibility:** O groups mothers do not possess antigen A or B groups fetus in O-groups mother invites antibodies of the mother causing partial destruction of erythrocytes and production of bilirubin. The baby, therefore, suffers from mild anaemia and jaundice. Similarly B-group fetus in A-group mother or A-group fetus in B-group mother is attacked by antibodies of mother. ABO hemolytic disease of new born is quite common and less severe as compared to Rh-incompatibility. It occurs even in first baby.

RECESSIVE DEFECTIVE AUTOSOMAL GENES

- **Sickle Cell Anaemia:** It is due to a recessive (now considered codominant) autosomal gene, Hb^S, Hb^S, Hb^S individuals die during infancy but Hb^A. Hb^S individuals survive. The allele has survival value because heterozygotes have an advantage over normal individuals in malaria infested areas because they resist damage from *Plasmodium falciparum* (30% population carries the allele in Nigeria). Hb^S produces haemoglobin with ?-chain having valine amino acid instead of glutamic acid at 6th position (Ingram, 1958). Heterozygotes are normal individual with 55 — 60% Hb A and 35 — 40% HbS. They develop sickle cell crisis under conditions of oxygen distress like high altitude and strenuous exercise. At this time 6 — valine develops hydrophobic bonds with complementary site of an adjacent strand. Other interactions amongst molecules also occur causing development of helical polymer of about 14 strands. It changes membrane permeability and development of sickle cell form. Sickle cells are rigid and obstruct capillary blood flow. It results in further deoxygenation and sickling. A mild form of sickle cell anaemia occurs in Singhalese.
- **Thalassemia:** It is a group of genetic disorders which result from defective synthesis of subunits of haemoglobin. In thalassemia out of the four genes present on 11th chromosomes, absence of two genes produces microcytic and slight hypochromic erythrocytes without significant anaemia but deficiency of third genes develops microcytic hypochromic erythroctyes with marked hemolytic tendency. Death occurs in foetus in case of deficiency of all the genes. In thalassemia the two genes present on 16th chromosomes are defective. In thalassemia minor (one defective gene) the erythrocytes are microcytic with higher RBC count but 15% lower haemoglobin than normal. In thalassemia major both the genes are defective. Disease manifestation begins at the age of 4 — 6 months .
- **Alkaptonuria:** Homozygous recessives do not produce liver enzyme homogentisate / alkapton oxidase which is essential for metabolism of homogentisic acid / alkapton formed from phenylalanine and tyrosine. As a result alkapton accumulates in body producing arthritis and other damages. Alkapton is also excreted in urine. Exposed urine appears brownish-black.
- **Phenylketonuria** (P.K.U.)**:** Homozygous recessive alleles cause absence of phenylalanine hydroxylase in liver. The enzyme is essential to change phenylalanine to tyrosine. There is increased phenylalanine in blood (hyperphenylalaninemia) and urine. By products of phenylalanine also occur in excess. They include phenylpyruvate, phenylacetate, phenyllactate, phenylacetylglutamine. There is severe mental retardation, hypopigmentation of skin and hair, eczema, mousy odour of skin, hair and urine.
- **Albinism:** Enzyme tyrosinase (also inhibited by excess phenylalanine) is absent due to homozygous recessive autosomal alleles. Melanin or pigment formation from dihydrophe-nylalanine is stopped. There is lack of pigment in skin, hair and iris. Eye disorders may occur due to damage from bright light.
- **Tay Sach's Disease/Infantile Amourotic Idiocy:** Recessive autosomal disorder due to deficiency of enzyme, D-N-acetylhexosaminidase. It cause accumulation of lipid GM_2 or Tay-Sach's ganglioside that damages brain and spinal cord resulting in mental retardation and paralysis. Death of the child occurs at the age of 3 — 4 yrs.
- **Muscular Dystrophy:** Three types of muscular dystrophy occurs due to recessive autosomal alleles-limb-girdle, distal and congenital.

DOMINANT DEFECTIVE AUTOSOMAL GENES

- **Huntington's Disease/Huntington's Chorea:** It is a dominant autosomal disorder due to an allele on short arm of chromosome 4. The characteristics of disease may start at the age of 15—40 yrs but can also occurs in still older persons. There is atrophy of parts of brain resulting in respiratory irregularity, faulty articulation of speech irregular arrhythmic movements of limbs, a peculiar dancing gait and bizzare grimacing.
- **Polydactyly:** Having more than five digits.
- **Achondroplasia:** It is an inherited dominant autosomal disorder where the long bones do not grow resulting in dwarfism. Intellect is not affected.
- **Muscular Dystrophy:** Muscular dystrophy due to dominant autosomal gene, can be of four types — myotonic, facioscapulohumoral, caculopharyngeal and scapuloperoneal.

SEX LINKED DISORDERS

- **G 6 PD Deficiency Syndrome:** The sex linked recessive trait (present on X-chromoscomes), homozygous in

females, single in males, causes deficiency of glucose 6-phosphate dehydrogenase which is essential for carrying out hexose monophosphate shunt. The shunt is required to produce reduced glutathione for protecting sulphahydryl groups of haemoglobin and erythrocyte membrane during oxidant stress. In the absence of G 6 PD haemoglobin crystallises and erythrocyte membrane ruptures. Beans (hence favism) and certain drugs induce hemolysis in G 6 PD deficient persons e.g., Vitamin K, chloramphenicol and quinine (no effect in certain cases), p-aminosilicylic acid, phenacetin, actanilid, sulphonamide, sulphanilamide, chloroquine, pamaquine, etc.

- **Hemophilia** (Bleeder's Disease, John Otto, 1803)**:** It is a sex linked recessive trait which is known as bleeder's disease because the exposed blood does not clot due to the absence of plasma thromboplastin (haemophilia C/ christmas disease) or antihaemophilia globulin (haemophilia A). The defect has been inherited in the family of British Crown through Queen Victoria.
- **Red-Green Colour Blindness:** It is a sex-linked recessive trait which is more common in males due to presence of only one X-chromosome. In the syndrome the sufferers are unable to distinguish between red and green colour.
- **Congenital Night Blindness:** The sex-linked recessive trait causes reduced development of visual purple and hence night blindness. Night blindness caused by vitamin A deficiency is acquired night blindness.
- **Muscular Dystrophy:** Sex linked muscular dystrophies are of two types : (i) ***Duchenne's Pseudohypertrophic muscular dystrophy*** which onsets at the age of 5 with progressive weakness of girdle muscles, inability to walk after the age of 12, cardiomyopathy, mental impairment, respiratory failure in 2nd or 3rd decade. (ii) ***Becker's/ Benign pseudohypertrophic muscular dystrophy*** is milder form in which symptoms appear late and are less severe. Respiratory failure occurs after 4th decade.

AUTOSOMAL ABNORMALITIES

- **Down's Syndrome/Mongolian Idiocy/Mongolism** (L.Down 1866, cytological basis J. Lejeune, 1959)**:** It is due to trisomy of 21st chromosome (47, + 21st). The syndrome in characterised by rounded face, broad forehead, flattened nasal bridge, open mouth, projecting lower lip, protruding tongue, skin fold at eye corners, short neck, small flat hands with stubby little fingers, loose jointedness at ankles, mental retardation, cardiac deformities, under developed gonads and genitals. Risk of Down's syndrome is higher in parents below 18, fathers above 49 and mothers around 45.
- **Edward's Syndrome:** Trisomy of 18th chromosome. Malformed ears, receding chin and defective nervous system.
- **Patau'Syndrome:** Trisomy of 13th chromosome. A chromosomal abnormality in which a patient has an additional chromosome 1. It disrupts normal course of development, camsing heart and kidney defects.
- **Barr Body:** It is a darkly stained heterochromatic X-chromosome which appears below nuclear envelope when cells are stained with orcein dye. It is absent in human males, one in normal human females, one in males with Klinefelter's syndrome, two in super-females.
- **Y-Spot** : Quinacrine stained nucleus shows a bright flourescent band on the long arm of Y-chromosome. A single spot indicates normal male, two super males.
- **Amniocentesis :** Taking out of small quantity of amniotic fluid and testing biochemicals as well as cells contained in it. Cells of both the mother and foetus are present. Amniocentesis is important for determination of sex, genetic abnormality and physiological defects.

SEX CHROMOSOME ABNORMALITIES

- **Turner's Syndrome** (Turner et al, 1938)**:** There is single X-chromosome (44 + XO) due to fusion of (22 + O) ovum with gymnosperm (22 + X). The defect is also called female Turner's syndrome. Male Turner's syndrome does not survive (44 + Y). The individuals are female with limited secondary sex characters, rudimentary ovaries, lack of menstrual cycle, undeveloped breasts, short stature, webbed skin over neck, low set ears, shield like chest, abnormal jaw formation, subnormal intelligence.
- **Klinefelter's Syndrome** (Klinefelter, 1942): Sex complement is XXY. It is produced by fusion of normal androsperm (22 + Y) with egg having 2 •~ (22 + XX) or normal egg (22 + X) with sperm having both chromosomes (22 + XY). The individuals are males with undeveloped testes, feminine secondary sex characters (gynecomastia) like very few body hair and enlarged breasts, small prostate gland, long limbs with occasional mental retardation.
- **Super females:** The sex complement is XXX, XXXX or XXXXX. They are mentally retarded and commonly infertile.
- **Supermales:** The sex complement is XYY (Hauschika, 1962). There is overproduction of testosterone and defects produced thereof. The super males have no superior traits. They may be taller with a criminal bend of mind.

MENTAL HEALTH

Mental Health is a state of development of individual's personality and emotional attitude towards family members, society, social institutions, work, leisure, stresses and strains, and balanced satisfaction of potential conflicting instinctive drives. A mentally sick person has (a) Inability to concentrate. (b) Absence of sound sleep. (c) Worrisome behaviour. (d) Short temper. (e) Unhappiness. (f) Mood fluctuations from depression to elation (g) Tendency to get upset by a change in routine. (h) Apprehensive nature (i) Bitterness. (j) Dislike of others. (i) Considering others to be

wrong. (k) Children getting on nerves. (m) Feeling of pains / aches in different body parts without any actual ones.

Mental illness is a state of mind in which a person is not able to think, behave and interact with others normally. Onset of mental illness is exhibited by (i) Changes in behaviour and personality due to abnormality of thoughts, memory, feelings, perception and judgement. (ii) Difficulty in adjustment with family members and colleagues. (iii) Inability to carry on daily business, with signs of tension, trembling, depression, aggressive behaviour, fear, phobia, etc. There is thus social and vocational dysfunctioning.

Types of Mental Illness

1. **Pyschosis/Insanity/Madness:** It is a serious type of mental illness in which the patient loses touch with reality. Psychosis may be caused by disease of central nervous system. The patient is not aware of illness and refuses to take the treatment.
2. **Mental Disabilities:** The disabilities are caused by physical, physiological and psychological defects like (i) Injury (ii) Infection from worms, tuberculosis, measles, leprosy or encephalitis. (iii) Nutritional deficiency during development of infant. (iv) Radiation damage during neural development. (v) Toxicity of lead and mercury. (vi) Degeneration due to ageing. (vii) Tumors or neoplasms. (viii) Poor availability of oxygen, glucose / blood supply. (ix) Excessive intake of alcohol. (x) Excessive use of psychotropic drugs.

- **Epilepsy** is a mental illness charactersied by abnormal electrical discharge in a pat of brain often leading to warning cry, fits of convulsions like jerking, stiffness, tongue biting, sensory changes, loss of bladder and bowel control, ending in loss of consciousness, falling down and sleep.
- **Parkinson's Disease** is a sporadic disorder of middle and late life which is characterised by stooped posture stiffness and slowness of movements, fixity of facial expression and rhythmic tremor of limbs which subsides on relaxation of actively willed movement. The disease is caused by development of melanin containing nerve cell aggregates in brain stem and Lewy bodies in the cells.

3. **Neurosis/Psychoneurosis:** It is a less severe form of mental illness where the patient is aware of the problem and tries to seek help. There is abnormal anxiety, fear, sadness, vague aches and pains. Neurosis develops due to stress and anxiety in patient's environment. The patient shows excessive / prolonged reaction to a given stress, e.g., anxiety neurosis, hysteria, obsessional neurosis, reactive depression.

- **Schizophrenia** is a type of mental illness which is charactersied by disorganised personality, shallowness of emotional life, auditory hallucinations, delusions, illogical thinking, sense of being influenced by others and feeling of being controlled by outside forces. Schizophrenia can be caused by excessive dopamine production, alternations in neuropeptides, increased ventricular brain ratios and decreased frontal lobe activity.

UNIVERSAL/NATIONAL IMMUNISATION PROGRAMME

With the success of small pox eradication programme, an impetus has been given to eradication of six preventable diseases through universal immunisation programme. The six diseases are diphtheria, pertussis (whooping cough), polio tetanus, tuberculosis and measles. The programme was launched by W.H.O. in May, 1974 and is expected to reach every child by 2000 A.D. In India, it was launched in 1985 with reaching every child in 1992. India has fixed the year 2000 A.D. as the year of health for all. Vaccination schedule against six short-listed diseases and two additional ones (cholera and typhoid) followed in India.

Age	*Vaccination*	*Dose*
Birth to 12 months	*1. D.P.T. (triple vaccine, against diphtheria, whooping cough/pertussis and tetanus)*	*Three doses (commonly oral) at intervals of 4— 6 weeks.*
	2. Polio (Sabin's oral, previously Salk's injectable)	*Three doses at intervals of 4 — 6 weeks.*
	3. B.C.G. (against T.B. Bacillus Calmette Guirin) vaccine	*Intradermal, one*
9 — 15 months	*Measles vaccine (M.M.R. or Measles, Mumps and Rubella)*	*One dose.*
8 — 24 months	*1. D.P.T.*	*Booster dose*
	2. Polio (oral)	*Booster dose*
	3. Cholera vaccine (can be repeated every year before summer)	*One*
5 — 6 years	*1. D.T. (Bivalent vaccine against diphtheria and tetanus)*	*Booster dose*
	2. TAB (vaccine against Salmonella typhi, S. paratyphi A and S. paratyphi B) or Typhoid Paratyphoid vaccine	*Two doses at intervals of 1 — 2 months*
10 years	*1. Tetanus*	*Booster dose*
	2. TAB (Typhoid)	*Booster dose*
16 years	*1. Tetanus*	*Booster dose*
	2. TAB	*Booster dose*
Mothers (Pregnant Women)	*Tetanus*	*Non-Immunised. Two doses, first between 16-24 weeks and second between 24 — 32 weeks*
		Immunished Previously. One dose four weeks before the expected date of delivery.

Treatment of Mental illness

Drugs/Psychochemotherapy : A number of drugs are available to treat different types of mental illness, e,.g. sedatives for promoting sleep, transquillisers for reducing anxiety (e.g. lithium), antidepressants (e.g., trimipramine, trazodone), antipsychotic (e.g. chloropromazine, thioridazone, thiothixene, loxapine, clozapine, supiride)

Shock Treatment/Electropathy/ECT (Electroconvulsive Therapy)**:** The treatment is useful in curing acute depression, acute mania, stupor (Confusional state) and some types of schizophrenia. The treatment given by expert psychiatrists involves placing of electrodes on the head of the patient and providing an electric stock for a fraction of second by passing a current of definite voltage. It produces convulsion.

Psychotherapy: It is treatment involving psychological techniques like psychonalysis, discussion, explanation, reassurance, etc. Psychoanalysis (founded by Freud) is a method of reviving past and forgotten emotional experiences of a person so as to find out the reason for mental illusion and helping the patient to readjust attitude to causal experiences. Pychotherapy also allows the patient to talk about one's troubles, reassuring suggesting and helping the patient to find out the solution or readjustment.

SocialTherapy/Rehabilitation: Mental health is governed to a large extent by adjustment of an individual in the community and the attitude of the individual towards the community. Sympathy shown by family members and community is extremely useful to an individual to overcome misery and adjust to stresses and strains.

- **Acrophophobia:** Fear of height/altitude.
- **Algophobia:** Fear of pain.
- **Claustrophobia:** fear of enclosed space.
- **Lyssophobia:** Fear of becoming insane.
- **Mysophobia:** Fear of dirt and contamination.
- **Nyctophobia:** Fear of darkness.
- **Xenophobia:** Fear of strangers.

ADDICTION

Addiction is the state of having yielded to and becoming physically, physiologically or psychologically dependent on a habit, practice, drug, tobacco, alcohol and other beverage. Medically addiction is of three types—tobacco, alcohol and drugs.

Tobacco Addiction

The use of tobacco originated in America where Red Indians used to smoke it. It spread to other parts of the world in 1600s. Tobacco is smoked as cigarette, cigar, biri, pipe, hookah (hubble-bubble), chewed in betel or lime, flavoured pan masala, etc.

Smoking and chewing tobacco is harmful because of heat, irritation to lips, throat, respiratory tract and ingredients of tobacco or its smoke.

Nicotine is an addictive toxic chemical. In small quantity nicotine relaxes muscles, improves nerve transmission and releases adrenaline that enhances heart beat, contracts peripheral blood vessels and increases blood pressure. Regular use leads to coronary diseases, coronary artery occlusion and heart failure. Tobacco leads to male infertility. In pregnant women, nicotine causes abnormal foetus development. Tobacco addiction often leads to gastric and duodenal ulcers. Heat, irritants and carcinogens (cyclic hydrocarbons, heavy metals and others) cause cancers in various parts. Mouth cancer occurs in tobacco chewers and reverse smokers. Lip cancer is more common in pipe and cigar smokers. Tongue, pharynx, larynx and lung cancers occur due to smoking, 95% of lung cancers are related to heavy smoking.

Alcoholism/Alcohol Addiction

Alcoholic beverages are of two types — low alcohol content (e.g., Bear, Wine, Toddy) and high alcohol content (e.g. Vodka, Brandy, Whisky, Gin, Rum, Arrack). Major effects are:

1. **Gastric Disorders:** Alcoholism causes gastric ulcers and inflaminationa of gastric mucosa/gastritis.
2. **Depressant:** Alcohol is general depressant and reduces efficiency of all organs.
3. **Arterial Dilation:** The arteries undergo dilation, become rigid and brittle.
4. **Energy:** Alcohol is oxidised to release energy which is dissipated from skin making the face flushy. Alcohol addiction reduces level of blood sugar so that nutrient supply to different tissues becomes deficient. Alcoholism leads to brain damage. Amnesia or loss of memory is quite common.

Drug Addition/Drug Dependence

In common usage a drug is a chemical formulation used to prevent/cure a disease or enhance physical/mental welfare. Addictive drugs are usually psychoactive or influencing brain. Psychotropic/neurological drugs are those drugs which influence brain altering behaviour, consciousness and power of perception — hence mood altering drugs. Depending upon the effect on CNS, psychotropic drugs are of two types, narcotics and stimulants.

- **Narcotics —** Drugs that depress CNS, e.g. opiates, sedatives, transquillisers.
- **Stimulants —** Drugs that stimulate/activate CNS e.g. amphetamine, caffeine, cocaine.

Types of Drugs

Psychotropic drugs are Tranquillizers differentiated into four types — sedatives and transquillizers, opiate narcotics, stimulants and hallucinogens.

1. **Sedatives:** Sedatives and Tranquillizers depress brain activity to give feeling of calmness and relaxation. The drugs or formulations overcome mental irritability and excitement, assuage pain, and lower activity causing drowsiness or sleep, e.g barbiturates. **Barbituarate** are derivatives of barbituric acid, a chemical formed from urea and melonic acid.

2. **Tranquillizers:** They are formulations that reduce anxiety, mental tension and fatigue without inducing sleep e.g. benzodiazepine, chlordiazepoxide, methyl pentynol, meprobamate, hydroxyzine, etc. Some drugs have both sedative and transquillizer properties, tranquillo-sedatives**,** e.g diazepam (Valium).

3. **Opiate/Opioid Narcoties:** Opium is dried latex of unripe capsules of Poppy plant. It is taken orally or smoke. Opium has narcotic, analgesic, astringent and sedative effect. It contains a number of alkaloids like morphine, codeine, papaverine, thebaine, etc. Semisynthetic drugs produced from morphine and thebaine are hydromosphone, oxycodone, heroin or diacetyl morphine. Synthetic opiods are methadone, meperidine, propoxyphene, diphenoxylate, pentazocine, etc. Opiates are widely used to numb pain, relieve spasm, reduce anxiety / tension and cause drownsiness. They are, however, addictive.

4. **Stimulants:** These drugs provide excitement and make a person more active and wakeful. Addiction leads to psychological dependence. Physical or physiological dependence is absent. Withdrawal leads to restlessness, depression and anxiety.

- **Caffeine** is present in small quantities in Tea, Cocoa-Cola and other nonalcoholic beverages. In small quantities as contained in these drinks. caffeine brings about a refreshing change. It is diuretic.

- **Amphetamines** in common uses are methedrine, dexedrine and benzedrine. The drugs are popularly called 'pep pills'. They are used by some persons to work continously for hours or to reduce weight.

- **Cocaine** is a local anaesthetic, vasoconstrictor and powerful stimulant which is obtained from the leaves of Cocoa plant. The drug is bitter, white, crystalline powder. It is inhaled or injected. Cocaine gives a feeling of pleasure followed by hallucination. There is increase in heart beat, blood pressure and body temperature. Plasma half life is about I hour.

- **Habucinogens** are formulations which change one's perceptions, thoughts and feelings without any true sensory stimulus.

- **Mescaline** is a water soluble white powdery alkaloid, which is obtained from the crowns of cactus *Lophophora.* The alkaloid is similar to LSD and is highly hallucinogenic. It is also used in experimental psychology to produce hallucinations.

- **Psilocybine/Psilocybin** is a hallucinogenic drug obtained from mushroom *Psilocybe mexicana.* The mushroom contains both psychotropic and hallucinogenic drugs. It has been in use by locals in Mexico during various ceremonies.

- **LSD** or D-Lysergic acid diethylamide is crystalline alkaloid derived from ergot, an extract got from fruiting body of fungus *Claviceps purpurea*. There is marked hallucinaion, ecstasy and emotional outburst. There are mood changes, visual illusions, conflicting often bizarre preceptual changes, LSD leads to CNS damage, noncoordination of body parts, chromosomal aberrations and psychosis.

- **PCP/Phencyclidine** is a veterinary medicine used in immobilising large animals (dissociative anaesthetic). PCP is available to addicts as angel dust or white granular powder.

- **Hemp/Cannabis** produces four types of hallucinogenic products. (i) ***Bhang-*** It is fresh / dried leaves and flowering shoots of both male and female plants used as ingredient of a drink or other food article (ii) ***Ganja/ Marijuana-*** Dried unfertilised female inflorescence. Usually smoked in cigarettes. (iii) ***Charas/Hashish-*** Resin collected from flowering tops of generally female plants. Smoked (iv) ***Hash Oil-*** A lipid soluble plant extract. Highly concentrated.

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APPLICATIONS OF BIOLOGY

CHRONICLE IAS ACADEMY
A CIVIL SERVICES CHRONICLE INITIATIVE

DIAGNOSTIC INSTRUMENTS

- **ECG (Electrocardiograph:** It is an instrument used to record myo-electrical changes during cardiac cycle. **Electrocardiogram** is the recording to electrical potential produced during cardiac cycle from initiation and spread of cardiac impulse from SA node to AV node, AV bundle and Purkinje fibres. Abnormality in any part of the wave indicates pathological disorder of the region like myocardial damage, angina pectoris, valvular defects, coronary thrombosis, arterial flutter, sino-arterial block and ventricular fibrillation. **Ecocardiography** is sonographic (ultrasound) imaging of heart, great vessels, heart valves, heart walls, etc to know any abnormality. It is also used to record blood flow velocity and blood turbulance.
- **EEG (Electro-encephalograph):** It is an electricity operated instrument having electron tubes, transistors, microprocessors, microcomputers and digitals that is used in recording frequency, amplitude and morphology of electric activity from different parts of the brain. **Electro-encephalogram** is the recording of electrical potentials originating from different parts of the brain in the form of waves. EEG can diagnose epilepsy, brain tumours, abscesses, subdural haematoma, brain injury, drug induced hypothermic necrotic and other types of electrocerebral silent areas, sleep disorders, metabolic and drug effects on brain.
- **Squid:** Super-conducting quantum interference device, e.g., magnetoencephalograph.
- **MET:** It is magnetoencephalographi technique which employs SQUID for picking up weak magnetic waves emanating from brain. The technique gives information about the health of various parts of the brain.
- **Autoanalyser:** It is a fully automatic, computerised instrument which can analyse qualitatively and quantitatively various biochemicals present in body fluids like urea, uric acid, ketones, chloesterol, glucose, proteins, enzymes, etc.

IMAGING INSTRUMENTS

- **Tomography:** It is a technique of development of three-dimensional impression of an internal area through imaging of different layers. Tomography can indicate cysts, tubercular foci, calculi, cancer, etc.
- **CT Scanning** (Computerised/Computed Tomographic Scanning)**:** It is based on X-rays. X-ray imaging is carried out to detect diseases of lung, heart, fractures, joints, health of hollow organs, including kidneys through formulations having barium and iodine. However, direct X-rays cannot differentiate soft tissues. Images of all the structures in the path of X-rays are also superposed. **CT/scanning** was developed by Godfrey Hansfield in 1972 (Nobel-Prize 1979). It is a noninvasive technique with low level of radiation. CT scanning employs more than 30,000, 2 — 4 mm beams of X-rays falling in different horizontal plains. Computer reconstructs the images. The technique is useful in diagnosis of disorders in any part of the body like abdomen, chest, spinal cord and brain, internal haemorrhages, tumours, abscesses, disc-diseases, etc. It determines the method useful for treating disorders and for assessing result of treatment.
- **CAT Scan:** Computerised axial tomography (CAT) is specialised radiological technique (X-rays) for study of various parts inside the skull and location of any pathological condition. Now replaced by CT scanning.
- **PET:** Positron emission tomography or positron tomographic scanning is an investigative technique in which positron (positive electron) emitting radio-isotopes (generated by cyclotron) of common elements like ^{11}C, ^{13}N, ^{15}O and ^{18}F are incorporated in biochemicals like glucose, ammonia, amino acids, oxygen, carbon dioxide, etc. The biochemicals are injected or inhaled in small amounts and traced in the body. When provided to brain and monitored by **PET** comeras, computer indicates where neurons are damaged and are not metabolising normally. Thus **PET** is useful in measuring (i) Metabolic rates. (ii) Regional blood volume and blood flow. (iii) Areas of abnormalities like disease and defects. (iv) Identification of specific centres in brain like colour processing in visual cortex of humans.
- **MRI/Magnetic Resonance Imaging:** NMR is a noninvasive technique which can map internal tissues, highlight pathological changes and study tissue metabolism. A strong external magnetic field is created by large water cooled resistive magnets/super conductive magnets using liquid helium. Patient lies in the centre of magnetic ring. The external magnetic field generates magnetic resonance in nuclei of hydrogen atoms. Nuclei of carbon, phosphorus and sodium can also produce magnetic resonance. The signals are picked up by receiver coil, changed to digital form, and supplied to computer for image formation. Spectroscopy is used

for study of tissue metabolism. NMR is superior to CT and PET because (i) No ionising radiations are employed (ii) Images can be obtained from any plane instead of only cross-sectional area. (iii) Study of tissue metabolism (**PET** gives information of regional metabolic rate, **CT** only static anatomic images).

- **Sonography/Ultrasound Imaging:** Ultrasound (beyond human hearing or above 20,000 Hz) is produced by passing electricity through crystals of lead zirconate/ **piezoelectric effect.** Ultrasound is impinged on body parts. It is partly reflected as it passes from one layer to another. The reflected waves are picked up by lead zirconate crystals and changed to electrical signals which can be observed by oscilloscope screen/film. Sonography is also called **echography.** The visual record is known as **echogram/sonogram.** Ultrasound imaging is useful in studying the health of internal organs and diagnosing the disorder (e.g., kidney stones, gall bladder stones, intestinal obstruction fallopian tubes, uterus, etc.). It is often employed in determination of age, health and sex of the foetus.

THERAPEUTIC INSTRUMENTS

- **Pace-maker:** It is an electric device first developed by Chardack (1960) which is connected to heart for covering up any deficiency of myogenic functioning so as to make it beat normally (72-80/min, say from 30-40/min). A pace-maker has a pulse generator having long lasting lithium halide cells and a biocompatible plastic covered fine metallic string for functioning as electrode. In the common type, the pulse generator is placed below skin under right clavicle while the string/cable is passed via superior vena cava, right atrium and allowed to rest against the tip of right ventricle.
- **Laser:** Laser or light amplified by stimulated emission of radiation is a beam of very high energy particles. Depending upon the source of generation, it is called argon laser, carbon dioxide laser or neon laser. Medical lasers are used in place of several types of operations because they can be targeted on any tissue/organ inside the body, e.g., removal of opacity of eye lens, gall bladder stones (broken into powder form), treatment of tumours (e.g, retinal, brain, cancerous), kidney stones, etc. Laser beam focussed on a tissue can selectively burn out cancerous cells, or break stones into fine powdery mass.
- **Angioplasty:** It is a technique of opening a blocked coronary artery through balloning. The process is called percutaneous transluminal coronary angioplasty **(PTCA)**. Coronary artery-bypass surgery (CAS) is resorted to when the main left coronary artery or three-vessel coronary artery is blocked. A deflated dilation catheter and a guiding catheter are advanced over a guide wire into the blocked segment of coronary artery. The balloon is inflated with several atmospheres of pressure for 30 — 40 sec for two or more times till the blockage is removed. The same is confirmed through coronary angiography.
- **Angiography/Arteriography:** A radio-opaque contrast medium or fluoroscopic chemical is passed through various parts of the heart to study health of walls, valves, atria, ventricles, coronary arteries, etc. For study of coronary arteries (coronary angiongraphy), the chemical is injected directly into each coronary artery orifice and filming the progress of chemical 30 — 60 times per second.
- **Implants:** Implants are devices fitted in various body parts to overcome disorders, e.g., heart valves, joints, vascular grafts, cosmetic surgery. The material used in implants is nontoxic and biocompatible. Two common types of implants are artificial heart valves and vascular grafts.
- **Artificial Heart Valves:** Heart valves (semilunar, bicuspid, tricuspid) are working round the clock, some 1,04,000 operations a day and 1000 million cycles in 26 : 5 years. They may becomes damaged due to wear and tear, rheumatic fever and other diseases. Such valves require replacement with artificial ones as defective heart valves can lead to heart failure. Artificial valves are of two types :

  (i) Mechanical Valves. They are made of special biocompatible plastics, metal alloys and ceramics, having ball/disc occulder. Mechanical valves develop tendency of blood coagulation. Hence, blood anticoagulants are required.

  (ii) Tissue Valves. Obtained directly from pigs, cadavers (corpses) or made from pericardium of animals. The valves have the tendency to calcify with time, especially in young.
- **Vascular Grafts/Artificial Arteries:** Parts of blood vessels, especially arteries may become defective due to blockage, atherosclerosis, disease or aneurysm (dilation like a balloon with chances of rupturing and consequent death) requiring replacement. Artificial arteries/vascular grafts are pliable tubes generally made of fibrous plastic of **dacron** or **teflon.** They are less efficient when diameter is less than 6 mm. Rubber metallic (silver) and glass tubes can also be used.

BIOTECHNOLOGY

Biotechnology is the study and utilisation of living organisms or substances obtained from them in industrial/domestic and agricultural processes for producing useful materials. It is used in preparation of biogas, biofertilisers, alcoholic beverages, nonalcoholic beverages, sewage treatment, bread and other foods, dairy products, organic acids, enzymes, vitamins, antibiotics, vaccines, steroids,

hormones, transplants, gene therapy, etc. Biotechnology has advanced rapidly in the last two decades due to advances in biology, microbiology, biochemistry, immunology, molecular biology, genetic engineering and chemical engineering. Any organism can be used in biotechnology, e.g, cattle, pig, sheep, horse, monkey, yeast and a large number of microorganisms. For better yield, it is imperative to select a suitable strain / variety, evolve a suitable technique for extraction and purification of product. The first use of biotechnology must have been in pre-historic time when humans discovered the fermentation for alcoholic beverages and dairy products.

Methodology

Industrial utilisation of a biotechnology invovles three processes — laboratory scale process, pilot plant scale and manufacturing unit. The development from laboratory scale to manufacturing unit is called calling up.

1. **Laboratory scale:** Soon after the discovery of use of microorganism, the maximum number of strains are searched and the most suitable strain is selected and multiplied. A laboratory scale apparatus / plant is manufactured. It has a glass fermenter. All the parameters of the process are worked out like nutrients for the microbe, pH, aeration, disposal of CO_2 if evolved, optinum temperature, byproducts, product inhibition or stimulation, time of optimum production, separation of product and its purification. Ultimately, the laboratory scale process is finalised.
2. **Pilot Plant Scale:** It is an intermediate stage where working of the laboratory scale process is tested, cost and quality of the product are evaluated. Glass vessels are replaced by metallic containers. The container where fermentation is carried out is called **bioreactor.** Aeration system, pH corrections and temperature adjustments are perfected.
3. **Manufacturing Unit:** Its size is determined by the economic worked at during the pilot plant scale process. Bioreactor is often large. Microorganisms are added in bioreactors in three ways : (i) Support growth system or on surface of nutrient medium. (ii) Suspended growth system or suspended in nutrient medium. (iii) Column or immobilised growth system where microorganisms placed in calcium alginate beads are kept in columns.

ALCOHOLIC FERMENTATION

Louis Pasteur found for the first time that beer and butter milk are produced due to activity of Yeast and Yeast-like microorganisms. Yeast species used in alcoholic fermentation are *Saccharmoyces cerevisiae* (Brewer's Yeast), *S. ellipsoidens* (Wine Yeast), *S. sake* (Sake Yeast) and *S. pireformis* (Ginger Beer / Ale Yeast). The nutrient medium is barley malt for beer, fermented cereals for whisky, fermented molasses for rum and fermented juices for wines and brandy. Yeast does not possess sufficient diastase / amylase. Therefore, either 1% malt or *Rhizopus* is used when the nutrient medium consists of complex carbohydrates as present in cereals and Potato. Hydrolysis of starch is carried out in separate tank.

1. Bioreactor / fermentation tank is sterilised with the help of steam under pressure. The nutrient medium is added into the tank and sterilised similarly. The nutrient medium diluted with warm water is called **mash.**
2. When the nutrient medium is cooled down to appropriate temperature, it is inoculated with appropriate strain of Yeast. Fermentation occurs in three ways: (i) **Batch Process-** Bioreactor is very large (capacity upto 2,25,000 litres of medium). Yeast and nutrient are allowed to remain there till maximum alcohol content is achieved (6-12%). It is called wash / wort. The same is removed and the tank sterilised for the next batch. (ii) **Continuous Process-** There is a regular removal of a portion of fermented liquor / wash and addition of more nutrient. (iii) **Immobilised Yeast-** Lately Yeast is being used in immobilised state in calcium alginate beads. The technique is 20 times more efficient.
3. In case of beer, the fermented liquor is filtered, lightly hopped and pasteurised. In case of wines, 10-27% alcohol content is achieved through refinement and concentration. Fortification by direct addition of alcohol content is achieved through refinement and concentration. Fortification by direct addition of alcohol may also be carried. Distillation is done in other cases.
4. Bye-products of alcoholic fermentation are CO_2 and Yeast. A number of other chemicals can be formed with the change of nutrient medium, pH and aeration-n-propanol, butanol, amyl alcohol, phenylethanol, glycerol, acetic acid, pyruvic acid, succinic acid, lactic acid, caproic acid, ethyl acetate, acetaldehyde, diacetyl, etc.

Food Yeast

Common food yeast is *Torulopsis utilis.* It is cultured over molasses and starchy materials like Potato at 5 pH. Ammonium phosphate is added for stimulating growth. Waste sulphite liquor of paper industry is also used. Yeast obtained from brewing industry can be used as substitute food yeast. Food yeast is collected from culture, washed, dried and changed into cakes or pellets. It has 40-50% proteins, smalll quantity of fat, carbohydrates and vitamins. Fat rich food yeast is *Endomyces vernalis.* Both fats and proteins occur in *Cryptococcus* species. Vitamins include niacin, folic acid, thiamine and some others.

- **Baker's Yeast:** Selected strains of *Saccharomyces* are used as Baker's Yeast. It is available as powder or cake. The same is added to flour during kneading. Yeast secretes amylase (changes some starch to maltose), maltase (maltose to glucose) and zymase (glucose to ethyl alcohol and CO_2) evaporate. The bread becomes soft and porous.

Cheese

It is nutritive product of curdling and fermentation of milk that contains protein (20-35%), fat (20-30%), minerals and vitamins.

- **Unprocessed Cheese:** Milk is curdled with the help of cheese culture *Streptococcus lactis, S.cremoris, Leuconostoc citrovorum,* etc. Curd is heated gently to separate cheese from liquid called whey. Any liquid left in cheese is allowed to drain by hanging it in cloth. It is salted and mixed with cream for marketing. Unprocessed/ unripened cheese has short shelf life.
- **Processed Cheese:** It is of two types, cottage/unripened and ripened. Pasteurised skimmed milk is inoculated with cheese culture. Within 1-2 hours, rennet is added. Formerly, stomach of sheep and goat (lining has rennin) or sap of fig trees (enzyme ficia) was used. Rennet was isolated from Calf's stomach by Christian Hansen (1874). Fruit extract of *Withania coagulans* is also effective. Curd is placed in cloth lined porous containers for draining the whey. The left out solidified material is called cottage cheese. It can be consumed as such. Whey contains lactic acid, lactose and minerals. Blocks of cottage cheese are salted and placed in brine solution for a few days. The salt is now wiped and the cheese allowed to ripen for 1-16 months.
- **Yoghurt:** It is produced by first curdling of milk with the help of *Streptococcus themophilus* and *Lactobacillus bulgaricus* at 40—46°C and then partial fermentation by Yeast.
- **Butter Milk:** It is acidulated product which is formed by inoculating milk with starter culture of *Streptococcus cremoris, S.Lactis. Lactobacillus acidophilus, Leuconostoc citrovorum* or *L. dextranicum* followed by fermentation with Yeast.
- **Dextran:** It is a plasma extender having 6 — 10% solution of dextrins which is given in case of haemorrhage, shock and hehydration. Dextrins are soluble polyglucans or polymers of D-glucose. They are preparted either through partial hydrolysis of starch or partial polymerisation of simple sugars through microor ganism *Leuconostoc mesenteroids* or enzyme **dextran sucrase.** The enzyme is more useful as detran (= dextrin) of suitable molecular weight can be obtained more easily.

Organic Acids

Lactic acid was the first organic acid produced through fermentation.

BIO TECH. ENZYMES

Rene Reamer (1752) demonstrated digestive power for gastric juice. Dufrunfaut (1830) found that malt extract has the potential to change starch into sugar. Payen and Persoz (1833) prepared alcoholic extract of malt and named it diastase. Kuhne (1878) named the biocatalyst as enzyme. Buchner (1897) extracted the fermenting enzymes complex of Yeast and named it as zymase. Duclaux (1883) developed a system of naming enzymes. Over 2220 enzymes are known but only 250 (1-1.5%) are used in industry. Enzyme extraction and purification is difficult and expensive. Change in pH, temperature and a number of other factors deactivate enzymes.

Immobilisation of Enzymes: It is the process of fixing enzyme to or enclosing it in a solid support so as to protect it from deactivation and attack from proteases, maintain enzyme purity, ability to recover it after reaction and perform continuous reactions. Enzyme immobilisation is achieved by (i) Cross-linking of enzyme molecules. (ii) Attaching covalently to a solid support. (iii) Entrapping in a gel. (iv) Encapsulating in small artificial cells.

Enzyme	*Source*	*Applications*
1. Protease	*Mortierella renispora, Aspergillus oryzae, Bacillus subtilis*	*Chill proofing of alcoholic drinks. Cleaning of hides. Degumming of silk, Removing proten stains, manufacture of liquid glue, Softening of bread and meat.*
2. Amyases	*Rhizopus oryzae, Aspergillus oryzae, A. niger (taka diastase) Bacillus species.*	*Separation and desizing of fibres, Clearing of starch related turbidity in jucies, Softening and sweetening of bread, Alcoholic beverages from starchy nutrients. Amylase, glucoamylase and gluco-isomerase are used in converting Corn starch into sweet fructose rich Corn Syrup (sweeter than sucrose) that is used in sweetening and flavouring buiscuits, cakes and soft drinks.*
3. Rennin/Rennet	*Stomach of calf.*	*Preparation of cheese.*
4. Cellulase	*Myrothecium verrucaria (fungus)*	*Dissolving cell walls for specific staining and protoplast fusion.*
5. Pectinase	*Byssochalmys fulvo*	*Clearing of fruit juices, Retting of fibres, Preparation of green coffee.*
6. Glucose Oxidase	*Aspergillus niger, Penicillium notatum*	*Removal of glucose in foods to prevent browning (e.g., Egg).*
7. Lactase	*Saccharomyces fragilis, Torula cremoris.*	*Prevents crystal formation in ice cream and processed cheese.*
8. Protein Modifying Enzymes	*VArious Sources*	*Pig insulin to human insulin or humulin.*
9. Streptokinase (T.P.A or Tissue Plasminogen Activator)	*Hemolytic Streptococci*	*Fibrinolytic, used in clearing blood clots inside blood vessels.*

1. **Acetic Acid:** It is both microbial and synthetic. **Vinegar** is 10 - 13% ripened acetic acid. Initially melasses or other sugar solution is allowed to undergo alcoholic fermentation by least. It is an anaerobic process. As soon as 10 — 12% alcohol is formed, the liquid is filtered to remove Yeast. It is aerated and inoculated with *Acetobacter aceti.* The latter produces acid. When 10 — 13% acetic acid content is achieved, the liquid is filtered. The filtrate is allowed to ripen. It is pasteurised and called vinegar. The acid is concentrated for other purposes. Vinegar is used as souring agent, preservative and condiment. Acetic acid is used in plastics, pharmaceuticals, and production of solvents and flavouring agents.

2. **Citric Acid:** *Aspergillus niger, Mucor* species and Yeast (when medium is deficient in Fe and Mn) can ferment sugar to produce citric acid. Citric acid is preservative (food and canies) and flavouring agent. It is also used in medicines, engraving, dyeing and inks

3. **Lactic Acid:** First organic acid to be fermented, lactic acid is obtained by the activity of a number of bacteria like *Streptococcus lactis, Lactobacillus delbreukin, L. bulgaricus* and fungus *Rhizopus* over a variety of nutrient media like hydrolysed corn or potato starch, molasses, sulphite liquor, etc. It can also be extracted from whey. Lactic acid is used in clearing, flavouring and preserving confectionery, fruit juices, lemonades, pickles, curing of meat, canned fish vegetables and medicines. It is used as mordant in tanning, dyeing, printing of wool and preparation of plastics.

4. **Other Organic Acids:** (i) **Gallic acid** is obtained with the help of Aspergillus niger. It is employed in ink making. (ii) **Gluconic acid** is manufactured through the agency of *Penicillium purpurogenum,* for use as calcium gluconate (providing calcium to infants, lactating mothers and treating **milk fever** in high milk yielding cows) and in preparation of pharmaceuticals.

VITAMINS

Funk while working on causes and treatment of ber-beri isolated Vitamin B_1 (thiamine) in 1911 and coined the term of vitamin in 1912. Vitamin A was discovered by Mc Collum, Vitamin C by Szent-Gyorgyi (1928) and Vitamin D by Mellanby. First vitamin obtained through microbial activity was Vitamin C. Most vitamins are synthesised. Microbial activity is used in following cases:

1. **Vitamin B_2 (Riboflavin):** Manufactured chemically, secreted by intestinal bacteria, it was first obtained from activity of mould *Ashbya gossypii* in 1938. Present day strains yield 100 — 300 time more vitamin. Other microbes used are *Clostridium butyricum, C.acetobutylicum* and yeast-like *Eremothecium ashbyii.* Nutrient medium consist of crude sugar (1%), corn syrup (1%) , sulphite liquor (0.5%), some peptone of animal source and antifoaming agent. Aeration is provided. After four days, cells are collected. They contain upto 2.5% riboflavin. Butyl alcohol is used in extraction. Reside after separation of fermented mash also contains B_2.

2. **B_{12} (Cobalamin/Cyanocobalamin):** It was first isolated from liver extract in 1948 and fermentation during antibiotic production. Organisms used are *Propionibacterium frendeureichii, Pseudomonas denitrificans, Bacillus megatherium* and *Streptomyces oliaceous.* Nutrient medium is made of starch, corn syrup, corn sugar or molasses. The cells are harvested and autolysed to separate the vitamin.

3. **Vitamin C:** *Acetobacter* is helpful in dehydrogenation of D-sorbitol and its conversion to L-sorbose. The latter is precursor vitamin C or L-ascorbic acid.

- **Pasteur:** First to prove that Beer and Butter Milk are products of fermentation by Yeast.
- **Christian Hansen** (1874)**:** First to purify an enzyme, rennet.
- **Streptomyces griseus:** Produces 41 different types of antibiotics.
- **Bacillus subtilis:** Forms 60 types of antibiotics.
- **Saccharomyces pombe:** Ginger Beer Yeast.
- **Saccharomyces prombe:** African beer Yeast.
- **DNA Finger Printing:** Developed by Alec J. Jeffreys in 1985. He found hypervariable repeating sequences in DNA as distinctive for every human being. First used for a criminal case in 1988.
- **Babes** (1855)**:** First demonstrated antibiosis. Concept was propounded by Paul Vuillemin (1889).

STEROIDS

They are complex crystallisable lipids having a tetracyclic hydrocarbon core (one 5-carbon and three 6-carbon rings) and a long side chain. They are constitutents of cell membranes, hormones and some important biochemicals like cholestrol, progesterone oestrogen, testosterone cortisterone, and cortisone. Steroids are used medicinally in correcting hormonal imbalance, anabolic stimulants, birth control pills, antifertility drugs, anti-inflammatories, relieving pain and suppressing immune responses, Various steroids differ from one another in radicals like**—OH=O,—$COCH_3$,—$COCH_2OH$**. Murray and Peterson (1950) found that *Rhizopus stolonifer* could bring about hydroxylation required for steroid synthesis. Since then a number of microorganisms have been found to perform this activity. Different microorganisms produce different steroids from progesterone like pregnane, cortexolone, androsterone, etc. Formation of anti-inflammatory drug prednisolone from cartexolone requires microbe-mediated first hydroxylation and then microbe-mediated dehydrogenation.

ABC OF ANTIBIOTIC

Antibiotic	Source	Action
Pencillin	Pencillium chryso-genum, P. notatum + Phenyl Acid	Tonsilitis, Sore Throat, Gonorrhoea, Rheumatic Fever, some Pneumonia types.
Griseofulvin	Penicillium griseofulvum	Antifungal, especially for Ringworm.
Nystatin	Streptomyces noursei	Antifungal for Candidiasis and overgrowth of Intestinal Fungi during excessive antibiotic treatment.
Hamycin	Streptomyces pimprei	Antifungal for Thrush
Fumagillin	Aspergillus fumigatus	Broad spectrum antibacterial especially against Salmonella and Shigella.
Bacitracin	Bacillus licheniformis	Syphilis, Lymphonema or Reticulosis.
Streptomycin	Streptomyces griseus	Meningitis, Pneumonia, Tuberculosis and Local Infections. Toxic in some through eighth cranial nerve.
Chloramphenicol/ Chloromycetin	Streptomyces venezuelae, S. lavendulae, Now synthetic	Typhoid, Typhus, Whooping Cough. Atypical Pneumonia, Bacterial Urinary Infections.
Tetracyclines/ Aureomycin Hydrogenation	Streptomyces aureofacines Chlorotetracyline	Viral Pneumonia, Osteomyelitis, Whooping Cough, Eye Infections.
Oxytetracycline/ Terramycin	Streptomyces rimosus	Intestinal and Urinary Infections (Spirochaetes, Rickettsiae, Viruses).
Erythromycin	Streptomyces erythreus	Typhoid, Common Pneummonia, Diphtheria, Whooping Cough etc.

ANTIBIOTICS

The term was coined by Waksman (1942). Clinically, an antibiotic is a substance produced by a microorganisms which in low concentration inhibits the growth and metabolic activity of pathogenic organisms without harming the host. Antibiosis was first shown by Babes (1855). Pasteur and Joubert (1899) proposed concept of antibiosis. Rene Dubois was first to produce an antibiotic named **tyrothricin** from *Bacillus brevis.* However, first antibiotic is generally associated with the name of Alexander Fleming (1928) when he discovered **penicillin** from *Penicillium notatum* (did not allow growth of *Staphylococus aureus*). Waksman and Woodruff isolated actinomycin in 1941 and streptothricin in 1942. Waksman and Albert (1943) and Waksman (1944) discovered streptomycin. Burkholder (1947) isolated chloromycetin.

Over 7000 antibiotics are known. Every year some 300 new antibiotics are discovered by means of **hypersensitive microorganisms** (started in 1970). *Streptomyces griseus* produces more than 41 antibiotics while *Bacillus subtilis* can give about 60 antibiotics.

- **Broad Spectrum Antibiotic:** It is an antibiotic which can kill or destroy a number of pathogens that belong to different groups with different structure and wall composition.
- **Specific Antibiotic:** It is an antibiotic which is effective only against one type of pathogens.
- **Action**. An antibiotic acts on pathogen by (i) Disruption of wall synthesis. (ii) Disruption of plasmalemma repair and synthesis. (iii) Inhibition of DNA/RNA/protein synthesis.
- **Good Antibiotic:** (a) Harmless to host with no side effect. (b) Harmless to normal micro-flora of alimentary canal. (c) Ability to destroy pathogen as well as broad spectrum. (d) Effective against all strains of pathogen. (e) Quick action.
- **Resistance to Antibiotics:** Pathogens often develop resistance to existing antibiotics so that newer antibiotics so that newer antibiotics are required to be produced. The resistance is produced due to (i) Development of copious mucilage. (ii) Alteration of cell membrane so that antibiotic cannot recognise the pathogen. (iii) Alteration of cell membrance which prevents antibiotic entry. (iv) Change to L-form by pathogen. (v) Mutation in pathogen. (vi) Development of pathogen enzyme capable of modifying antibiotic.
- **Production of Antibiotic:** Suitable strain of microorganism is cultivated on a sterilised nutrient medium provided with optimum pH, aeration, temperature, antifoaming agent and antibiotic precursor (if any). When sufficient antibiotic has diffused into the medium, the microorganism is separated and the antibiotic extracted from medium by precipitation, absorption or solvent. It is purified, concentrated and bioassayed before packing.

Antibiotics are obtained from lichens, fungi eubacteria, and actinomycetes. The common antibiotic, from lichens is usnic acid (*Usnea and Cladonia).* Amongst elubacteria, two account for most antibiotics, *Bacillus* (70%) and *Pseudomonas* (30%), Fungi yield a number of antibiotics like penicillin, patulin and griseofulvin (*Penicillium* species), cephalosporins, antiamoebin (*Emericellopsis)*, polyporin (*Polystictus sanuineus)*, clitocybin (*Clitocybine gigantea*), citrinin (*Aspergillus clavatus, Penicillium citrinum)*, clavacin (*Aspergillus clavatus)*, etc. Most famous drugs are got from actinomyeetes, especially *Streptomyces.*

VACCINES

Vaccine is a liquid containing dead, attenuated form or antigens of a pathogen which can be injected or taken orally to provide immunity (acquired active, short or long duration) towards that pathogen. Vaccination or administration of vaccine was discovered by Edward Jenner (1796) when he immunised a boy against small pox by inoculating him with milder cow pox. The technique of attenuating or weakening of pathogen was discovered by Louis Pasteur (1879, agaisnt cholera).

- **First Generation Vaccines:** They are the ones obtained by conventional technique involving killing or weakening (attenuation) of the pathogen. The vaccines are seldom of uniform quality. They may have side effects.
- **Second Generation Vaccines:** They are vaccines made of pure surface antigens of the pathogens only which are multiplied through genetic engineering or recombinant DNA technique, e.g., vaccine against hepatitis **B.**
- **Third Generation Vaccines:** They are purest, highest potency vaccines which are synthetic in nature.

■■

BIOLOGY (SAMPLE QUESTIONS)

Civil Services CHRONICLE

1. Which of the following is/are true about Japanese Encephalitis?
   I. It is spread by mosquitoes.
   II. Its vaccine is prepared at Central Drug Research Institute, Lucknow.
   III. The government has allocated separate budget allocation for its eradication.
   (a) Only I. (b) Only II.
   (c) Only III. (d) I, II and III.

2. Which of the following are true about Polio?
   I. It is a non-communicable disease.
   II. There is no drug to kill its virus or control its spread.
   III. The virus enters the body through mouth and multiplies in intestine.
   IV. All the people infected by virus don't get Polio.
   (a) I , II and III. (b) I, II and IV.
   (c) II, III and IV. (d) I, II, III and IV.

3. Consider the following statements:
   1. Iron fortified Iodized Salt is to be promoted to battle Malnutrition in the Country.
   2. Double fortified salt has been made mandatory in PDS distribution.

   Which of the above statement(s) is/are correct?
   (a) 1 only (b) 2 only
   (c) Both (d) None

4. Pigeon pea provides a well-balanced diet when accompanied with cereals and known as the "poor people's meat" because of its high -------
   (a) fat content
   (b) carbohydrate content
   (c) protein content
   (d) iron content

5. Nowadays there is a large scale promotion of for using Olive oil in cooked food. Which of the following is implicit to this?
   1. Olive oil has more than 70% mono-unsaturated fats, meaning a single bond in its structure which reduces bad fats and triglycerides.
   2. Using these oils can be highly beneficial in reducing the fat deposition in liver.
   3. There is also a problem associated with olive oil-its overabundance of oleic acid, which creates an imbalance on the cellular level that can inhibit prostaglandin production, which can increase the risk of breast cancer.
   4. It is widely considered to make a significant decrease in the waist circumference, body mass index levels and insulin resistance in people.
   (a) 1 and 2 (b) 2, 3 and 4
   (c) 3 and 4 (d) all of the above

6. Which of the following statements is NOT correct about breathalyzer?
   (a) It is used for estimating blood alcohol content from breath sample.
   (b) It analyses breath by oxidizing ethanol content in the breath into acetic acid.
   (c) Breathalyzer also uses infrared beam to analyze alcohol content in breath.
   (d) Use of breath mints or onion can fool a breathalyzer test.

7. (1) WBC's are formed in bone marrow, while RBC's are formed in Liver & Spleen.

   (2)WBC's count is higher in females, whereas RBC content is higher in males.

   Which of the above statements are correct?
   (a) (1) is correct
   (b) (2) is correct
   (c) Both are correct
   (d) Both are wrong

8. Which of the following is fat soluble vitamin?
   (a) Vit. B & C (b) Vit. A & D
   (c) Vit. B & E (d) Vit. K & C

9. In the human body, which structure is the appendix attached to?
   (a) Large intestine (b) Small intestine
   (c) Gall bladder (d) Stomach

10. The food we eat has to be processed to generate particles which are small and of the same texture. This is achieved by crushing the food with our teeth. When we eat something we like, our mouth 'waters'. This is actually not only water, but fluid called saliva secreted by the salivary glands. The saliva contains an enzyme called -------
   (a) salivary protease
   (b) salivary amylase
   (c) salivary lipase
   (d) pepsin

11. Consider the following statements:
   I. During the process of respiration, complex organic compounds such as glucose are broken down to provide energy in the form of ADP.
   II. Anaerobic respiration makes more energy available to the organism.

   Select the correct answer from the below code:
   (a) Only I
   (b) Only II
   (c) Neither I nor II
   (d) Both I and II

12. Vitamins are organic food substances found only in living things, i.e. plants and animals. They are essential for human bodies to function properly, for growth, energy and for our general well-being. Match the following Vitamins in list I with their correct benefits to the human body in list II.

Vitamins	Benefits
A. Beta Carotene	I. helps the body turn food into energy
B. Ascorbic Acid	II. promotes a healthy immune system
C. Riboflavin	III. form collagen, a tissue that helps to hold cells together
D. Niacin	IV. Aids in reproduction and cell regeneration

Codes:
(a) A-I; B-III; C-II; D-IV
(b) A-II; B-III; C-IV; D-I
(c) A-I; B-IV; C-II; D-III
(d) A-II; B-IV; C-III; D-I

13. Recently scientists have created the world's first genome-wide digital atlas of gene enhancers in the brain. Consider the following statements about gene enhancers and select the correct answer?
   I. Gene Enhancers are short pieces of DNA in the human genome.
   II. They are actual genes, so they give rise to proteins.
   III. 'They are switches that tell the actual genes when to become active and make a protein.

Codes:
(a) I, II only
(b) II, III only
(c) I, III only
(d) All

14. Consider the following statements about Cyanobacteria and select the correct answer?
   I. Cyanobacteria, also known as blue-green bacteria or blue-green algae are a phylum of bacteria that obtain their energy through photosynthesis.
   II. Cyanobacteria can be found only in aquatic habitat both oceans and fresh water.
   III. Cyanobacteria can convert carbon dioxide into 2, 3 butanediol, that can be used to make paint, solvents, plastics and fuels.

Codes:
(a) I, II only
(b) I, III only
(c) II, III only
(d) All

15. Cellular respiration is the process of breaking down food molecules to obtain energy and store it in the form of adenosine triphosphate (ATP) molecules. The process of breakdown of glucose molecules involves two major stages - glycolysis (anaerobic respiration) and aerobic respiration. Read the following stements:

I. Glycolysis process takes place in the cytoplasm of the cells.

II. Aerobic respiration takes place in mitochondria.

III. The breakdown of pyruvate to give carbon dioxide, water and energy takes place in cytoplasm of the cell.

Which of the above statements is/are correct?

(a) I and III

(b) II and III

(c) I and II

(d) All of the above

16. Couples could be assisted to have children through certain special techniques commonly known as assisted reproductive technologies (ART).Consider these statements regarding this:

I. Artificial insemination (AI), followed by embryo transfer (ET) is one of such methods. In this method, popularly known as test tube baby programme, ova from the wife/donor (female) and sperms from the husband/donor (male) are collected and are induced to form zygote under simulated conditions in the laboratory.

II. Transfer of an ovum collected from a donor into the fallopian tube (GIFT - gamete intra fallopian transfer) of another female who cannot produce one, but can provide suitable environment for fertilisation and further development is another method attempted.

III. In in vitro fertilisation (IVF)), the semen collected either from the husband or a healthy donor is artificially introduced either into the vagina or into the uterus (IUI - intra-uterine insemination) of the female.

Which of the statements is/are correct?

(a) Only I and II

(b) Only II and III

(c) Only III

(d) Only II

17. Immunization is one of the most important preventive health actions in children's lives, as it provides protection against the most dangerous childhood diseases. GOI has recently introduced the pentavalent vaccines in few states. Read the following statements regarding Pentavalent vaccines:

I. The vaccine protects children from diphtheria, tetanus, whooping cough, hepatitis B and Haemophilus influenza type b.

II. It was introduced as a pilot project in India in Kerala only. Whereas now it has been introduced in Gujarat, Karnataka, Haryana,Goa, J&K and Pondicherry.

III. It will be provided along with the current Hepatitis B and DPT primary vaccination schedule in the immunization programme.

Which of the above statements are true?

(a) Only I

(b) Only I and II

(c) Only II

(d) Only II and III

18. The brain is one of the largest and most complex organs in the human body. It is made up of more than 100 billion nerves that communicate in trillions of connections called synapses. Read the following statements realted to human brain and choose the correct answer from the codes given below:

I. The human brain is the fattest organ in the body.

II. The cerebellum is the largest part of the brain, accounting for 85 percent of the organ's weight, controls all voluntary actions in the body.

III. The two hemispheres of the brain contribute to the processing and understanding of language: the left hemisphere processes the rhythm, stress, and intonation of speech while the right hemisphere processes the emotions conveyed by it.

IV. The Hypothalamus part of the brain regulates body temperature much like a thermostat.

Codes:

(a) II and III

(b) III and IV

(c) I, II and IV

(d) I, III and IV

19. Mitochondria are powerhouse of the cell and it has symbiotic origin. Choose the correct statements about mitochondria:

i. Mitochondria are involved with synthesis of ATP in the cell.

ii. Mitochondria are absent in bacteria.

iii. Mitochondrion contains DNA and Ribosome.

Choose the correct answers:

(a) i, ii and iii

(b) i and ii

(c) i and iii

(d) ii and iii

20. Which of the following statements are true about Human Genome Project's result?

I. The total number of genes in human call is about 30000.

II. Exact functions of about 50 percent genes are unknown.

III. About 98 percent of genome codes for protein.

Choose the correct answers:

(a) I, II and III

(b) I and II

(c) I and III

(d) II and III

21. Consider the following statements:

I. DNA computing will use DNA codes to store enormous amount of data.

II. A hard strain of bacteria has been selected for DNA computing called Bacillus subtilis.

III. DNA computer can deliver the drug and scan the tissue for a specific disease.

Which of the above statements is/are NOT correct?

(a) Only I and II

(b) Only II and III

(c) Only I

(d) None

22. Transpiration is the evaporation of water from aerial parts of plants, especially from leaves but also from stems and flowers. Which of the following statements are true in relation to transpiration and water movements in plants?

I. Removing all the leaves from a plant will increase the flow of water up the stem.

II. Covering both sides of leaf with a plastic film will reduce both stomatal and cuticular transpiration.

III. Leaves with bigger surface will transpire faster and leaves with smaller surface will transpire slower.

Codes:

(a) Only II

(b) I and II

(c) II and III

(d) I and III

23. Which of the following statements are true about tears secreted by the glands?

I. Tear fluid contains water, glucose, urea, sodium, and potassium.

II. They lubricate the eye, and help to keep it clear of dust.

III. It contains an enzyme known as lysozyme.

Codes:

(a) I and II

(b) II and III

(c) I and III

(d) All

24. What is the importance of roughage in our diet?

I. It helps in retaining water in the body.

II. It is necessary for normal functioning of the liver as it balances intestinal pH.

III. Attracts water and forms a viscous gel during digestion, slowing the emptying of the stomach and intestinal transit, shielding carbohydrates from enzymes, and delaying absorption of glucose, which lowers variance in blood sugar levels.

Codes:

(a) I and II

(b) II and III

(c) I and III

(d) III only

25. Bile is a complex fluid containing water, electrolytes and a battery of organic molecules including bile acids, cholesterol, phospholipids and bilirubin. Which of the following are true about bile?

I. It is an enzyme secreted by the liver which helps in emulsifying fats in food.

II. It is a watery green liquid.

III. The gall bladder stores and concentrates bile during the fasting state.

IV. Biles are critical for digestion and absorption of fats and fat-soluble vitamins in the small intestine.

Codes:

(a) I, II and III

(b) II, III and IV

(c) I, III and IV

(d) III and IV

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BIOLOGY (SAMPLE QUESTIONS) (ANSWERS)

CHRONICLE IAS ACADEMY
A CIVIL SERVICES CHRONICLE INITIATIVE

1 (a)
2 (c)
3 (a)
4 (c)
5 (c)
6 (d)
7 (d)
8 (b)
9 (a)
10 (b)
11 (c)
12 (b)
13 (c)
14 (b)
15 (c)
16 (d)
17 (a)
18 (d)
19 (a)
20 (b)
21 (d)
22 (c)
23 (d)
24 (c)
25 (b)

❖❖❖

BIOLOGY (UPSC QUESTIONS)

Civil Services CHRONICLE

1. Recombinant DNA technology (Genetic Engineering) allows genes to be transferred
   1. across different species of plants
   2. from animals to plants
   3. from microorganisms to higher organisms

   Select the correct answer using the codes given below.
   (a) 1 only
   (b) 2 and 3 only
   (c) 1 and 3 only
   (d) 1 2 and 3 only

2. Improper handling and storage of cereal grains and oilseeds result in the production of toxins known as aflatoxins which are not generally destroyed by normal cooking process. Aflatoxins are produced by
   (a) bacteria
   (b) protozoa
   (c) moulds
   (d) viruses

3. Consider the following organisms
   1. Agaricus
   2. Nostoc
   3. Spirogyra

   Which of the above is / are used as biofertilizer / biofertilizers
   (a) 1 and 2
   (b) 2 only
   (e) 2 and 3
   (d) 3 only

4. Which of the following adds / add nitrogen to the soil?
   1. Excretion of urea by animals
   2. Burning of coal by man
   3. Death of vegetation

   Select the correct answer using the codes given below.
   (a) 1 only
   (b) 2 and 3 only
   (c) 1 and 3 only
   (d) 1, 2 and 3

5. Which of the following diseases can be transmitted from one person to another through tattooing?
   1. Chikungunya
   2. Hepatitis B
   3. HIV-AIDS

   Select the correct answer using the codes given below.
   (a) 1 only
   (b) 2 and 3 only
   (c) 1 and 3 only
   (d) 1, 2 and 3

6. Consider the following minerals
   1. Calcium
   2. Iron
   3. Sodium

   Which of the minerals given above is/are required by human body for the contraction of muscles?
   (a) 1 only
   (b) 2 and 3 only
   (c) 1 and 3 only
   (d) 1, 2 and 3

7. With reference to the food chains in ecosystems, which of the following kinds of organism is / are known as decomposer organism/organisms?
   1. Virus
   2. Fungi
   3. Bacteria

Select the correct answer using the codes given below.

(a) 1 only

(b) 2 and 3 only

(c) 1 and 3 only

(d) 1, 2 and 3

8. Consider the following fauna of India:
   1. Gharial
   2. Leatherback turtle
   3. Swamp deer

   Which of the above is/are endangered?

(a) 1 and 2 only

(b) 3 only

(c) 1, 2 and 3

(d) None

9. Which of the following leaf modifications occurs/occur in desert areas to inhibit water loss?
   1. Hard and waxy leaves
   2. Tiny leaves or no leaves
   3. Thorns instead of leaves

   Select the correct answer using the codes given below.

(a) 1 and 2 only

(b) 2 only

(c) 1 and 3 only

(d) 1, 2 and 3

10. Widespread resistance of malarial parasite to drugs like chloroquine has prompted attempts to develop a malarial vaccine to combat malaria. Why is it difficult to develop an effective malaria vaccine ?

(a) Vaccines can be developed only against bacteria

(b) Man does not develop, immunity to malaria during natural infection

(c) Malaria is caused by several species of Plasmodium

(d) Man is only an intermediate host and not the definitive host

11. With reference to 'stem cells', frequently in the news, which of the following statements is/are correct?
   1. Stem cells can be derived from mammals only.
   2. Stem cells can be used for screening new drugs.
   3. Stem cells can be used for medical therapies.

   Select the correct answer using the codes given below:

(a) 1 and 2 only (b) 2 and 3 only

(c) 3 only (d) 1, 2 and 3

12. At present, scientists can determine the arrangement or relative positions of genes or DNA sequences on a chromosome. How does this knowledge benefit us?
   1. It is possible to know the pedigree of livestock.
   2. It is possible to understand the causes of all human diseases.
   3. It is possible to develop disease-resistant animal breeds,

   Which of the statements given above is/are correct?

(a) 1 and 2 only

(b) 2 Only

(c) 1 and 3 only

(d) 1, 2 and 3

13. When the bark of a tree is removed in a circular fashion all around near its base,it gradually dries up and dies because

(a) Water from soil cannot rise to aerial parts

(b) Roots are starved of energy

(c) Tree is infected by soil microbes

(d) Roots do not receive oxygen for respiration

14. Regular intake of fresh fruits and vegetables is recommended in the die since they are a good source of antioxidants. How do antioxidants help a person maintain health and promote longevity?

(a) They activate the enzyme necessary for vitamin synthesis in the body and help prevent vitamin deficiency

(b) They prevent excessive oxidation of carbohydrates, fats and protein in the body and help avoid unnecessary wastage of energy

(c) They neutralize the free radical produced in the body during metabolism

(d) They activate certain genes in the cells of the body and help delay the ageing process

15. King Cobra is the only snake that makes its own nest. Why does it make its nest ?
    (a) It is a snake-eater and the nest helps attract other snakes
    (b) It is a viviparous snake and needs a nest to give birth to its offspring
    (c) It is an oviparous snake and lays its eggs in the nest and guards the nest until they are hatched
    (d) It is a large, cold blooded animal and needs a nest to hibernate in the cold season

16. Which one of the following processes in the bodies of living organisms is a digestive process?
    (a) Conversion of glucose into glycogen
    (b) Breakdown of glucose into CO2 and H20
    (c) Breakdown of proteins into amino acids
    (d) Conversion of amino acids into proteins

17. From the point of view of evolution of living organisms, which one of the following is the correct sequence of evolution ?
    (a) Otter -Tortoise - Shark
    (b) Shark - Tortoise - Otter
    (c) Tortoise - Shark - Otter
    (d) Shark - Otter - Tortoise

18. Consider the following statements :
    1. Hepatitis B is several times more infectious than HIV/AIDS
    2. Hepatitis B can cause liver cancer.

    Which of the statements given above is /are correct ?
    (a) 1 only
    (b) 2 only
    (c) Both 1 and 2
    (d) Neither 1 nor 2

19. Excessive release of the pollutant carbon monoxide (CO) into the air may produce a condition in which oxygen supply in the human body decreases. What causes this condition ?
    (a) When inhaled into the human body, CO is converted into CO2
    (b) The inhaled CO has much higher affinity for haemoglobin as compared to oxygen
    (c) The inhaled CO destroys- the chemical structure of haemoglobin
    (d) The inhaled CO adversely affects the respiratory centre in the brain

20. Consider the following statements :
    1. Every individual in the population is equally susceptible host for Swine Flu.
    2. Antibiotics have no role in the primary treatment of Swine Flu
    3. To prevent the future spread of Swine Flu in the epidemic area, the swine (pigs) must all be culled.

    Which of the statements given above is/are correct ?
    (a) 1 and 2 only
    (b) only
    (c) 2 and 3 only
    (d) 1, 2 and 3

21. With regard to the transmission of the Human Immuno deficiency Virus, which one of the following statements is not correct ?
    (a) The chances of transmission from female to male are twice as likely as from male to female
    (b) The chances of transmission are more if a person suffers from other sexually transmitted infections
    (c) An infected mother can transmit the infection to her baby during pregnancy, at childbirth and by breast feeding
    (d) The risk of contracting infection from transfusion of infected blood is much higher than an exposure to contaminated needle

22. Consider the following statements about probiotic food :
    1. Probiotic food contains live bacteria which are considered beneficial to humans.
    2. Probiotic food helps in maintaining gut flora.

    Which of the statements given above is/are correct ?

(a) 1 only

(b) 2 Only

(c) Both 1 and 2

(d) Neither 1 nor 2

23. What is the pH level of blood of normal persoan?

(a) 4.5-4.5

(b) 6.45-6.55

(c) 7.35-7.45

(d) 8.25-8.35

24. Among the following, which one lays eggs anad does not produce young ones directly ?

(a) Echidna

(b) kangaroo

(c) Porcupine

(d) Whale

25. The release of which one of the following into ponds and wells helps in controlling the mosquitoes ?

(a) Crab

(b) Dogfish

(c) Gambusia fish

(d) Snail

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BIOLOGY (UPSC QUESTIONS) (ANSWERS)

CHRONICLE IAS ACADEMY
A CIVIL SERVICES CHRONICLE INITIATIVE

1 (a)
2 (c)
3 (b)
4 (c)
5 (b)
6 (c)
7 (b)
8 (c)
9 (d)
10 (b)
11 (b)
12 (d)
13 (a)
14 (c)
15 (c)
16 (c)
17 (b)
18 (c)
19 (b)
20 (a)
21 (a)
22 (c)
23 (c)
24 (a)
25 (c)

❖❖❖