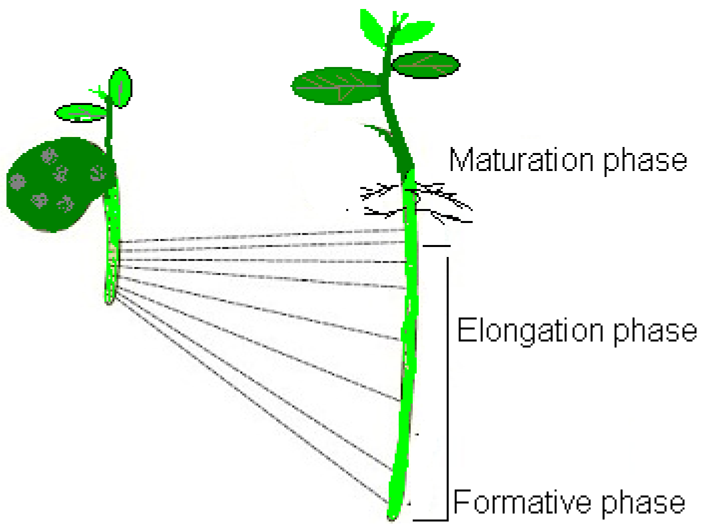
- Growth is a process in which there is increase in the size by cell division and enlargement accompanied by the formation of new cellular material. It results in the irreversible increase in size, length area or volume accompanied by increase in dry weight. In living beings, growth is internal or intrinsic in contrast to extrinsic growth observed in some non-living objects. Irreversible increase in size, mass or volume of living beings is an external manifestation of growth. Further growth is a quantitative phenomenon which can be measured in relation to time.
- Development can be defined as a process in which there is a sequence of qualitative changes, towards a higher or more complex state. It includes all the changes an organism undergoes from the time of birth till death. In development plant shows a regular sequence of seed germination, growth, differentiation, maturation, seed formation and senescence.

CHARACTERISTICS OF GROWTH

- Primary growth is formation of primary permanent tissues and organs. It is caused by activity of apical and intercalary meristems.
- Secondary growth is increase in girth. It occurs by two types of lateral meristems, vascular cambium and cork cambium.
- Unlimited growth is growth that continues throughout life as it occurs in case of root and stem. Limited growth is that growth which stops after some time, e.g. leaves, flowers, fruits
- In higher plants the growth involves three steps or phases
  - Phase of cell division
  - Phase of cell enlargement
  - Phase of cell maturation



GROWTH RATES

The expression of increased growth per unit time is called growth rate.

Growth rate shows two types of increase

- Arithmeticgrowth : It is a type of growth in which the rate of growth is constant and increase in growth occurs in arithmetic progression 2,4,6,8 etc. Here after mitosis, only one daughter cell continuous to divide. Other take part in differentiation and maturation i.e. root elongating at constant rate. Here a linear curve is obtained with value

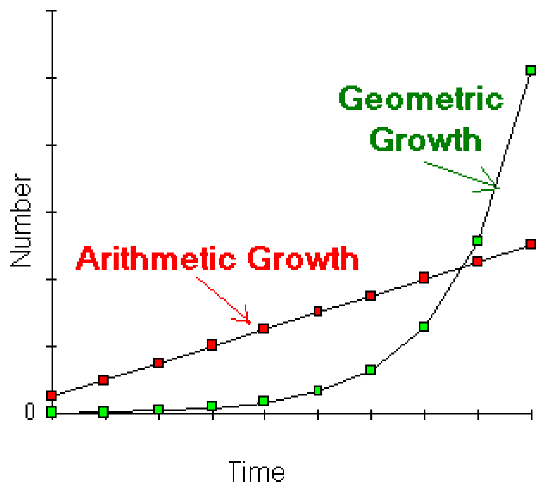
$$L_t = L_o + rt$$

L_t : Length at time t

L_o = Length at time 'zero'

R : growth rate

- Geometric growth: It is quite common in unicellular organisms when growth in nutrient rich medium. Here every cell divides. The daughter grow and divide. The granddaughter repeat the process and so on. Number of cells is initially small so that initial growth is slow. Later on, there is rapid growth at exponential rate. An embryo log or exponential growth. An embryo initially shows geometrical growth in cells, but later it passes into arithmetic phase



GROWTH CURVE

- The exponential growth curve can be represented by equation

$$W_t = W_o e^{rt}$$

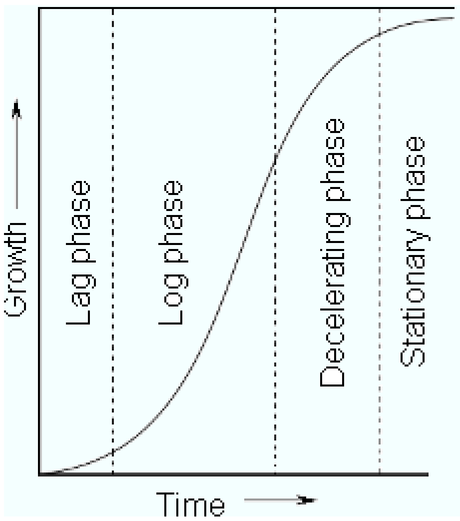
W_t : Final size

W_o : Initial size at beginning of the time period

r : growth rate

t : time of growth

- V.H. Blackman (1919) suggested 'r' might be used as a measure of the ability of a plant to produce new plant material and called it efficiency index
- The rate of growth is not uniform for a cell, organ or an organism. If the growth rates of a plant are plotted against time on a paper, a sigmoid growth curve or S-shaped growth curve is obtained. It consists of lag phase or slow phase, log phase or exponential growth phase, rate becomes more rapid and senescence phase or declining phase. A steady phase or stationary phase(limited growth) occurs at the end.



MEASUREMENT OF GROWTH

- Growth is measured with the help of auxometer, horizontal microscope and crescograph (developed by Sir J.C.Bose)
- Growth can be measured by measuring increase in weight area and volume in fresh and dry form. In yeast and bacteria, increase in length, number of cells can be taken into account.
- In arc auxometer, when growth occurs, stem increases in length. Due to pressure of weight wheel rotates gradually. This leads to movement of indicator on arc scale. This reading on graduated arc provides information about the rate of growth.

FACTOR INFLUENCING GROWTH AND DEVELOPMENT

1. LIGHT
   It controls photosynthesis, transpiration, pigment formation, tissue differentiation seed germination, etc. Ultraviolet ray are inhibitory. They induce rosette formation. Red light promotes growth but plant organs are soft. Blue light produce normal slightly less growth. Low light intensity increases intermodal length and leaf size. High light intensity decreases their size but allows more Certain seed germinate only in the presence of light, eg. Viscumalba. Seeds of lettuce and tobacco require red light for their

germination. Certain other seeds e.g. onion cannot grow in the presence of light. Light induces tissue differentiation in plants. Light induced tissue differentiation is called photo-morphogenesis. It involves photoreceptor pigment system called phytochrome. This can be observed by growing seedlings in dark. The seedlings are pale and weak. The phenomenon is etiolation and seedlings known as etiolated seedlings.

Etiolated seedlings have:

(i) Pale colour
(ii) Long internodes
(iii) Subterminal hook
(iv) Small pale leaver
(v) No mechanical tissue
(vi) Small and few roots

2. TEMPERATURE
   Minimum, optimum and maximum temperature for plant growth are 2^{O} -5^{O} C. 20^{O} -30^{O} C., 40^{O} -50^{O}C. Lower temperature inactivates enzymes. It increase density of protoplasm. There is little absorption of water from soil. Internal water can be frozen. Chilling and freezing injury may occur. Cold storage or refrigerator is due to inhibition of growth of plant organs, reduced metabolic activity influences seed germination, growth and seasonal development of plants. Some plants require low temperature treatment for their growth and flowering. The phenomenon is called vernalisation.
   High temperature of 45^{O}C and above reduces growth due to excessive transpiration, denaturation of enzymes and coagulation of protoplasm. Its effect is externally visible as leaf scorch, heat canker and desiccation.
3. WATER
   Optimum hydration is essential for cell elongation, cell turgidity and functioning of metabolic machinery. Growth is reduced even in slight deficiency of water. It however, promotes differentiation. Water stress completely stops growth.
4. OXYGEN
   It is required for release of energy during respiration. Energy is needed for anabolic activities of growth
5. SOIL
   It provides minerals, some growth stimulants and water
6. CARBON DIOXIDE
   Essential for photosynthesis and hence nutrition. However, in higher concentration carbon dioxide inhibits growth
7. HERIDITARY POTENTIALITY
   Growth and differentiation is genetically determined
8. GRAVITY
   It determines the direction of root and shoot growth.

9. STRESS
   Stress factors like excess or deficiency of salts, low or high temperature, excess and deficiency of water have a detrimental effect on growth.
10. NUTRITION
   It provides raw material for growth and differentiation as well as source of energy.
11. GROWTH REGULATORS

DIFFERENTIATION, DEDIFFERENTIATION, REDIFFERENTIATION

- Differentiation: It is the permanent qualitative changes in structure, chemistry and physiology of cell wall and protoplasm of cells, their tissues and organs. It is caused by repression of some genes.
- Dedifferentiation: It is the process of despecialisation of differentiated living cells so that they regain the capacity to divide and for new cells. A dedifferentiated tissue can act as meristem e.g.interfasicular vascular cambium, cork cambium, wound cambium. In culture experiments, parenchyma cells dedifferentiate to produce a mass of dividing cells called callus.
- Redifferentiation : Structural, chemical and physiological specialization of cells derived from dedifferentiation. It is similar to differentiation of cells and tissues formed by primary meristems. Secondary phloem, secondary xylem, cork, secondary cortex are some of the tissues formed through redifferentiation.

PHOTOPERIODISM

- Photoperiodism is the effect of duration of light and darkness on the growth, development and behavior of organisms. It is especially connected with flowering of plants, formation of underground storage organs, leaf fall etc. the effect of photoperiods on flowering was discovered by Garner and Allard (1920)incase of maryland of mammoth variety of Tobacco on the basis of their response to photoperiods.
  Plants are of the following types
  1. Long Day plants (LDP)
     Plants flowers after receiving light above a critical length e.g. wheat oat, sugarbeet, spinach, radish, lettuce, poppy.
  2. Short Day Plants (SDP)
     Plants flower only when they receive light below a critical length e.g. tobacco, potato, Xanthium, rice, dahlia, chrysanthemum, soya bean
  3. Day Neutral Plants (DNP)
     Photoperiods have no impact on these plants which come to flower after completing their vegetative growth e.g. tomato, maize, cotton, sunflower, cucumber
  4. Short-long Day Plants (SLDP)

Short photoperiod for initiation of lower and long photoperiods for blossoming e.g. Campanula medium, Trifoliumrepens.

5. Long-short Day Plants (LSDP)
   Long photoperiods for initiation of flowering and short photo photoperiod for blossoming e.g. Bryophyllum, cestrum

- Day Neutral Plants are more common in tropical areas. They can be made to flower throughout year. In subtropical and temperate areas short day plants flower during autumn and spring while long day plants flower during summer.
- Critical day length is that continuous duration of light which must always be exceed in short day light.
- Critical dark period is that continuous duration of darkness. Long day plants do not require any continuous dark period. They are, therefore, called short night plants (SNP). Short day plants are known as long night plants (LNO)
- The phenomenon of perceiving appropriate light periods and obtaining the stimulus of flowering is known as photoperiodic induction. Photoperiodic induction requires
  (i) A minimum vegetative growth
  (ii) A minimum number of appropriate photoperiod
  (iii) Photoreceptor pigment called phytochrome

$$\text{Bluish phytochrome P660} \underset{\text{light 730 nm}}{\overset{\text{light 660 nm}}{\rightleftharpoons}} \text{yellowish green 730}$$

  (iv) Fully developed leaves which receive the stimulus of light

VERNALISATION

- Vernalisation means ability of low temperature treatment to convert cereal into spring cereal
- Site of vernalisation is apical meristem or all the meistematic cells. E.g. shoot, tip, embryo tips, root apex
- As a result of vernalization, a flowering hormone called vernaline is formed but vernaline has never been isolated.
- Once a plant is vernalized, it can be devernalized by exposing the plant to temperature of 30^{O}C or above. For establishing vernalization, plant should be kept at 20^{O}C for 4-5 days

CONDITIONS NECESSARY FOR VERNALISATION

- Temperature : 1 – 6^{O}C is the optimum temperature
- Duration : 1 to 1.5 months low temperature treatment is necessary
- Oxygen : As vernalisation is aerobic process, so it requires O_2
- Water : Proper hydration is necessary

IMORTANCE OF VERNALISATION

- Crop can be grown earlier
- Plants can be grown in such regions where normally they do not grow
- Yield of the plant is increased
- Resistance to cold and frost is increased
- Resistance to fungal disease

SENESCENCE

It is the process of ageing which is caused by increased entropy, cellular breakdown, reduced homeostasis, increased metabolic failure and errors of replication as well as transcription

1. Whole plant senescence
   Monocarpic plants begin to undergo senescence along with fruit ripening. Eg. Bamboos and sago palm
2. Shoot senescence
   Certain perennial herbs produce annual aerial shoots for photosynthesis, bearing of flowers and fruits. With maturity of fruits, the aerial shoot undergo senescence underground parts perennate. Eg. Ginger, Narcissus, banana
3. Sequential / progressive senescence
   Polycarpic evergreen perennial plants show progressive senescence of older leaves, lateral organs and branches, flower, fruit bearing shoots as new growth occurs near the tip eg. Mango, eucalyptus
4. Simultaneous/ Synchronous leaf senescence.
   In perennial polycarpic deciduous plant all the leaves undergo senescence and are shed simultaneously in a particular season, commonly autumn E.g. Elm, maple, mulberry

GROWTH REGULATORS

(a) Characteristics
- Plant growth regulators are small, simple molecules secreted in minute quantities that influence various physiological functions in plants. They are of diverse chemical composition, as given below
  - (i) Indole compounds : Indole-3-acetic acid (IAA)
  - (ii) Adenine derivatives : Kinetin, N^6 – furfuryl amino purine
  - (iii) Derivatives of carotenoids : Abscisic acid (ABA)
  - (iv) Gases : Ethylene

(b) Classification
- Plant growth regulators are grouped into two categories based on the nature of their action
  - (i) Plant growth promoters e.g. Auxins, cytokinins, Gibberellins
    They promotes growth activities like cell division, cell enlargement, flowering, fruiting and seed formation, tropic growth movement etc.

(ii) Plant growth inhibitors e.g. Abscisic acid
They play an important role in plant response to wounds and stress of biotic and a biotic origin
They are involved in growth inhibiting activities such as dormancy, abscission etc.

AUXIN

(a) Discovery
- Charles Darwin and his son Francis Darwin observe that the coleoptiles of canary grass responded to unilateral illumination by growing towards the light source (phototropic curve)
- After a series of experiments, it was concluded that tip of the coleoptiles is the site of production of a substance, that caused the bending of coleoptiles.
- F.W. Went isolated auxin from the tips of coleoptiles of oat seedlings

(b) Isolation
- The word auxin is derived from Greek word 'auxein' meaning to grow
- It was first isolated from human urine
- Indole-3-acetic acid (IAA) and Indole butyric acid have been isolated from plants
- Naphthalene acetic acid (NAA) and 2,4 dichlorophenoxy acetic acid (2,4-D) are synthetic auxins

(c) Physiological effects
- Auxins control growth of plant cells.
- They also control cell division in vascular cambium and xylem differentiation
- They are responsible for apical dominance in plants
- They prevent the formation of abscission layer and there by prevent premature fall of leaves, flowers, fruit etc

(d) Application / Use
- Auxin are used to initiate rooting in stem cuttings.
- They are used to induce parthenocarpic fruits in tomatoes.
- 2, 4 D is used as a weedicide/ herbicide to kill dicotyledonous weeds
- They promote flowering in pineapples and litchi
- Auxins are used to prevent the premature fall of leaves, flowers, fruits etc

GIBBERELLINS

(a) Discovery
- The 'Bakan' (foolish seedlings) disease in rice seedling was caused by a fungus Gibberellafujikuroi
- EE. Kurosawa found that the symptoms of the disease could be developed in uninfected seedling by treating them with sterile filtrate of the fungus
- The active principle was later identified to the gibberellin acid.

(b) Isolation

- There are more than hundred gibberellins reported from various higher plants and fungi.
- They are denoted as GA_1, GA_2, GA_3 and so on
- GA_3 is the most intensively studied form of GAS

(c) Physiological effects

- They cause elongation of the internodes
- They promote bolting in rosette plants like cabbage, beet root etc
- GA_3 initiates synthesis of hydrolases to digest and mobilize the reserve food materials of the seed to the developing embryo and thus it breaks seed dormancy

(d) Applications/ Uses

- Gibberellins are used to increase the length of grape stalks
- They causes the fruits like apple to elongate and improve shape
- They delay senescence and hence the fruits can be left on the trees for longer period; this increases/ extend the market period
- GA_3 is used to speed up malting process in brewing industry
- By increasing the length of internodes in sugarcane, GA_3 increases the yield of sugar cane by about 20 tonnes/acre.
- Spraying juvenile conifers with GA_3 hastens their maturity and leads to early seed production.

CYTOKININS

(a) Discovery

- Skoog and his co-workers observed that tobacco callus could proliferate only if the medium contains in addition to auxin, the extracts from yeast, coconut milk or DNA.
- Skoog and miller later identified and crystallized the cytokinesis – promoting substance and called it kinetin

(b) Isolation

- Cytokinins were discovered as kinetic from the autoclaved herring sperm DNA.
- Kinetin does not occur naturally in plants and search for natural substances with cytokinin – like activities led to the isolation of zeatin from corn-kernels and later a cytokinin from coconut milk
- Later several naturally –occuringcytokinins and synthetic compounds with cell division – promoting activity have been identified.
- Natural cytokinins are synthesized in plants in regions where rapid cell division occurs e.g. root apices, shoot buds, young fruits et

(c) Physiological effects

- Cytokinins help in the growth of lateral buds into branches and help to overcome apical dominance
- They also promote adventitious shoot formation as they help to produce new leaves and chloroplasts in leaves
- They promote nutrient mobilization and help to delay senescence

(d) Applications
- They are used to make the lateral buds grow into branches
- They are used to delay leaf senescence

ABSCISIC ACID (ABA)

(a) Discovery
- There independent researchers reported three kinds of growth inhibitors:
  - (i) Inhibitor – B
  - (ii) Abscisin II
  - (iii) Dormin
- Later all of them were found to be chemically similar and named abscisic acid

(b) Isolation
- It was discovered from its role in regulating abscission and dormancy

(c) Physiological effects
- It plays an important role in seed development and inducing seed dormancy, by this it helps the seed to withstand desiccation and other unfavourable factors.
- It stimulates the closure of stomata under conditions of intense solar radiation and water stress
- It increases tolerance of plants to various stress and hence called as stress hormone
- ABA stimulates the formation of abscission layer and abscission of leaves flowers and fruits

(d) Application
- Seeds are treated with ABA to remain dormant during storage

ETHYLENE

(a) Discovery
Cousins confirmed that ripened organs released a volatile substance that fastened the ripening of the stored banana ; later this volatile substance was identified as ethylene

(b) Isolation
- Ethylene is synthesized in large quantities by the tissues of ripening fruits and senescing organs

(c) Physiological effect
- It promotes horizontal growth of seedlings and swelling on the axis.
- It induces apical kook formation (called epinasty) in dicot seedlings
- It promotes senescence and abscission of leaves and flowers
- It promotes root growth and root hair formation, thereby increasing the absorptive area.
- It promotes rapid elongation of internodes and petioles of deep water rice plants and helps the leaves to be above water level

(d) Applications

- Ethephon is the compound used to supply ethylene, it is an aqueous solution that is readily absorbed and transported within the plant and it releases ethylene slowly.
- It hastens fruit ripening in tomatoes and apple
- It promotes the production of female flowers on a monoecious plant
- It accelerates abscission of flower and fruits in cotton, cherry, walnut etc
- It is used to initiate flowering and for synchronizing fruit set in pineapples
- It breaks seed and bud dormancy and initiates germination in peanut seeds and sprouting of potato tubers

PLANT MOVEMENT

Plants have the capacity of changing their position in response to external (environment) or internal stimuli, which are known as plant movement.

The specific region or site where the stimulus is received for changing the position called perception site or region. The minimum period for which stimulus should be given for inducing plant movement is called presentation time

Summary of movement flow chart on next page

PLANT MOVEMENT

- **Movement of locomotion** – Change in place
  - **Autonomic/ spontaneous**
    - **Ciliary** – through cilia e.g. *Volvox* *Clamydomonas*
    - **Amoeboid** – through pseudopodia e.g Slime moulds
    - **Cyclosis** – movement around one vacuole
      - **Rotation** – movement around one vacuole e.g. in leaf cells of *Hydrilla* , and *Valisnaria*
      - **Circulation** – movement around many vacuole e.g. shoot hairs of gourds and in staminal hairs of *Tradescantia*
    - **Excretory** – movement during excretion e.g. apicalpart of *Oscillatoria*
  - **Induced/ paratonic (tactic)** – in response to external stimuli
    - **Phototactic** – induced by light e.g. movement of algae towards light
    - **Chemotactic** – iduced by chemical e.g. antherozoid movement towards malic acid in pteridophytes
    - **Thermotactic** – induced by temperature e.g. algal movement from cold water to warm water
- **Movement of curvature** – change in position of plant part from one direction to another
  - **Vital** – in living parts
    - **Autonomic** – induced by internal stimuli
      - **Growth movement** – result in growth
        - **Nutation** – zig zag movemnt of plant part e.g. tendril
        - **Epinasty** – growth on upper side e.g opening of leaves
        - **Hyponasty** – growth onlower side e.g rolling of leaves
      - **Movement of variation** – result in variation
    - **paratonic/Induced**
      - **Growth movement** (Tropic) – on response to unidirectional stimuli
        - **Phototropic** – light induced
          - **Negatively phototropic** e.g root
          - **Positively phototropic** e.g shoot
        - **Geotropic** – gravity induced
          - **Negatively geotrophic** e.g shoot
          - **Positively geotropic** e.g root
        - **Hydrotropic** – water induced e.g. young root
        - **Thigmotropic** – Touch induced e.g in tendrils
        - **Chemotropic** – Chemical induced e.g. growth of pollen towards micropyle
      - **Movement of Variation** – in relation with direction
        - **Nyctinastic** – induced by light as well as temperature e.g leaves of *Oxalis* , flower of *Tulipa*
        - **Seismonastic** – in response to touch e.g. *Mimosa pudica*
        - **Thigmonastic** – in response to different type of external stimuli e.g. *Dionaea* and *Drosera*
  - **Mechanical** – in non living part
    - **Xerochasy** – by loss of water e.g. pods dehisence
    - **Hydrochasy** – by absorption of water e.g peristominal teeth of moss capsule

- Life can be defined as unique complex organization of molecules expressing itself through chemical reactions (metabolism) which lead to growth, development, responsiveness, adaptation and reproduction.
- Living things possess certain characteristics, which makes them different from non-living things.

CHARACTERISTICS OF LIVING BEINGS

Characteristics of living beings are as follows

I) METABOLISM

- Metabolism is a process by which all living things assimilate energy and use it for various purposes like growth, movement, development, responsiveness, reproduction, etc

- Chemical reactions are classified into catabolism and anabolism

Catabolic activities

(i) Catabolic activities release energy

(ii) Energy liberating reactions are termed as 'exergonic'

(iii) These are some total of breakdown or destructive process.

(iv) These reactions from simple substances from complex ones

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

Anabolic activities

(i) Anabolic reactions store energy.

(ii) Energy absorbing reactions are termed as 'endergonic'.

(iii) These are some total of building up or constructive process.

(iv) These reactions produce complex molecules from the simpler ones.

$$6CO_2 + 12H_2O \xrightarrow[\text{enzymes}]{\text{Sunlight}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

- However, some of the metabolic reaction can be carried outside living system. Isolated metabolic reactions 'in vitro' are not living things, but are living reactions.

Growth

- All living organisms show growth either by multiplication or by increase in size. It is an irreversible increase in mass of individual.
- For larger organisms, growth is related to the development of new parts either in between or within the older ones. Thus, a sort of internal growth is visible in living beings.
- Two types of cells are produced by cells, i.e. apoplastic and protoplastic. Protoplastic substances are components of living matter like cytoplasm and nucleus. Apoplastic substances are non-living material formed by the cells which becomes components of tissue, e.g. cell wall, fibres of connective tissue, matrix of bone and cartilage. So, we can say growth is common characteristic feature of all living beings.
- Plants grow throughout their life while animals grow for a certain period only. Although some non-living things like mountains, sand mounds and crystal also grow, but their growth is due to the addition of matter from outside. This process is called accretion.

REPRODUCTION

- It is formation of new individuals of similar kind either by asexual (uniparental) or sexual (biparental) mode. This is required for perpetuation of a population/ species and also help in passing on traits from one generation to the next. Although some organisms live for a very long time, no organisms lives forever. Because all organisms dies one day, ongoing life is impossible without reproduction. Thus the process of reproduction is essential for the continuity of life on the earth.

- Fungi reproduces asexually producing millions of asexual spore, while yeast, Hydra multiply by building.
- Planaria exhibit true regeneration by fragmentation. In amoeba, growth and reproduction are synchronized. When repeated reproduction is there in life cycle of any organism at regular interval it is called itereoparity.
- Although reproduction and metabolism are most important features of living beings, but when we compare these two the importance of metabolism comes first. It is due to this reason that we do not include viruses in living beings inspite of the fact that viruses have power of reproduction.
- All organisms consists of one or more cells, i.e. complex organized assemblage of molecules in the form of cell organelles enclosed within the biological unit membranes. So cellular structures is a defining property of living beings cells are made of living matter called protoplasm. Cell work together in hierarchical manner to form tissues organ and organ systems.

RESPONSIVENESS

- All organisms respond to external stimuli which can be physical, chemical or biological and this property is called irritability. The stimulus response may be either simple (e.g. movement of an organism towards alight source) or quite complex such as responding to a complicated series of signals in mating ritual.
- Stimuli are perceived by sense organs in animals, but plants can response to external factors like light, water, temperature, pollutants etc. Both plants and animals respond to photo periods which influence their reproduction cycles as well. Actually, all living phenomena are due to underlying interaction.

- The properties of tissues are not present in the constituent cells, however, arise as a result of interactions among component cells. The appearance of new characteristic at a given level of organization is called emergence and these properties are called emergent properties.

NUTRITION

- All living organisms need food. The food is used as a source of energy and materials for the processes of life such as growth. Light and chemical energies are used by all the living organism. Those organisms specialized for using light energy carry out photosynthesis e.g. plants, algae and photosynthetic bacteria. The organisms which use chemical energy, always depend on other living organisms, e.g. humans, animal and non-green plants i.e. fungi.

RESPIRATION

- All life processes require energy and much of it is food obtained by the nutrition which is used as a source of this energy. The energy is released during the breakdown of certain energy rich compounds in the process of respiration.
- The energy is stored in ATP (Adenosine tri phosphate), a compound known to occur in all living cells and is referred to universal energy carrier.

MOVEMENT

- Animals and some unicellular forms have the ability to move from place to place, called as locomotion. This is necessary to obtain their food, shelter and mate. Plants lacks locomotion. Nevertheless, some movements of part of body structure can be seen in plants. E.g. roots move in search of water under the soil or flower closes at night etc.

Excretion

- Excretion is the removal of waste products from the body. Every living cell, whether it exists independent or as part of a multicellular organism, must eliminate waste products otherwise it might poison the body, if stored inside.
- For example, the process of aerobic respiration produces a waste product CO_2(carbon dioxide) and must be eliminated because it can be harmful in excess. Animals take in food during nutrition, this material breaks down during metabolism and need to be excreted.

HOMEOSTASIS

- It is a property of all living organismshomois –alike, statis – standing. Maintenance of a favorable dynamic constancy of internal environment despite changes in the external environment is called homeostasis.
- It is carried out by regulatory mechanisms which coordinate internal functions such as providing nutrients to cells and transporting substances. Some organisms attain, homeostasis be adapting to change in temperature, salinity and other aspects of environment
- This process occurs at all levels i.e. from cellular level to ecosystem level. The term 'homeostasis' are used by Cannon (1932)
- Most of the known modes of homeostasis occur through

1. Maintenance of an internal environment

2. Self –regulatory mechanisms using genetic clock

3. Feedback system (in which the rate of the product formation is regulated by gathering information about the amount left out at any time). They generally involve switching on and switching off mechanism operating at different levels in all organism.

DEATH

- Ageing is a progressive deterioration of structure and function of cells, tissues and vital organs so, that the ability to repair and resist disease declines. It leads to death. Death is stoppage of life activities in an individual due to degeneration of body parts and increase in entropy.
- In nature, death occurs due to ageing predation, accident or disease.
- Biological death occurs when brain and other body parts begin to degenerate due to non-availability of nutrients and oxygen.
- Clinical death is characterized by stoppage of vital functions like pulse, heart beat and breathing etc. Death is essential for keeping a population under check and recycling of minerals.

DIVERSITY IN THE LIVING WORLD

- The planet earth is full of variety of animals and plants. This refers to biodiversity. Every distinct geographical location has its own set of flora and fauna. Each different kind of plant, animal or organism represent a species.
- The number of species that are known and described range between 1.7 - 1.8 million. The number of known species are increasing day-by-day because of projects like Global Biodiversity information facility and species 2000.
- The estimated number of living organism on earth is now between 5-30 million, most occurring in dense tropical rain forests and under water reefs.

IDENTIFICATION

- It is about finding a correct name and place of an organism with the help of identification keys and comparing similarities and dissimilar comparing similarities with already known organism

CLASSIFICATION

- By observing the fundamental characteristics of organism and their comparison with the organism already known, we include the new organism in special class or group which represent distinct biological entities. John Ray developed the key for identification.

NOMENCLATURE

- It is a science of providing distinct and proper names to organism so that they can easily be recognized and differentiated from others.
- These are the names given to the organisms by biologists based on agreed principles and criteria for their acceptability all over the world. These are

(i) Polynomial system of nomenclature : Prior to 1750, biologists used descriptive names for organisms with each name being made up of several Latin words e.g. 'Caryophyllumsaxnatilis, Folisgramineus, umbellatiscorymbis' (Caryophyllum growing on rocks having grass-like leaves and umbellate corymb flower)

(ii) Trinomial system of nomenclature: Sometimes, binomial nomenclature can also be extended to trinomial system of nomenclature, where the names of sub species or varieties can be incorporated. E.g, Brassica oleracea botrytis.

(iii) Binomial system of nomenclature.

- This system was proposed by C Linnaeus in 1753 in his book species Plantarum. Though the idea of binomial nomenclature was first introduced by Gaspard Bauhin.
- As per this system, name of any organism consists of two parts or epithets i.e. Generic epithet and Specific epithets E.g. Botanical name of Mango is *Mangiferaindica* in which *mangifera*is generic epithet, which

represents its genus and *indica* is specific epithet which represents its species.

- The following rules are followed for Binomial Nomenclature as given below

  (a) Names are in Greek or Latin language.

  (b) Names are in begins with Capital letters (Mangifera) and is placed before specific name small letters (indica)

  (c) The scientific name should be either underlined in case of hand written or italicized if printed

  (d) Name of the authority should be written after specific epithet in an abbreviate form.

TAXONOMY

- It is the branch of study that deals with principles and procedure and classification code for Botanical nomenclature (ICBN) has developed a system for identification and classification of plants. Similarly international code of zoological nomenclature (ICZN) has developed a system for identifying and classifying the animals. The term ‘Taxonomy’ was given by deCandolle (1813).

BRANCHES OF TAXONOMY

Varous branches of taxonomy are as follows:

(i) Classical taxonomy or ɑ-taxonomy or old systematic is based on the morphological traits.

(ii) Artificial taxonomy makes use of habit and habitat of organisms. Pling used this system first time

(iii) Practical taxonomy is based on the utility of organisms

(iv) Natural taxonomy is based on natural, similarities amongst organisms

(v) Phylogeny or evolutionary history of a species.

(vi) Experimental taxonomy is based on experimental determination of genetic inter-relationship

(vii) Chemotaxonomy is based on the presence or absence of chemical in cells or tissues.

(viii) Numerical taxonomy is based on the number of shared characters of various organisms. It is also called phonetic or Adanosonian classification

(ix) Cytotaxonomy is based on cytological studies.

(x) Karyotaxonomy is based on nuclear and chromosomal studies

(xi) Morphotaxonomy is based on morphological studies of organisms

Note

- ICBN – International code of Botanical Nomenclature.
- ICZN – International code of zoological Nomenclature.
- ICNB – International code for Nomenclature of Bacteria.
- ICNCP – International code for Nomenclature of cultivated Plants
- ICTV – International Committee on Taxonomy of Viruses

TAXON

- A taxon is a taxonomic group belonging to any rank in a given system of classification. The term 'taxon' was introduced for the first time by ICBN in 1956.
- Mayr(1964) defined taxon to be taxonomic group of any rank that is sufficiently distinct to be worthy of being assigned a definite category.

SYSTEMATIC HIERARCHY

- The systematic is the analytical approach to understand the diversity and relatedness of organisms.

- The system by which various taxonomic categories are arranged in a proper descending order is called taxonomic or systematic hierarchy

KINGDOM
↓
PHYLUM IN ANIMALS
OR
DIVISION IN PLANTS
↓
CLASS
↓
ORDER
↓
FAMILY
↓
GENUS
↓
SPECIES

- Kingdom is the highest rank and species is the lowest or basic rank.
- Hierarchy of categories is also called Linnaean hierarchy because it was first proposed by Carolus Linnaeus.

SPECIES

- Species is the fundamental or smallest unit of classification. The concept of species was proposed by John Ray. The definition of species is given by Ernst Mayer
- Species is a group of individuals which resemble each other in morphological, physiological, biochemical and behavioral characters. These individuals are capable of inbreeding freely in between themselves under natural conditions, but are incapable of breeding with the membranes of other species is an important boundary between different species.

GENUS

- Genus comprises a group of related species, which have more common characters in comparsion to the species of another genera. Hence genera are aggregates of closely related species. For example , potato (*Solanumtuberosum*), tomato (*Solanumlycopersicum*) and brinjal (*Solanumnigrum*) are three different species but all belong to the genus *Solanum.*
- Some genera have only one species and is called monotypic, whereas others have a large number of closely related species and are called polytypic

FAMILY

- Family is a taxonomic category, which contains a group of related genera with still less number of similarities as compared to the genus and species. All genera of a family have some common features and are separated by some important characteristic difference.
- Families are characterized on the basis of both vegetative and reproductive features of plant species. Among plants, for example 3 different genera *Solanum, Petunia* and *Datura* are placed in the family- *Solanaceae.*

ORDER

- An order includes a group of related families. Generally, order and other higher taxonomic categories are identified based on the aggregates of characters. Order is an assemblage of families, which exhibit a few similar characters. The similar characters are less in numbers as compared to different genera included in a family.
- Plant families like convolvulaceae, Solanaceae are included in the order. Polymoniales mainly based on the floral characters.

CLASS

- Class is group of related order. For example, order-primata comprising monkey, gorilla and gibbon is placed in class-mammalia alongwith order carnivore that includes animals like tiger, cat and dog.

PHYLUM

- Phylum is group of classes, Phylum Chordata comprises animal like fishes, amphibians, reptiles, birds along with mammals. All these are included in Phylum chordate, based on common features like the presence of notochord and dorsal hollow neural system.
- In case of plants, classes with a few similar characters are assigned to a higher category called division.

KINGDOM

- Kingdom is the highest taxonomic category. All the plants are included in kingdom-plantae, while all animals to kingdom-Animalia

TAXONOMICAL AIDS

- Biologist use herbarium, botanical gardens, museums, zoological park. Flora, fauna and keys in taxonomical studies.

HERBARIUM

- A herbarium is a collection of plants which have been dried, pressed, mounted on herbarium sheets, identified and classified according to any universally accepted system of classification (mostly Bentham and Hooker)
- A herbarium sheet carries label providing information about data and place of collection, English, local and botanical names, family, collector’s name etc.

BOTANICAL GARDEN

- A botanical garden is essentially a collection of living plants maintained for both pure and applied studies.
- The botanical gardens play the following roles

  (i) On site teaching: Collection of plants is often displayed according to the families, genera or habitats and can be used for self-instruction or demonstration purposes

  (ii) Conservation” Botanical gardens are now gaining more importance for their role in conserving genetic diversity and rare, endangered species.

  (iii) Aesthetic appeal: Botanical gardens have an aesthetic appeals and attract large number of visitors from the observation of general plant diversity as also the curious plants.

  (iv) Material for Botanical garden: Botanical gardens generally have a wide range of species growing together and offer ready material for botanical research, which can go a long way in understanding taxonomic affinities.

  (v) Seed exchange: More than 500 botanical gardens of the world operate an informal seed exchange scheme, offering annual lists of available species and a free exchange of seeds.
- Major Botanical gardens of the world are as follows

  (a) New York Botanical garden, USA

  (b) Royal Botanical Garden, Kew, England

  (c)Pisa Botanical Garden, Italy

  (e) Berlin Botanical garden and museum, Berlin – Dahlem

  (f) Cambridge University Botanical Garden USA
- Major Botanical gardens of India are

  (a) Indian Botanical Garden, Sibpur, Kolkata, was established in 1787. It has an area of 273 acre

(b) National Botanical Garden, Lucknow now known as National Botanical Research Institute

MUSEUMS

- Museums have collection of preserved plants and animal specimens for the study and reference.
- Some important museums are listed below

a) Natural History Museum, London (England)

b) United states National Museum, Washington (USA)

c) Field Museum of Natural, History, Chicago (USA)

d) Musee de l'Homme, Paris (France)

e) Zoology Museum, Amsterdam

f) Prince of Wales museum, Mumbai

g) Indian Museum, Kolkata

h) National Meseum of Natural History (NMNH) Delhi

i) MaharajaSawai Man Singh(II) museum,Jaipur

j) Forest Museum, Andaman and Nicobar Islands.

ZOOLOGICAL PARK

- Zoological parks (Zoos) are the places where wild animals are kept in protected environments under human care and which enable us to learn about their food habits and behavior some common zoos of India are listed below

(i) Nehru Zoological Park, Hyderabad

(ii) Zoological garden, Alipore, Kolkata.

(iii) Himalayan zoological Park, Gangtok

(iv) National zoological Garden, Delhi

(v) Kamala Nehru Zoological Garden, Ahemdabad

(vi) Prince of Wales zoological Park, Lucknow

KEYS

- Keys is taxonomical aid used for the identification of plants and animals based on the similarities and dissimilarities. The keys are based on the contrasting characters generally in a pair called couplet.
- It represents the choice made between two opposite options. Each statement in the key is called a lead.

MONOGRAPH

- A monograph is a comprehensive treatment of a taxon in biological taxonomic of any one taxon.
- The first ever monograph of a plant taxon was given in Robert Morison, 1672 PlantarumUmbelliferum Distribution Nova.

SYSTEMS OF CLASSIFICATION

These systems can be categorized into three main types

i) Artificial system of classification

ii) Natural system of classification

iii) Phylogenetic system of classification

ARTIFICAL SYSTEM OF CLASSIFICATION

- The first attempt of classifying plants was made by Theophrastus, the father of Botany. He classified about 450 plants on the basis of form and texture in his book HistoriaPlanarum. He classified them into herbs, under-shrubs, shrubs and trees. He also distinguished between annual, biennial and perennial plants, also noted the difference between centripetal and centrifugal inflorescences, epigynous, perigynous and hypogynous corolla and monocot and dicot plants

- CarolusLinnaeus is the father of modern Botany. He followed the binomial system of nomenclature describing hundreds of plants from various parts of the world. His important works were species Plantarum and EloraLapponica. He proposed an artificial sexual system of classification in System Natural (1735) containing twenty four classes. The system was based on the number, cohesion length and various other characters of the stamens.

NATURAL SYSTEM OF CLASSIFICATION

- A natural system of classification was proposed by the French botanist A.P. de Candelle in his work Theories elementaire de la Bontanique (1818). This system provided the base for Bentam and hooker's Classification. He divided the plants into Cellulares(algal to bryophytes) and Vasculares(pteridophytes to angiosperms) which were further divided into classes and orders.
- D.de. Jussiey(1699 -1776) was not satisfied of classification and modified it into a natural one. He divided the flowering plants into groups on the basis of monocots, dicots, ovary positions, presence or absence of petals. His opinions were published by his new nephew A.L. de Jussieu in Genera Plantarum (1789). He divided plants into 15 classes based mainly on the number and positions of cotyledons and adhesion of petals.
- George Bentham and J.D. Hooker gave most important system of classification of angiosperms and published it in three volumes of 'Genera Plantarum'. They described 202 families. In this system description of plants was based on their detailed studies and dissections. It is widely acceptable and all British Commonwealth countries including India widely follow this system for practical purpose and hence it is called practical classification

PHYLOGENETIC SYSTEM OR CLADISTICS

- Biologists are now developing new approaches using taxonomic affinity based on evolutionary as well as genetic relationship amongst organism besides morphology. They ignore the morphological similarity or differences. This system of classification is designated as phylogenetic classification or cladistia.
- This system is based on evolutionary sequence as well as the genetic relationship among the living beings. It reflects the true relationship among the organism.

REPRODUCTIVE HEALTH

Reproductive health is a state of physical, emotional, behavioural and social fitness for leading responsible, safe and satisfying reproductive life. Briefly speaking reproductive health refers to healthy reproductive organs with normal functions. World Heath Organisation (WHO) has defined reproductive health as total well being in all aspects of reproduction, its emotional, behaviroral and social aspects along with the physical one.

PREPRODUCTIVE HELTH-PROBLEMS AND STRATEGIES

(1) Main problem of India is its excess population which is directly connected with reproductive health. To achieve total reproductive health, some plans and programmes were started. Family planning programmes was initiated in 1951 and was periodically assessed. These programme were popularly called , names Reproductive and Child Health Care (RCH). The major tasks carried out under these programmes are to provide facilities and support for building up a reproductive healthy society.

(2) Audio-visual and print media governmental and non-governmental agencies are doing good job to create awareness among. People about reproduction, in humans. Parents, close relatives, friends and teachers also play a major role in giving information

(3) Sex education in schools should also be introduced and encouraged to provide right information about myths and misconceptions about sex-related aspects

(4) Proper information about reproductive organs, adolescence, safe and hygienic sexual practices, sexually transmitted diseases (STD) e.g. AIDS etc would help lead a reproductively healthy fife.

(5) Fertile couples and people of marriageable age group should know about available birth control, care of pregnant mothers, postnatal (after birth) care of the mother and child, importance of breast feeding, equal importance for male and female child etc.

(6) Awareness of problems due to uncontrolled population growth, social evils like sex abuse and sex-related crimes etc. need to be created so that people should think and take up necessary steps to prevent them and thereby build up a reproductively healthy society

(7) For successful action plans to attain reproductive health requires good infrastructural facilities, professional expert knowledge and material support. These are necessary to provide medical help and care for reproduction related problems like menstrual problems, infertility, pregnancy, delivery, contraception, abortions, sexually transmitted diseases (STDs)

(8) Amniocentesis is foetal sex determination and disorder test based on the chromosomal patron in the amniotic fluid surrounding the developing embryo

(9) Research should be encouraged and supported to find out new methods of birth control " Sheli" a new oral contraceptive for the females was developed by our scientists at Central Drug Research Institute (CDRI) in Lucknow. India

(10) Better awareness about sex related problems, parental care of mother, medically assisted deliveries and post natal care of infant decreases maternal and infant mortality. Smaller families, better detection and cure of sexually transmitted disease and increased medical facilities for sex-related problems etc. indicated improved reproductive health of male and female individuals and children.

POPULATION EXPLOSION

The rapid increase in population over a relatively short period is called population explosion.

Reasons for population explosion

- Increase in longevity due to decline in death rate, maternal mortality rate (MMR) and infant mortality rate.
- Control of diseases has reduced the death rate and increased the average human age.
- Better sanitation.
- Proper care of new born children and their mother.
- Better nutrition and life amenities.

- Better public health care, improvement in medical facilities and grater medical attention are playing crucial role in decreasing death rate and increasing birth rate.
- Advancement in agriculture, improvement in food storage conditions and better means of transport are causing rapid increase of human population.
- Protection from natural calamities has decreased death rate.
- Certain religions are against family planning.
- Lack of education in developing countries.
- Early marriage, child labour.
- Desire of male child.

Consequences of over population

Over population leads to number of not only national but also individual family problems. Some of these are described below

(1) It increases poverty in the family as well as in the country.
(2) If the production of food does not increase it will lead to shortage of food supply.
(3) Rapid increase in population leads to unemployment and educational facilities.
(4) It is very difficult to provide house for everyone in case of rapid increase in population.
(5) Over population causes eco-degradation in more than one way such as rise in pollution, unhygienic condition and deforestation etc.
(6) Over population leads to shortage of essential goods there by resulting hike in their prices.
(7) Increase in population has created energy crisis. The demand of fuel wood, oil, gas coal and electricity is increasing.

Measures to control population

(1) Reduction in birth rate is the only practicable and direct method to control the population. It can be done in various ways.
(2) People particularly those in the reproductive age group, should be educated about the advantage of small family.

(3) Posters showing a happy couple with two children with slogan “ Hum do Hamare Do” should be displayed.
(4) At present marriageable age is 18 years for girls and 21 years for boys. By increasing the age of marriageable population, growth can be checked.
(5) Couple with small families can be encouraged by giving incentives.
(6) There are many birth control measures which can check birth rate such as use of contraceptives.

BIRTH CONTROL (CONTRACEPTION)

The regulation of conception by preventive method or devices to limit the number of offsprings is called birth control or contraception.

Birth control methods act by blocking one of the three major steps in the reproductive process.

(1) Blocking sperms transport to the ovum.
(2) Blocking ovulation.
(3) Blocking implantation of early embryo.

Methods of birth control

The various birth control methods can be grouped into following three steps.

(1) Temporary method.
(2) Permanent method.
(3) Medical termination of pregnancy.

I) Temporary method

These are of many types

(i) Natural methods.
Safe period or periodic abstinence
Week before and week after menses is considered the safe period for sexual intercourse. This is because
(a) Ovulation occurs on about the 14^{th} day of menstruation.
(b) Ovum survives for 1-2 days.
(c) Sperms remains alive about three days.

- These method may reduce the chances of pregnancy by about 80%

- Safe period or rhythm method is called natural family planning because it requires temporary abstinence from sexual intercourse when conception is most likely.
- Changes in cervical mucus and body temperature during the menstrual cycle are physiological changes which marks ovulation time.
- The effectiveness of this method is limited because only a few women have regular menstrual cycles and actual time of ovulation can not be produced as the ovulation in humans occurs about 14 days before onset of the next menstruation.

Coitus interruptus or withdrawal method

- It involves withdrawal of the penis from the vagina by the male just before ejaculation so that semen is not deposited in the vagina and there is no fertilization.
- This method is only moderately effective because male produces some lubricating fluid from his cowper's glands before ejaculation that contains many sperms.

Lactational amenorrhoea method (absence of menstruation)

- It is based on the fact that ovulation and therefore the menstrual cycle do not occur during the period of intense lactation following child birth (parturition).
- This method is considered effective only up to a maximum period of six months following parturition.

(ii) Barrier method

These are mechanical devices which prevent deposition of sperms into vagina and their passage to uterus. The common barrier methods are condoms, diaphragm, fem shield and cervical cap.

- Condom

  It is tubular latex sheath which is rolled over the male copulatory organ during sex. The common brand provided by family welfare services is “Nirodh”. The device also provides protection against sexually transmitted disease. It should be discarded after single use.

- Fem shield (Female condom)
  The device is polyurethane pouch with ring at either end. The inner ring is smaller and present at the inner closed end. The device covers the external genitalia as well as lines the vagina. Fem shield provides protection from sexually transmitted diseases.
- Diaphragms
  It is soft rubber cap with flexible metal or spring ring at the margin which is fitted inside the vagina. It prevents sperm from reaching egg and gives protection against cervical cancer .
- Cervical caps
  It is a miniature diaphragm that covers cervix closely. It is fairly effective and can remain in place longer than diaphragm.
- Vault cap
  It is hemispherical dome like rubber or plastic cap with a thick rim which is meant for fitting over the vaginal vault over the cervix.

(iii) Chemical method
Foam tablets, creams, jellies and paste are inserted in the vagina before intercourse to prevent sperms from entering the uterus These contain spermicides such as lactic acid, citric acid, boric acid. Zinc sulphate and potassium permanganate which kills sperm. Sponge (Today) is a foam suppository or tablet containing nonoxynol-9 as spermicide. It is moistened before use to activate the spermicide.

(iv) Intra uterine devices (IUDS)

- Intra uterine devices (IUDS) are plastic or metal objects which are inserted by doctors in the uterus through vagina.
- These are available as non-medicated IUDS (i.e. Lippes loop) copper releasing (CuT, Cu7 , Multiload 375) and hormone releasing IUDS (progestasert, LNG-20)
- IUDS increases phagocytosis of sperms within the uterus and the Cu ions released by copper releasing IUDS suppress sperm motality and fertilizing capacity of sperms.

- Copper IUDS commonly called copper T have ionized copper which slowly diffuses at the rate of some 50 μg/ day. It has a local anti-fertility effect by bringing about release of toxic cytokines. The device is to be replaced after 3-5 years when copper release becomes scanty due to calcium deposition. CuT380A has a replacement period of 7-10 years copper IUDs are designed by the area of sq mm having copper
- The hormone releasing IUDs make the uterus instable for implantation and the cervix hostile to the sperms.
- Hormone releasing IUDs include progesterone IUD and levonorgestrel IUD. The device release small quantity of hormones which suppress endometrial changes and cervical mucus, cause anovulation and insufficient luteal activity.
- There are certain disadvantages of the intra-uterine devices. These are
  (a) IUDs are expelled without the knowledge of the wearers in about 10 to 15% of the women and they run the risk of becoming pregnant.
  (b) Risk of perforation and also risk of infection occurs.
  (c) They can cause menstrual bleeding and pain.

(v) Oral contraceptives

- Oral contraceptive are physiological contraceptive devices.
- These are used in the form of tablets, therefore, they are called pills.
- Pills have to be taken for 21days starting with the first five days of menstrual cycle. After a gap of seven days it has to be repeated.
- Pills are very effective with lesser side effects.
- Hormonal pills act in following four ways
  (a) By inhibiting the ovulation.
  (b) By inhibiting the motility and secretory activity of oviducts.
  (c) By changing the cervical mucus and impairing its ability to allow passage and transport of sperms
  (d) By alternation in uterine endo-metrium to make it unsuitable for implantation
- Oral contraceptive pills contain progesterone alone or a combination of progesterone and estrogen
- These are of two types: Combined pills and mini pills

- Combined pills are most commonly used contraceptive pills which contain synthetic progesterone and estrogen synthetic progesterone and estrogen to check ovulation. Mini pills contain progestin only
- Pills “Mala D” and “Mala N” are commonly used combined contraceptive pill. These are taken daily with out break.
- Saheli, a new oral contraceptive pill for female has been developed at Central Drug Research Institute (CDRI), Lucknow.
- It contains a non-steroidal preparation called centchroman which is taken once in a week dose for three month.
- It has very high contraceptive value with very little side effects.
- Oral contraceptive pills increases the risk of intravascular clotting. Therefore they are not recommended for women with history of disorder of blood clotting, cerebral, blood vessel damage, hypertension, heart diseases etc.

(vi) Subcutaneous implants (Norplant) . A new contraception is a subcutancous (under the skin) implantation of synthetic progesterone. It acts similarly to oral contraceptives by blocking ovulation and thickening the cervical mucus. Six matchstick sized capsules containing the steroid are inserted under the skin of the inner arm below the elbow. The capsules slowly release the synthetic progesterone for about five years.

(vii) Hormone injection (Depo-Prova)

- These are progesterone derivative injections which is given once every three months, that releases a hormone slowly and prevents ovulation.
- Depo medroxy progesterone acetate (DMPA) and N or – ethiosterone enantate (NET-EN); are two injectable hormonal contraceptives
- They are convenient and highly effective with no serious side effects. There is occasional heavy menstrual bleeding.

(viii) Emergency pills (morning after pills)

- Implantation can also be checked by so called morning after pills, also called morning after pills, also known s emergency contraceptive.
- The most common form of emergency contraceptive is a kit consisting of high dose of birth control pills. The kits can prevent pregnancy within 72 hours after unprotected sexual intercourse.

II) Permanent method

- Sterilization provides a permanent and sure birth control.
- Sterilization in male is called vasectomy and in female it is called tubectomy.

(1) Vasectomy (L.vas-vessel, ektome-excision)

- It is a surgical method of sterilization of males. Vas deferentia are blocked by cutting and occluding them so that sperms are unable to pass down the male reproductive system.

(a) Conventional vasectomy (scalpel surgery) under local anesthesia, transverse 1cm incision is made through the skin of the scrotum with the help of the scalpel over the area of casa deferentia. Each vas is exposed and cut. The two ends are separated and tied. A gap of 1-4 cm is must between the ends otherwise reunion can occur.

(b) No- scalpel vasectomy. Here instead of scalpel, a dissecting forceps and a ringed forceps are required. The skin is punctured and the vas is taken out. It is occluded by removal of 1-2cm followed by removal of 1-2cm followed by ligation of ends. Occlusion can also be achieved by heat and clips. Vasectomy is a reversible procedure as the cut ends can be joined together to open the sperm passage.

(2) Tubectomy (L-tubus – pipe, ektome-excision)

- It is a surgical procedure of female sterilization where a portion of both the fallopian tubes is excised or ligated to block the passage of ovum through them. Tubectomy is performed by conventional trans-abdominal surgery, conventional lap-arotomy and milaparotomy.
- In surgical procedures, the fallopian tubes are cut and the cut ends tied to prevent reunion. The procedure is reversible as the cut ends can be rejoined. In laparoscopic procedure, sterilization is achieved by loop development and constricting the basal region of loop with the help of silistic ring.

(3) Essure

It is a near permanent contraception in women who do not want to bear another child. Tow tiny metal coils are inserted in the two fallopian tubes through vagina and uterus by an instrument called hysteroscope. Within 3 months the tissue around coils grows blocking the fallopian tubes permanently.

[DIAGRAM]

MEDICAL TERMINATION OF PREGNANCY (MTP) OR INDUCED ABORTION

- Intentional or voluntary termination of pregnancy before the foetus becomes viable is called medical termination of pregnancy or induced abortion.
- It is one of the most widely used methods of fertility control in the world.
- MTP is comparatively safe up to 12 weeks (1^{st} trimester) of pregnancy. It becomes risky after the first trimester as the foetus becomes intimately associated with maternal tissue.
- During 1^{st} trimester of pregnancy misoprostol (a prostaglandin) along with mifepristone (antiprogesterone) is an effective combination.
- In india, there is medical Termination of pregnancy 1971. Which mainly meant for preventing unnatural maternal death due to unsafe abortions. Under this act, termination of pregnancy can be done up to 20 weeks, if pregnancy is likely to produce a congentially malformed child, is a result of rape and contraceptive failure or is likely to harm the mother.
- Second semester abortions are risky. They are generally performed after testing the sex of the baby through amniocentesis or sonography.
- It has resulted large scale female foeticide and complications due to unsafe abortions in the hands of untrained persons. To prevent such happening, the government has enacted a law Pre-natal Diagnostic Techniques (Regulation and Prevention of Misuse) Act, 1994 with amendments in 2003. It inhibits preconception and prenatal sex determination, contravention of this act is punishable with an imprisonment of 5 years and fine of Rs 1,00,000 along with cancellation of medical registration and license.

SEXUALLY TRANSMITTED DISEASES (STDs)

Diseases or infections which are transmitted through sexual intercourse with infected person are collectively sexually transmitted diseases (STDs) or venereal diseases (VD) or reproductive tract infection (RTID).

Except HIV infection, hepatitis-B and genital herpes all other STDs are completely curable if treated early and treated properly.

Symptoms of STDs

- The initial symptoms of most of the sexually transmitted diseases are minor. These include itching, burning after urination and ejaculation, fluid discharge, mild pain and swellings etc. in genital region. Infected females may often be asymptomatic and hence, may remain undetected for long.
- In women, the most commonly infected part of the body is the lower genital tract (vulva, vagina or urethra) and in men, the most commonly infected body part is the inside of the penis. The discharge from penis of gonorrhea infected person is yellow, white or green in colour.

Common STDs

(1) Syphilis
- Syphilis is caused by bacterium *Treponema pallidum.*
- The first stage symptoms of this disease are painless ulcer or chancer on 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 appears on palate, nose and lower leg. There can be paralysis, brain damage, blindness, heart trouble and aortic impairment.
- It is transmitted through sexual contact and from mother to children
- Incubation period is 10-90 days.
- It is diagnosed by clinical symptoms, microscopic examination and antibody.
- It can be cured by appropriate antibiotics. E.g. penicillin, tetracycline

(2) Gonorrhoea

- Gonorrhoea is caused by bacterium *Neisseria gonorrhoeae*.
- 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 in gonorrhea affected mothers.
- It is spread through sexual contact, common toilets and under clothes.
- Its incubation period is 2-5 days.
- It is diagnosed by clinical symptoms and gram staining of discharge and culture.
- It can be cured by the use of antibiotics such as penicillin and ampicillin.

(3) Chancroid

- Chancroid is caused by bacterium *Haemophilus ducreyi.*
- Appearance of ulcer at the site of infection generally over external genitalia and swelling of nearby lymph glands are common symptoms of the disease.
- It is spread through sexual contact.
- It is diagnosed by clinical symptoms, staining of discharge and cell culture.
- Effective antibiotics for the treatment are ceftrianone, erythromycin, ciprofloxacin and trimethoprin sulphametoxazole.

(4) AIDS

- AIDS is caused by human immunodeficiency virus (HIV).
- The symptoms of AIDS include fever, lethargy, pharyngitis, weight loss, nausea, headache, rashes etc.
- Because HIV attacks helper T lymphocytes, the patient gets immune. deficiency and he is unable to protect himself against infections.
- HIV is transmitted via semen and blood.
- Its incubation period is 6 month to 10 years.
- AIDS can be diagnoses by ELISA test western blotting is used for conformation of ELISA positive cases. PCR is also used to diagnose AIDS.

- Although there is not any permanent cure of AIDS yet certain anti-retroviral drugs such as zidovudline and didanosine are being employed to prolong the life of AIDS patient.

(5) Hepatitis B

- Hepatitis B is caused by hepatitis B virus (HBV).
- Its symptoms include fatigue, jaundice, persistent low grade fever rash and abdominal pain. It can cause cirrhosis and possibly liver cancer.
- It is most infectious diseases. Mode of transmission may be blood transfusion, sexual contact, saliva, tears, intravenous drug abuse, tattooing, ear and nose piercing, sharing of razors etc
- Incubation period is 30-80 days.
- It can be diagnosed by Ausralian antigen test which is now called hepatitis-B surface antigen (HBS Ag). It can also be diagnosed by ELISA.
- Complete rest is suggested by physician in cause of hepatitis B interferon is used for treatment vaccines have been produced by r-DNA technology to prevent hepatitis-B.
- Hepatitis C and hepatitis D are also considered as sexually transmitted disease.

(6) Genital herpes

- Genital herpes is caused by simple herpes virus
- Vesiculopustular lesions followed by clusters of painful erythenatous ulcer over external genitalia and perennial region, vaginal and urethral discharge and swelling of lymph nodes are some common symptoms of the disease
- The disease is primarily transmitted through genital secretions but also contact viroids and genitalia.
- It is diagnosed by antigen detection PCR and nucleic acid hybridization.
- Treatment consists of acyclovir, valacyclovir and fancyclovir.

(7) Genital warts

- Genital warts is caused by human papillona virus.

- Symptoms include benign, hard outgrowths with horny surface (warts) over the skin and mucosal surface of external genitalia and perianal area.
- It spreads through sexual intercourse with carriers of the viruses of this disease.
- Dianosis is done by clinical symptoms, antibody detection, culture and DNA hybridization.
- Cryosurgery is used in removal of warts podophyllum preparations and podofilon are useful in treatment. Imiquim and interferon inducer is also useful.

(8) Chlamydiasis

- Chalamydiasis is caused by *Chlamydia trachomatis*.
- Chlamydia causes urethritis, epididymitis, mucopurulent, cervicitis, inflammation of fallopian tube, proctitis crectal pain with mucus and occasional bleeding etc.
- It spreads by sexual contact with infected mating partner.
- Incubation period is about one week.
- It is diagnosed by Gram-staining of discharge, antigen detection and nucleic acid hybridization.
- Antibiotics like tetracycline, erythromycin and rifampacin are effective in treatment.

(9) Lymphogranuloma venerlum

- Ltmphogranuloma venerlum is caused by chlamydia trachomatis of L_1, L_2, L_3 stereotypes.
- Symptoms include cutaneous or mucosal genital lesion, urithritis or endocervictis and genital elephantiasis.
- It is diagnosed by Gram negative discharge, antigen detection, microscopic examination of scraping and nuclei acid hybridization.
- It spreads by sexual contact.
- Antibiotics tetracycline, doxycycline erythromycin and azithromycin are used for treatment.

(10) Trichomoniasis

- Trichomoniasis is caused by *Trichomonasis vaginalis*
- The parasite affects both males and females.

- In females it causes vaginitis with foul smelling, yellow vaginal discharge and burning sensation. In males, it causes urethritis, epididymitis and prostatitis resulting in pain and burning sensations.
- It is transmitted through sexual intercourse.
- It is diagnosed by microscopic examination, culture and immunofluorescent antibody staining.
- It can be treated by metronidazole.

(11) Scabies

- Scabies is caused by *Sarcoptes csabiei.*
- Its symptoms include painful itching and red patches on the skin of pubic region.
- The parasite is transmitted by intimate contact or by sharing cloth, sheets and blankets etc.

(12) Pediculosis pubis

- Pediculosis pubis is caused by *Phthirus pubis* (*Parasitic louse*).
- Its symptoms include painful itching and red patches on the skin of pubic region.
- The parasite is transmitted by intimate contact or by sharing clothes, sheets and blankets etc.
- Medical shampoos are recommended for treatment.

(13) Candidiasis

- Candidasis is caused by fungus *Candida albicans* (*Vaginal yeast*).
- Women with yeast infections experience painful inflammation of vagina often with a thick cheesy discharge.
- Man may develop a painful inflammation of the urethra through sexual contact with an infected woman.
- Antibiotics such as clotrimazole, miconazole and nystatin are used for the treatment.

INFERTILITY

- Inability to conceive or produce children inspite of unprotected sexual cohabitation is called infertility.
- It is caused by various reasons which can be grouped under Physical, Congenital, immunological or even psychological disorders.

- Specialized infertility clinics can help in the diagnosis and proper treatment of some of these disorders and enable these couples to have children.
- However, were such diagnosis and treatment are not possible, the couples can be assisted to have children through certain special techniques called assisted reproductive techniques (ART)

Assisted Reproductive Technologies (ART)

Assisted reproductive technologies(ART) include a number of special techniques which assist infertile couples to have children.

Some important are

(1) Test tube baby programme
(2) Artificial insemination technique
(3) Gamete intra fallopian transfer
(4) Intracytoplasmic sperm injection

I) Test tube baby programme

- The baby produced by conceiving in a culture dish and nursing in the uterus is called a test tube baby.
- This method involves in vitro fertilization (IVF) i.e. fertilization of male and female gametes outside the body in almost similar conditions as that in the body followed by Embryo Transfer (ET).
- Embryo upto 8 Blastomeres is transferred into the fallopian tube (ZIFT – zygote Intra Fallopian Transfer) to complete its further development.
- If the embryo is with more than 8 blastomers, it is transferred into uterus (IUT – Intra Uteriane Transfer) to complete its further development.
- A developing embryo can be inserted in the uterus of another female. A woman who substitutes or takes the place of the real mother to nurse the embryo is called surrogate mother or genetic mother
- The success rate of the technique of producing test tube babies is less than 20%. In India, the first test tube baby was born on August 6, 1986 at K.E.M Hospital, Mumbai. She was named kum. Harsha. The doctor was Indira Hinduja

(II) Artificial Insemination Technique (AIT)

- AIT is used in those females where the husband is either unable to inseminate the female or has very low sperm counts in the ejaculation.
- In this technique the semen collected either from the husband or a healthy donor is artificially introduced into the vagina or into the uterus of the female.

(III) Gamete Intra Fallopian Transfer (GIFT)

- This method is used in females who cannot produce ova but can provide suitable environment for fertilization and further development of embryo in the oviducts
- In this technique, ovum from the donor female is surgically removed and then introduce into the fallopian tube of females incapable of producing ovum for fertilization

(IV) Intra Cytoplasmic Sperm Injection (ICSI)

- In this technique sperm is directly injected into the ovum to form an embryo in the laboratory
- The embryo is later transferred by ZIFT or IUT in woman

DETECTION OF FOETAL DISORDERS DURING EARLY PREGNANCY

Foetal disorders during early pregnancy can be detected by following techniques

- Amniocentesis
- Chorionic Villi Sampling (CVS)
- Non-invasive techniques
- Foetoscopy

(I) Amniocentesis

- Amniocentesis is a foetal sex determination and disorder test based on the chromosomal pattern in the amniotic fluid surrounding the developing embryo

- Then a small amount of amniotic fluid is drawn by passing special surgical syringe needle in to the abdominal wall and uterine wall into the amniotic sac containing amniotic fluid.
- These cells are cultured and are used to determine chromosomal abnormalities.
- Unfortunately, this useful technique is being misused to kill the normal female foetuses. It has been legally banned for the determination of sex to avoid female foeticide.

(II) Chorionic Villi Sampling (CVS)

- In this technique the physician inserts a narrow, flexible tube through the mother's vagina and cervix into the uterus and withdraws a small amount of foetal tissue from the placenta.
- It is advantageous over amniocentesis in its speed and also that it can be performed early, between 8^{th} and 10^{th} week of pregnancy.

(III) Non-invasive technique

- One of the widely used non-invasive technique to determine foetal condition is ultra sound imaging.
- Another technique is based on the fact that a few foetal blood cells leak across the placenta into the mother's blood stream. A blood sample from the mother provides enough foetal cells that can be tested for genetic disorders.

(IV) Foetoscopy

Foetoscopy is another technique in which a needle-thin to be containing a viewing scope is inserted into the uterus, giving the physician a direct view of the foetus.

HUMAN REPRODUCTION AND EMBRYONIC DEVELOPMENT
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- Human beings reproduce sexually and are viviparous i.e. they give birth to young ones. The reproductive units in sexual reproduction are specialized cells called gametes.

PRIMARY SEX ORGANS

- Primary sex organs are those sex organs which produce gametes. They are also called gonads.
- They also produce steroid hormones essential for reproduction as well as the growth and development of the entire body.

SECONDARY SEX ORGANS

- Sex organs, glands and ducts which do not produce gametes and hormones but are otherwise essential for sexual reproduction are known as secondary sex organs.
- Secondary sex organs of human male reproductive system are vasa efferentia, epididymes, vas deferentia, ejaculatory ducts seminal vesicles, cowper's gland, urethra, prostate gland and penis.
- Secondary sex organs of human female reproductive system are fallopian tubes, uterus, vagina, external genitalia and mammary glands.

ACCESSORY OR EXTERNAL OR SECONDARY SEX CHARACTERS

- They are those external features which provide distinctiveness to the two sexes.
- Major accessory or external or secondary sex characters of human male are facial hair, body hair, more height, more muscles, broadening of shoulder, low pitched voice, narrow but strong pelvis
- Major secondary sex characters of human female are development of breasts, broader pelvis, rounded body contours, fat deposition in thighs, buttocks and face, high pitched voice, pubic hair and sterna breathing

PUBERTY

- Beginning of sexual maturity or ability to reproduce is known as puberty. It is the period when primary sex organs become functional and start secreting sex hormones which bring about developments of secondary sex organs and appearance of secondary sex characters.

- Puberty is characterized by rapid growth. The average age of onset for girls is 10 -14 years and for boys, 12 -15 years old
- In boys pubertal changes occur in response to testosterone, whereas in female child, estrogen is produced by ovarian follicles.

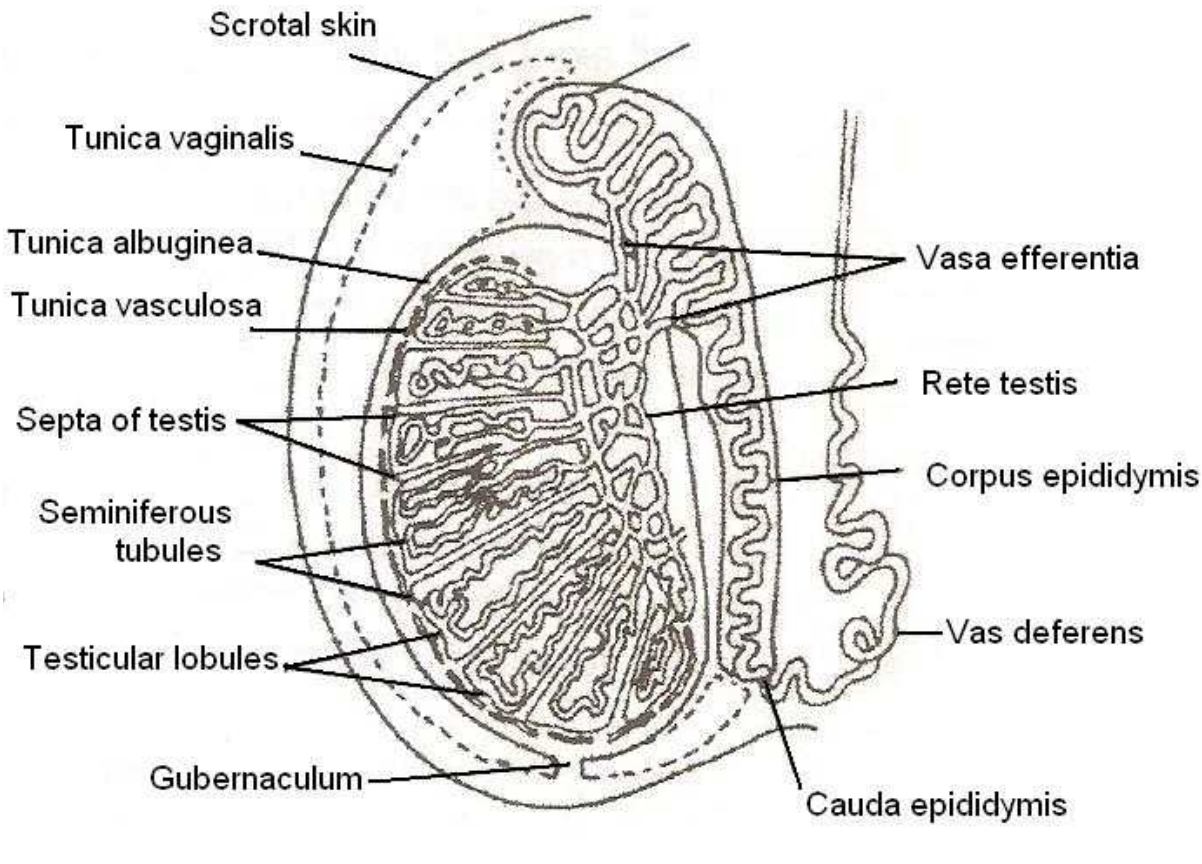
MALE REPRODUCTIVE SYSTEM

It is made of a pair of testes, scrotum, vasa efferentia, a pair of epididymes, a pair of vasa differentia, a pair of seminal vesicles, a pair of ejaculatory ducts, urethra, prostate gland, a pair of cowper's glands and penis

TESTES

- They are a pair of oval, pinkish primary sex organs of male reproductive system, each of with a size of 5cm (length), 3cm (thickness) and 2.5cm (width), weight about 12gm and lying obliquely in scrotum.
- During early foetal life, the testes develop in the abdominal cavity just below the kidney then they descend into the scrotum.
- The testis is surrounded by three layers
  (i) Tunica vaginalis, a bilayer of peritoneum with narrow coelomic cavity filled with coelomic fluid. It helps the testis in frictionless sliding
  (ii) Tunic albuginea, is the actual covering of the testes. The covering is made up of dense bluish with fibrous or collangenous connective tissue
  (iii) Tunica vasculosa, is delicate loose connective tissue which lines the testicular lobules inner to tunica albuginea. It has rich supply of blood vessels.
- Tunica albuginea also projects inside testes to form a thick incomplete vertical column called mediastimum and a number of transverse septa. The septa produces 200 – 300 conicular testicular lobules and each lobules is filled with connective tissue and 1-3 yellow convoluted seminiferous tubules. A total of 900 – 1000 yelloish seminiferous tubule occur in each testis. Each tubule is about 70-80 cm long. Seminiferous tubule join to form 20-30 short straight ducts called tubulic recti. Tubuli recti enter a network of channels called rete testes.
- The connective tissue lying in between seminiferous tubules are called Leydig's cell and it contain yellow pigment granules. Leydig cells are large polyhedral cells which have eccentric nucleus and small lipid containg vacuoles. They secrete testosterone and other androgens.

- The lining of seminiferous tubules is formed by a single layered germinal epithelium. The epithelium has two types of cells, spermatogenic (primary germ cells) and sertoli cells (supporting cells), Spermatogenic cells form 4-8 layers. The cells are destined to undergo spermatogenesis and form supermatozoa.
- Sertoli cells are large, elongated and pyramidal cells with bases resting on basal lamina (basement membrane) and apics projecting into the lumen of the seminiferous tubules. They secrete spermatogonic substances for nourishing and differentiation of cells undergoing spermatogenesis. They also secrete hormone inhibin for controlling FSH secretion.



L. S of testies

SCROTUM

- It is a pouch of deeply pigmented skin arising from lower abdominal wall below the pubic symphysis and hanging between and infront of groin part of the thighs. Scrotal skin bears sebaceous glands that produce a characteristic odour, sweat glands and nerve endings.

- Wall of scrotum has three layers – outer wrinkled skin, connective tissue and smooth muscles. An internal septum scroti divides the scrotum into two sacs, each for one testis. Left testis lies a bit lower than the right one. Scrotum possesses a smooth involuntary muscle called dartos muscle. A testis rests in its chamber over pad called gubernaculum.
- The scrotum remains connected with the abdomen or pelvic cavity by the inguinal canals. The spermaticord, formed from the spermatic artery, vein and nerve, bound together with connective tissue passes into the testis through inguinal canal.
- The testes develop in the abdominal cavity during the 7^{th} month of gestation descend permanently into the respective scrotal sacs
- The scrotum acts as a thermoregulator, maintaining the testes at a temperature $2^{O}C$ lower than that of the body. Movement of dartos muscle help in changing position of testes to keep them at proper temperature. When the body is chilled the smooth muscle contracts and brings the testes closer to the pelvic cavity to get warmth
- In some person testes fail to descend in scrotum. The condition is called cryptorchidism. It results in sterility

VAS EFFERENTIA

- Rete testies is connected to caput epididymis by 12-20 fine tubules called vasa efferentia
- Their lining epithelium is pseudostratified. It has large columnar ciliated cells and small nonciliated cells with endocytic activity, ciliated cells help in conducting sperms. Tubuli recti, rete testis and vas efferentia constitute an intratesticular genital duct system

EPIDIDYMES

- The epididymes is a mass of long narrow closely coiled tubule which lies along the inner side of each testis. coiling forms three parts – upper caput epididymes or head middle corpus epididymes or body and lower cauda epididymes or tail
- In the head of the epididymis, the sperms undergo physiological maturation, acquiring increased motility and fertilising capacity. In the tail of the epididymis sperms are stored before entering the vas deferens

- Epididymis is lined by pseudostratified epithelium that secretes nutrients required for maturation of spermatozoa. Non-ejaculated sperms are broken down after an interval.

VAS DEFERENS

- The vas deferens is a continuation of cauda epididymis which leaves the scrotal sac and enters the abdominal cavity. After entering abdomen it loops over the urinary bladder and dilates to spindle like ampulla for temporary storage of spermatozoa. It also conducts sperms.

EJACULATORY DUCTS

- They are shorter ducts of about 2cm length where male ejaculate is produced. Each duct is formed by joining of vas deferens and duct of seminal vesicle
- Ejaculatory ducts enter the prostate gland and join the prostatic urethra to produce a single urinogenital duct. In ejaculatiory duct, the sperm mix up with secretation of seminal vesicles. The walls of ejaculatory ducts are muscular to quickly conduct the ejaculate through urinogenital duct.

URETHRA

- It arises from urinary bladder and is about 20cm long, differentiated into three regions
  - (i) A short proximal prostatic urethra which is surrounded by prostate glands.
  - (ii) A very short middle membranous urethra without any covering
  - (iii) A long distal penile urethra that passes through a penis
- The urethra has internal sphincter of smooth muscle fibres at its beginning and external sphincter of straited muscle fibres around its membranous part

PENIS

- It is male erectile copulatory organ which transfers semen into reproductive tract of female during sexual intercourse
- The penis contains three cylindrical masses of erectile tissue – two dorsal corpora cavernosa and one ventral corpus spongiosum
- The corpus spongiosum, which contains the penile urethra, is enlarged at the distal end of the penis to form glans penis. It is covered with smooth skin, foreskin.

SEMINAL VESICLES

- They are a pair of lobulated contorted musculoglandular sacs of 5cm length between urinary bladder and rectum. Their ducts join the vasa deferens to form ejaculatory ducts.
- They produce an alkaline secretion which forms 60% of the volume of semen. The secretion of seminal vesicles contains fructose, citrate, prostaglandins, inositol and clotting protein.
- Alkaline nature of the acidic environmental of the male urethra which otherwise would inactivate and kill sperms
- The prostaglandins stimulate uterine contractions and thus may help the sperm to be moved towards female’s oviducts, where fertilization takes place. The clotting protein help semen coagulate after ejaculate.

PROSTATE GLAND

- It is a large grayish to red pyramidal gland of 4cm with and 3cm height that encloses a part of urethra including its junction with ejaculatory ducts
- The produces a milky slightly alkaline secretion which forms 25% of the volume of semen. It possesses calcium, phosphate, bicarbonates, enzymes, clotting enzymes, prefibrolysin and prostaglandins. Secretion of the prostate gland nourish and activates the spermatozoa to swim. Prostaglandins helps in liquefying cervical mucus and helps in liquefying cervical mucus and stimulating movement in the female tract.

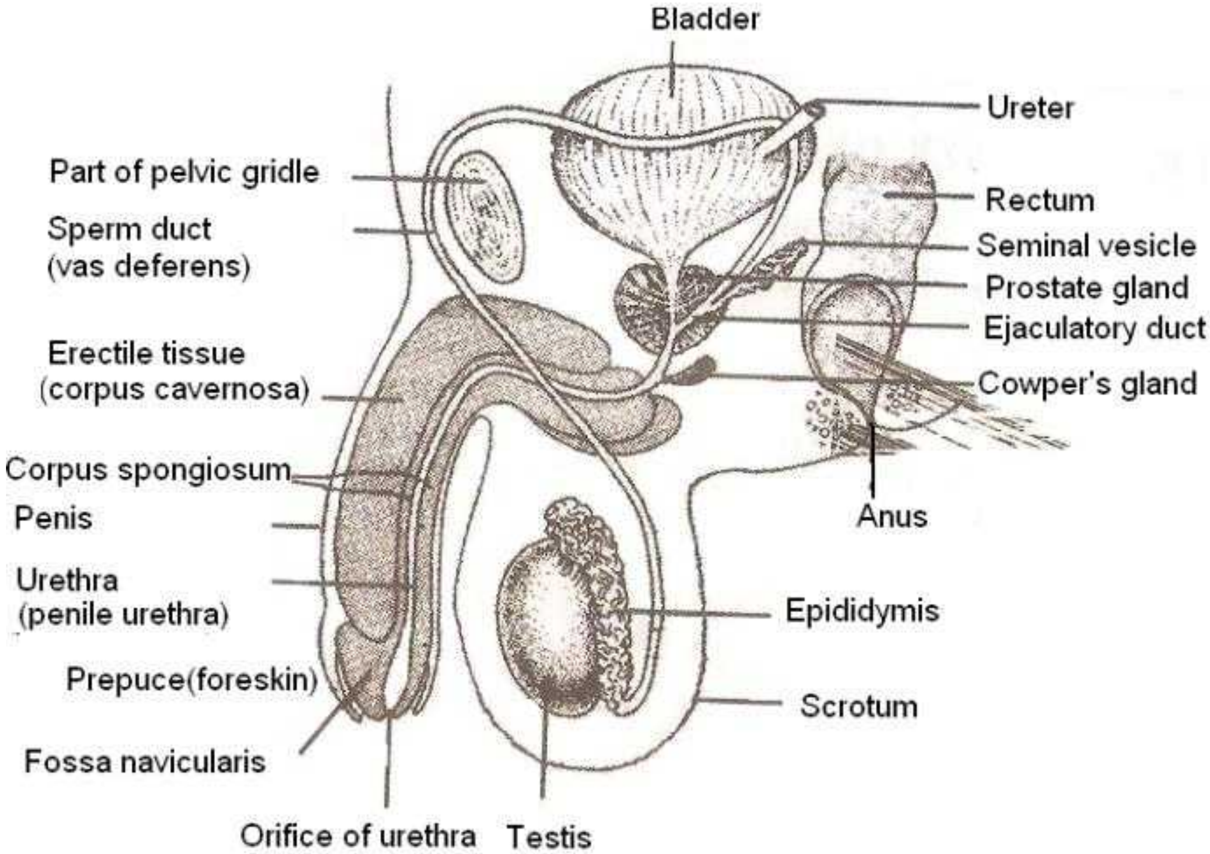
BULBOURETHRAL GLANDS

- A pair of small yellow pea seed sized lobulated tubualveolar glands, 4-5cm below prostate and opening into membraneous urethra by separate ducts
- The secretion has abundant mucus for lubrication of reproductive tract. It neutralizes the urethra from remains of urine. Secretion of cowper’s gland is produced before the ejaculation of semen

SEMEN

- The secretion of accessory sex glands and mucus are added to sperms to form seminal fluid, or semen or seminal plasma
- It rich in fructose, calcium and certain enzymes. It has a pH of 7.35 to 7.5.

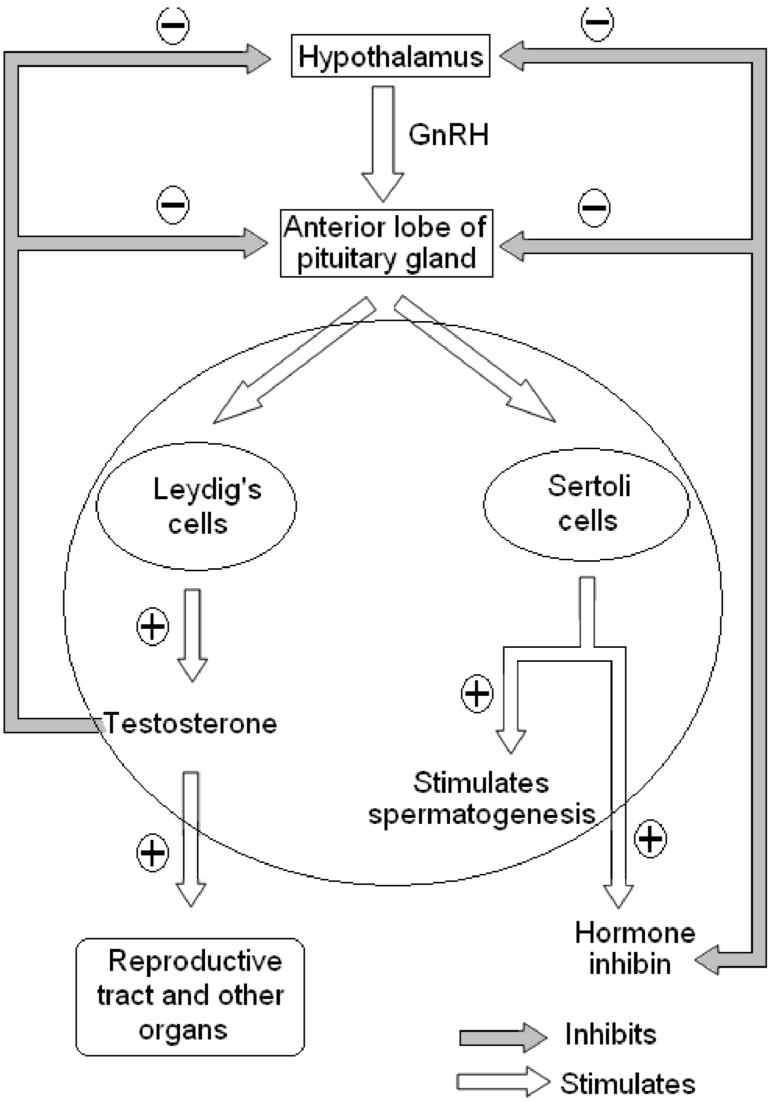
- It is ejected from the penis during ejaculation. A single ejaculation may contain 300 million sperms. It has many functions
  (i) It provides a fluid medium for transmission of sperms into vagina of the female.
  (ii) It nourishes and activate the sperms to keep them viable and motile
  (iii) It neutralizes the acidity of the urine in the urethra of male and vagina of female to protect the sperms
  (iv) It facilitates the sexual act by lubricating the reproductive tract of the female.



HORMONAL CONTROL OF MALE REPRODUCTIVE SYSTEM

- The growth, maintenance and functions of the male reproductive organs are under the hormonal control. GnRH (Gonadotropin releasing hormone) is secreted by hypothalamus. It stimulates the anterior lobe of pituitary gland to secrete and release LH and FSH. In male, LH is called interstitial cell stimulating hormone (ICSH) because it stimulates Leydig's cell of the testes to secrete androgens

- Testosterone is the principle androgen. The growth, maintenance and functions of secondary sex organs and functions of secondary sex organs and accessory glands are under the control of testosterone.
- FSH stimulates sertoli cells of testis to secrete an androgen binding protein (ABP) that concentrates testosterone in seminiferous tubule and also secrete a peptide inhibin which suppresses FSH synthesis. FSH acts directly on spermatogonia to stimulate sperm production.



COMMON DISORDERS OF MALE REPRODUCTIVE SYSTEM

(i) Prostatitis – It is inflammation of prostate generally caused by infection

(ii) Benign prostatic hypertrophy (BPH) – This is the enlargement of prostate gland. It often causes in old age causing frequent night urination. Untreated BHP may lead to kidney damage.

(iii) Prostate carcinoma – It is cancer of prostate which may grow unnoticed up to stage of metastatis
(iv) Impotence – It is the inability of the adult male to achieve penile erection.
(v) Sterility – Sperms are unable to fertilize the ovum due to low count or less motility.
(vi) Cryptochidism – It is a failure of one or both of the testicles to descend into scrotum. It is often results in pushing of an intestinal loop into scrotum, resulting in its abnormal size and discomfort.

FEMALE REPRODUCTIVE SYSTEM

The female reproductive system consists of a pair of ovaries, a pair of fallopian tubes, uterus, vagina, external genitalia and breasts

OVARIES

- They are a pair of almond shaped, solid, greyish pink gonads of the female. Each ovary is about 2-4 cm in length, 1.5cm in width and 1cm in the thickness. It is suspended from the dorsal body wall by a fold of peritoneum called mesovarium. It is held in position by ligaments which attach it to pelvic wall and uterus.
- Ovaries are differentiated into four parts

(i) Germinal epithelium is the outermost layer of the ovary which is formed of simple squamous and cuboidal cells
(ii) Tunica albuginea is poorly differentiated sheath of dense connective tissue that lies below the germinal epithelium and outside the cortex. Tunica albuginea provides greyish colour to ovary.
(iii) Cortex is a wide layer of connective tissue having a large number of spindle shaped fibroblasts, reticular fibres and ovarian follicles
(iv) Medulla is the central part of the ovary made of less dense connective tissue. Medulla is richly supplied with blood vessels. It has elastic fibres, smooth muscles.

- The ovarian medulla contains many rounded or oval bodies called ovarian follicles at various stage of development. The number of follicles in the two ovaries of young adult female is 1,20,000 – 1,60,000

FALLOPIAN TUBES (OVIDUCTS)

- They are pair of muscular and internally ciliated tubes of 10-12 cm length which lie horizontally over peritoneal cavity arising near and ending at uterus

- A fallopian tube is differentiated into four parts

(i) Infudibulum is a funnel shaped fimbriated free end of the oviduct. It opens into the body cavity by an aperture called ostium. Margin of the funnel bears motile, finger like projection called fimbriae. Fimbriae have folds lined with cilia that produce a slow current towards the ostium for passage of liberated ovum towards the inside of oviduct.

(ii) Ampulla is a curved dilated part of oviduct which is also the site of fertilization of ovum

(iii) Isthmus is the very short, narrow, thick walled, straight part of the oviduct which connects ampulla with lateral wall of uterus.

(iv) Uterine part is about 1cm long part that passes into uterine wall. Oviducal wall is composed of three layers – outer serosa of visceral peritoneum, middle muscularis and inner mucosa. Mucosa has an epithelium of ciliated and secretory columnar cells. Secretory cells produce a viscous secretion for nourishing and protection of ovum. Passage of ovum is facilitated by movement of cilia and muscular contractions of the wall.

- In most vertebrates both the ovaries and oviduct are functional. In birds the right ovary and right oviduct are atrophied

UTERUS

- It is the pyriform, hollow muscular thick walled but distensible median structure located above and behind urinary bladder that is meant for nourishing and development of foetus. For this, uterus is capable of tremendous enlargement. The empty uterus is 7.5cm, 5cm broad and 2.5cm thick
- Uterus is attached to pelvic wall by means of ligament
- Wall of uterus is differentiated into three layers

(i) Internal glandular endometrium
Endometrium has two parts, epithelium and lamina propia. Epithelium lines the luminar surface of uterus. It contains two types of columnar cell, ciliated and secretory. Lamina propia contains connective tissue with fibroblasts, tubular glands and blood vessels. Endometrium shows cyclic changes during menstrual cycle.

(ii) Myometrium is the middle layer of smooth muscles. It undergoes strong contractions during delivary of the baby

(iii) Perimetrium is an outer layer of uterus formed of either adventitia (connective tissue only) and serosa (connective tissue and mesothelium)

- Uterus is differentiated into three regions

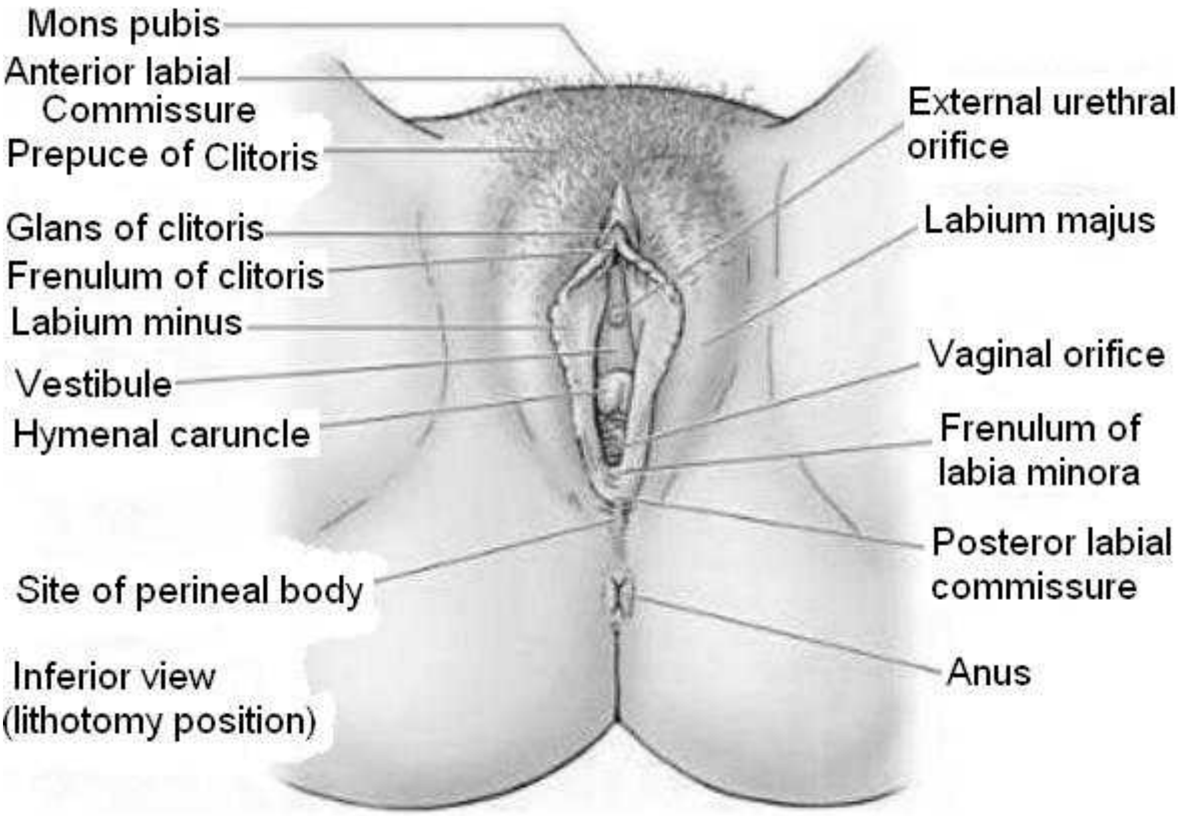
(i) Tundus: Upper dome – spahped part above the opening of fallopian tube
(ii) Body : It is broad towards fundus and narrow down towards the cervix
(iii) Cervix: 2.5cm long narrow inferior extremity of uterus which protrudes into vagina. It is connected to the body by internal child birth it becomes irregular bilipped. Upper part of uterus leans forwards. It is almost at right angle to vagina

VAGINA

- It is an elastic muscular tube of 8-10cm length which functions as female copulatory organ, pathway for menstrual flow and birth canal. It is easily stretched
- The opening of the vagina is called vaginal orifice. Vaginal orifice is partially covered by a perforate membrane called hymen. It often gets ruptured during vigorous physical exercise or during sexual intercourse. In some it persists even after coitus

EXTERNAL GENITALIA

- The area having external genitalia is characterized by mons pubis on the upper side, perineum on the lower side and vestibule or depression in the centre
- Mons pubis is an eminence formed by fat over the public symphysis bones. Vestibule has urinary meatus with urethral opening on the upper side and vaginal orifice on the lower
- A small erectile organs, the clitoris, lie at the anterior junction of labia minora. It is homologous to the penis. It consists of a short shaft with erectile tissue. its tip is round and of erectile tissue
- Vestibule is flanked by two pairs of fleshy folds of skin; the inner small, thin, moist labia minora which form clitoris in front and are connected behind by fourchette. They possess sebaceous gland. The outer larger, hair –covered labia majora. They also possess sebaceous gland.



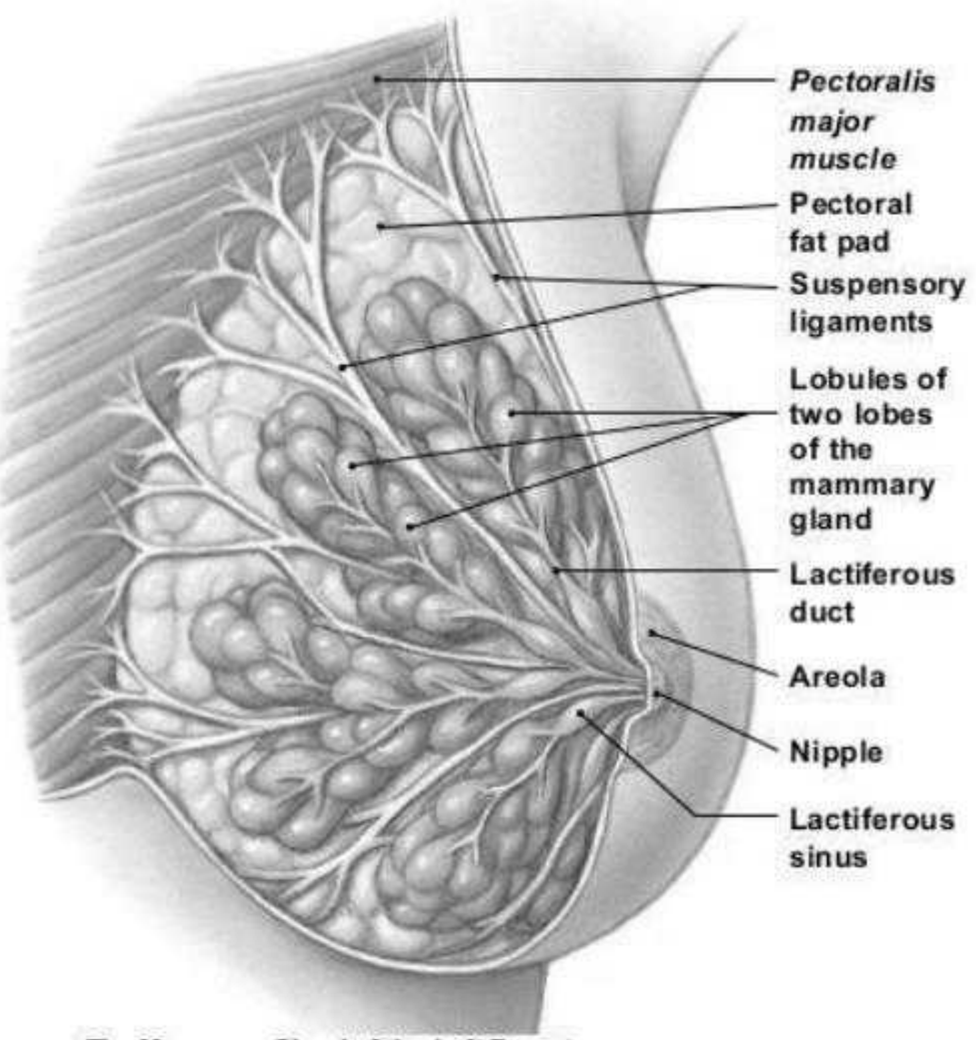
VESTIBULAR OR BARTHOLIN'S GLAND

- They are a pair of small tubulociner glands which open in the vestibule lateral to vaginal orifice. The secretion is thick viscid and alkaline for lubrication and counteracting urinary acidity. A number of small vestibular gland (paraurethral gland or gland of skene) are present on the either side of urethral opening.

MAMMARY GLAND OR BREASTS

- Mammary glands or breasts are modified sweat glands that lie over the pectoral muscle which develops during puberty but becomes active only after child birth
- Each breast has a broad tip called nipple for the release of milk. A circular pigmented area called areola lies below it. Each breast contains 15-20 glandlar lobes having secretory alveoli and each lobe is separated from each other by connective tissue and adipose tissue.
- The cells of alveoli produce milk which is stored in the cavities of alveoli. Alveoli opens into mammary tubules and then into mammary ducts.
- Mammary ducts forms mammary ampulla from which a lactiferous duct develops. Each lobe has a separate lactiferous duct and each opens at nipple by separate pores.

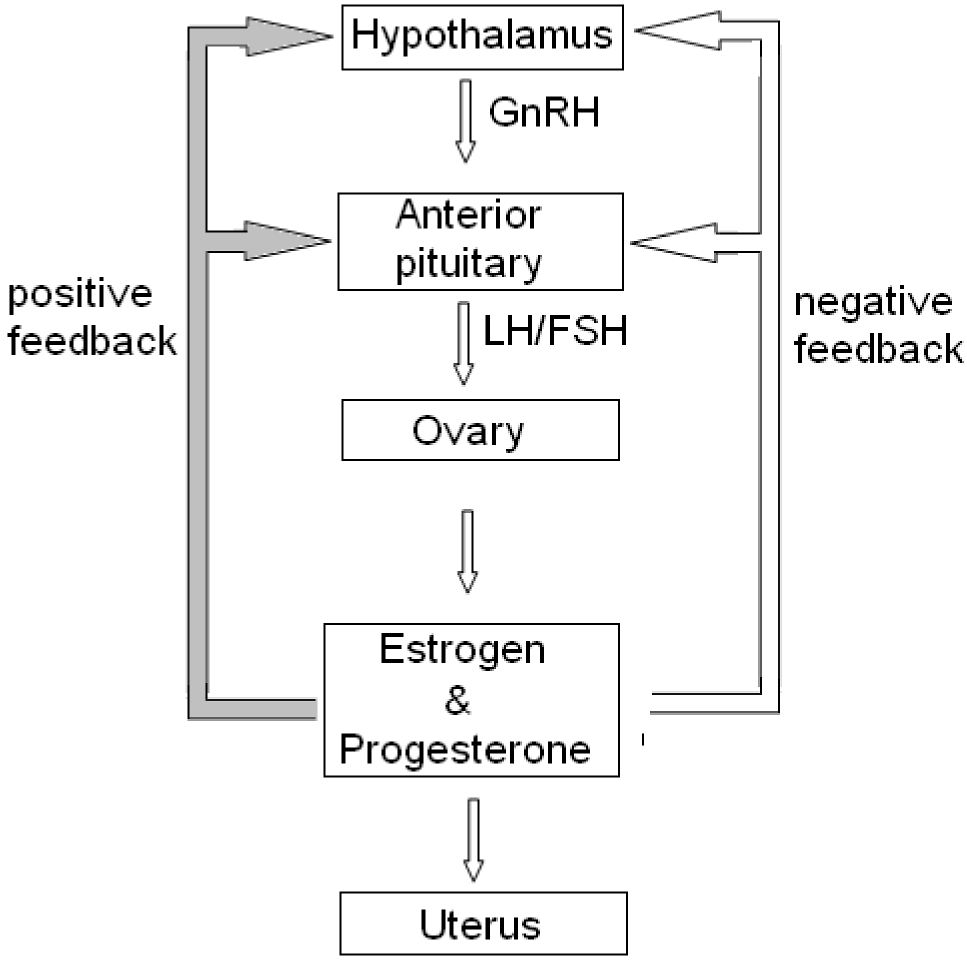
- During pregnancy, the glands grow under the influence of oestrogen and progesterone. On the infant's birth, the hormone prolactin stimulates the production of milk and hormone oxytocin causes release of milk as infant sucks the breast.



The Mammarv Gland of the Left Breast.

HORMONAL CONTROL OF FEMALE REPRODUCTIVE SYSTEM

- GnRH secreted by hypothalamus stimulates the anterior lobe of pituitary gland to secrete LH and FSH. FSH stimulates the growth of ovarian follicles and also increase the development of egg(oocyte with the follicle to complete the meiosis I to form secondary oocyte. FSH also stimulates formation of oestrogen.
- Lutenising hormone (LH) stimulates the corpus luteum to secrete progesterone.
- Rising level of progersterone inhibits release of GnRH which in turn inhibits the production of FSH, LH and progesterone.



MENSTRUAL CYCLE

- It is a series of cyclic changes that occurs in the reproductive tract of human females with periodicity of 28 days, right from menarche to menopause except during period of pregnancy.
- The first menstrual period is called menarche. This occurs between the age of 12 to 15 years. Menopause is stoppage of menstrual period. It occurs between 45-55 years.
- Menstrual cycle is controlled by gonadotropin and ovarian hormones.
- Menstrual cycle has following phases:-

I. Menstrual phase
   - This phase lasts for about 4 days.
   - If fertilization do not occur progesterone secreted by persistent corpus luteum inhibits the release of LH from pituitary.
   - Reduction of LH causes subsequent fall in progesterone level.

- The uterine lining due to deficiency of progesterone causing rupture of blood vessels and leads to discharge of blood, a serous fluid, cell debris and mucosal fragments.
- Lowered levels of progesterone causes release of FSH from the anterior pituitary. This initiates a new cycle.

II. Follicular phase (proliferative phase)

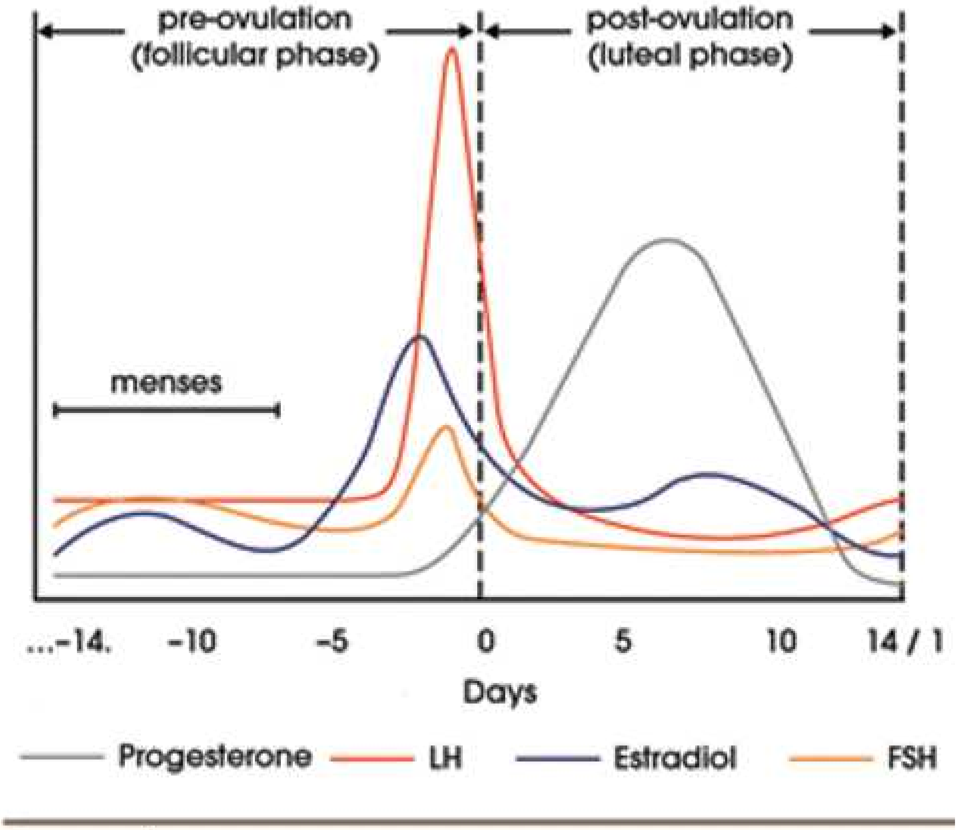
- In the presence of FSH released by anterior pituitary, 6-12 ovarian follicles begin enlargement through proliferation of their granulose cells to secrete estrogen. Estrogen stimulates the proliferation of the endometrium of uterine wall.
- After about a week of development only one ovarian follicle continues growth while the rest degenerates.
- Towards the end of proliferative phase the endometrium becomes about 3mm thick.

III. Ovulatory phase

- High level of both LH and estrogen cause rapid growth of graafian follicle.
- Graafian follicle rises to the surface of the ovary, produce a protuberance or stigma. The stigma ruptures and the ovum surrounded by corona radiate comes out in a viscous fluid. The process is called ovulation. It occurs after about 14 days.

IV. Luteal or secretory phase

- Under the influence of LH the empty graafian follicle continues growth.
- The follicular cells are converted into lutein cells by deposition of yellowish lipid inclusions. The phenomemnon is called lutenisation. The rupture graafian follicle is now called corpus luteum. It secretes progersterone.
- Both LH and progesterone help in further growth and thickening of endometrium. Thickness of endometrium becomes 5-6mm.
- Progesterone inhibits uterine movements as well asproliferation of new ovarian follicles. The phase lasts for about 10 days.



The "Normal" Pattern of Hormonal Changes that Regulate the Ovarian Cycles

- If puberty starts early then it is known as precocious puberty.
- Dysmenorrhoea is painful menses.
- Menorrhagia is excessive menstruation.
- Oligomenorhoea is infrequent menstruation.
- Amenorrhoea is non-occurences of menses.

DISORDER OF THE HUMAN FEMALE REPRODUCTIVE SYSTEM

(i) Breast cancer: Breast cancer increases after menopause. The standard treatment for breast cancer is mastectomy (removal of breasts).
(ii) Cervical cancer: It is relatively slow growing cancer. Cervical cancer may be treated by radiation or surgery.
(iii) Oophorocystosis: Ovarian cysts are fluid filled tumors of the ovary. Such cysts sometimes rupture and regresses during pregnancy.
(iv) Ectopic pregnancy: It is implantation of embryo at a place other than uterus, generally oviduct.
(v) Oophoritis: It is inflammation of ovary, usually caused by an infection.

(vi) Endometriosis: It is growth of endometrial tissue outside the uterus. Treatment is usually hormone therapy or surgery.

(vii) Infertility: Infertility in women is inability to become pregnant.

SPERMATOGENESIS

- Spermatogenesis is the process of formation of haploid spermatozoa(sperms) from diploid spermatogonia inside the testis of the male.

Formation of spermatids

(i) Multiplication phase: At sexual maturity, the underdiffernetiated germ cells divide several times by mitosis to produce a large number of spermatogonia(2N) are of two types:-
Type A spermatogonia fuction as stem cells and produce more spermatogonia.
Type B spermatogonia divide mitotically to form primary spermatocytes. This process is called spermatocytogenesis.

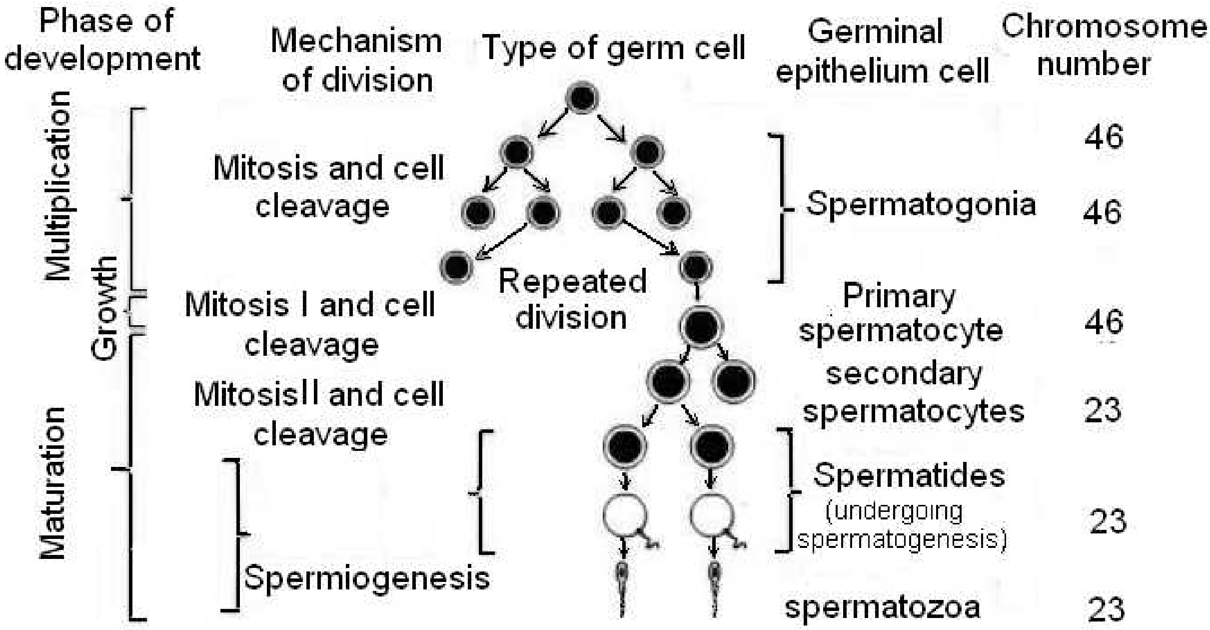
(ii) Growth phase: Primary spermatocytes grow to become almost double in size.

(iii) Maturation phase: Each diploid primary spermatocyte undergoes meiosis I to form two haploid secondary spermatocytes. Each secondary spermatocytes divides by meiosis II, giving rise to two haploid spermatids. The spermatids becomes partially embedded in sertoli cells for nourishment and support.

(iv) Spermiogenesis: The transformation of spermatids into spermatozoa is called spermiogenesis. The different changes which occur during spemiogenesis are

a. Formation of acrosome by golgi apparatus
b. Elongation and condensation of nucleus.
c. Separation of centrioles.

- Spermatogenesis requires about 64 days.
- The number of sperms produced by adult male per day is 10^{12}-10^{13}. Sertoli cells act as phagocytes. They consume the residual cytoplasm discarded during spermiogenesis.
- After maturation of spermatozoa, they get detach from sertoli cells. The process is called spermiation. The released sperms are stored in epididymis upto one month.



SPERM

- Human sperm is dart-like flagellate structure of 60 µm length and maximum breadth of 3.5µm.
- It has four parts:

(i) Head: Knob-like structure but flat terminal part, 4-5 µm long. It has two components acrosome and nucleus. Cytoplasm is nearly absent. Acrosome forms a covering over the anterior two third of head. It is derived from golgi apparatus from spermatid. It contains lysins like hyaluronidase and proteolytic enzymes. Surface contains compatibility protein bindin for attaching to receptors of egg. Nucleus is dense mass of chromatin having protamines. These may be one or more less dense areas called nuclear vacuoles. On the outside is present a double membrane head cap.

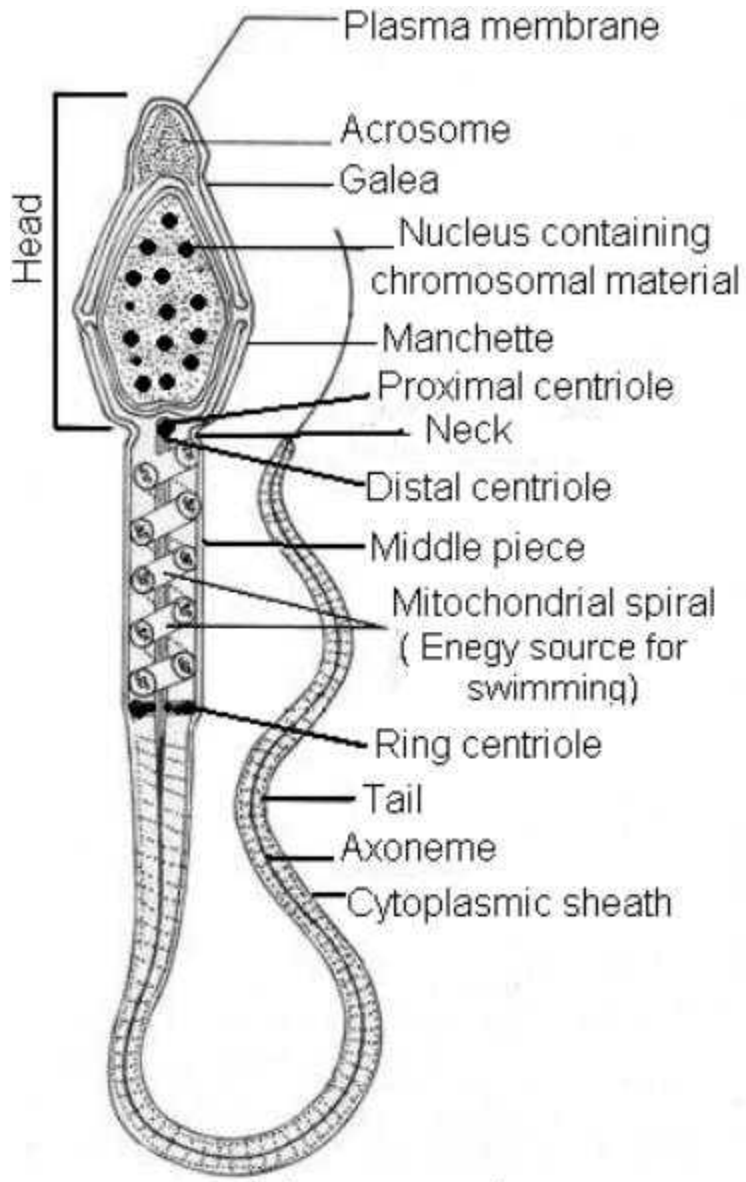
(ii) Neck: It is a short narrow part between head and middle piece which contains two centrioles, unconnected proximal centriole and distal centriole attached to filament that passes into middle piece.

(iii) Middle piece: It is a cylindrical part 5-7µm long and 1µm in breadth. It has axial filament surrounded by 10-14 spiral turns of mitochondria and bearing towards the end of a ring centriole. Mitochondria provides energy for swimming. All are embedded in a thin sheath of cytoplasm.

(iv) Tail: It is narrow vibratile long part about 50µm in length. The tail is broad at beginning but narrows down gradually.

SIGNIFICACE OF SPERMATOGENSIS

(i) During spermatogenesis, one spermatogonium produce four sperms
(ii) Sperms have half the number of chromosomes
(iii) During meiosis "I" crossing over takes place which brings variation



complete spermatozoan

OOGENESIS

Oogensis is the process of formation of functional haploid ova from the diploid germinal cells in the ovary

It consists of three phase

(i) Multiplication phase

- During foetal development, certain cells of the germinal epithelium of ovary which are larger than others function as germ cells. They undergo repeated mitotic divisions to produce undifferentiated germ cells oogonia or egg mother cells (2N)
- The oogonia multiply by mitotic divisions and vecomes primary oocyte
- Other oogonia forms a regular layer, the follicular epithelium around the primary oocyte to protect and nourish it. The structure thus formed, is called primary ovarian follicle.

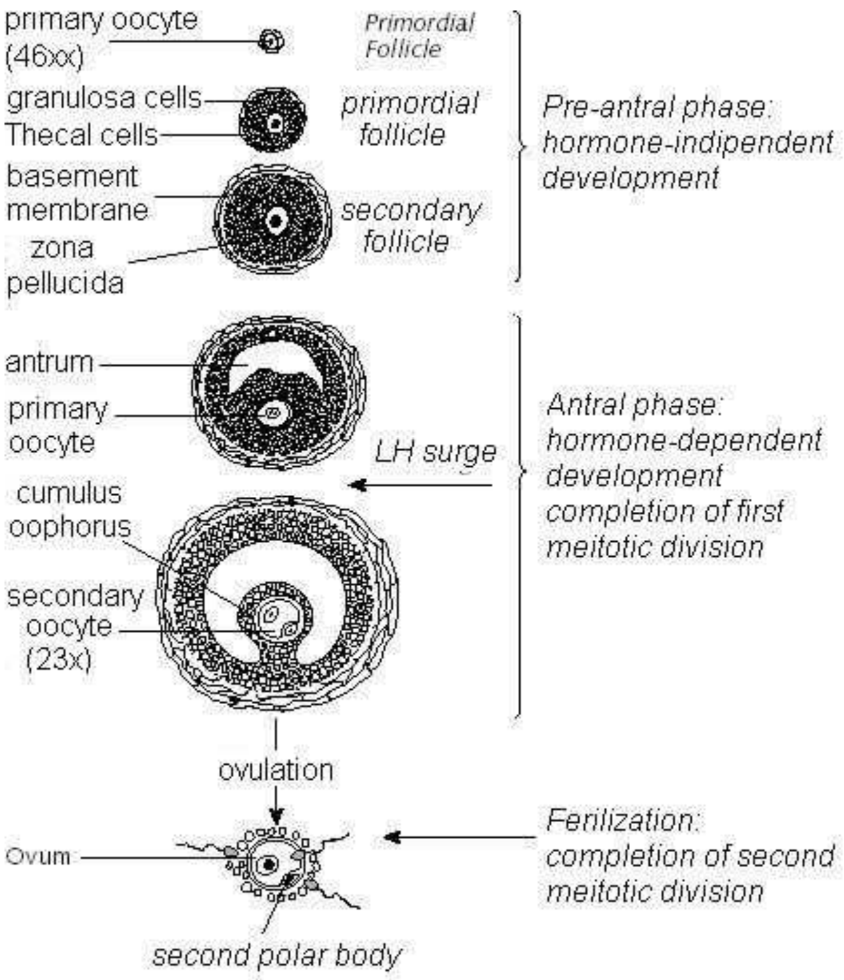
(ii) Growth phase

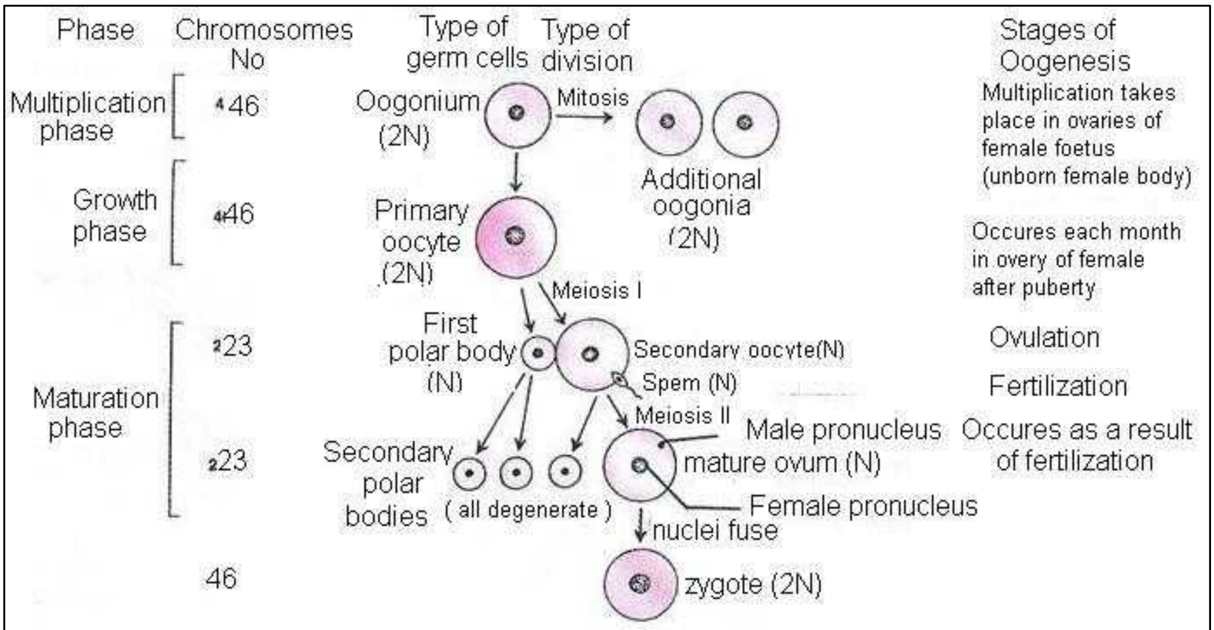
- This phase of the primary oocyte is very long. The oogonium grows into a large primary oocute by taking food from the surrounding follicle cells, it happens after puberty
- Meiosis begins in the primary oocytes soon after their formation. However, the oocytes are arrested in the early part of meiotic prophase “I”. This is the first resting stage. They undergo a round of DNA synthesis and chromosome pairing takes place, but meiosis does not proceed further until years later

(iii) Maturation phase

- After attainment of puberty, follicles and their contained oocytes resume development. Follicular sheath differentiates into layers of granulose cells. Another layer called theca, primary follicle is transformed into two layers. Granulosa cells secrete fluid that causes the development of a cavity or antrum around the primary oocyte. The stage is called tertiary follicle.
- Primary oocyte grows further and completes meiosis “I”. It produces a large secondary oocyte and a small polar body. Both are haploid. The polar body has a very small amount of cytoplasm but whole chromosome set. The bulk of nutrient rich cytoplasm is retained in the secondary oocyte.
- The follicle grows to maximum size and is called graafian follicle. Zoa pellucida develops around secondary oocyte

- The secondary ooccyte proceeds with meiosis II but division gets arrested in metaphase II stage due to accumulation of metaphase promoting factor (MPF). This is the second resting stage
- It is in this stage of oocyte that the ovum is shed during ovulation. It passes into oviduct, where in ampulla part, cell cycle will resume only after the entry of sperm. It triggers the breakdown of MPF and promotes synthesis of anaphase promoting complex(APC) meiosisII is completed.
- As secondary polar body is extruded. The first polar body is extruded. The first polar body divide to form two second polar bodies. Thus form one oogonium, one ovum and three polar bodies are formed. In human females the polar body does not divide further. The oocyte is now changed into ovum or ootid. The ovum is actual female gametes. The polar bodies take no part in reproduction and soon degenerates due to lack of cytoplasm and food. The formation of non-functional polar bodies enables the egg to get rid of excess chromosomes. The unequal cytoplasmic division enables the ovum to retain the whole of the cytoplasm of the primary oocyte in it for the development of the future





Stages of oogenesis

SIGNIFICANCE OF OOGENESIS

(i) One oogonium produces one ovum and three polar bodies
(ii) It helps to retain sufficient amount of cytoplasm in the ovum which is essential for the development of early embryo
(iii) During meisosis first crossing over takes place which brings about variation

OVUM

- Human egg or ovum is noncleidoic (without shell) and alecithal (absence of yolk) rounded female gamete having diameter of about 100μm
- The ovum possesses three coverings – inner plasma membrane, middle glycoprotein zona pellucidaa and outer cellular corona radiate with radially elongated scattered cells held in mucopolysaccharide.
- Zona pellucidaa carries compatibility receptor proteins collectively called as fertilizing. In between plasma membrane and zona pellucida is perivitelline space in which one polar body is present towards animal pole. The opposite end is vegetal pole. Cytoplasm of ovum is called ooplasm. It has a large nucleur or germinal vesicle.
- Typical nucleus or pronucleus is formed at the time of fertilization
- Ectoplasm possesses mucopolysaccharides granules and microtubules. Mucopolysaccharides granules or cortical granules are extruded membrane and zona pellucida for preventing entry of another sperm. Endoplasm has

mitochondria, golgi apparatus, ribosomes, RNA, fat droplets, glycogen particles and proteins.

TYPES OF OVUM

On the basis of amount of yolk, eggs are classified as:

(i) Alecithal – No yolk, example : human egg
(ii) Microlecithal – Small amount of yolk example : Sea urchin
(iii) Mesolecithal – Moderate amount of yolk, example frog and other amphibian egg
(iv) Macrolecithal or polylecithal – Large amount of yolk example : reptilian and avian eggs

- On the basis of distribution of yolk, eggs are classified as:-

(i) Isolecithal or Homolecithal _ Having homogenously distributed yolk, example : Protochordates and echinoderms.
(ii) Hetrolecithal – egg with unevenly distributed yolk
(iii) Telolecithal – Having yolk concerned in one half

Example : amphibian eggs

(iv) Centrolecithal – yolk is concentrated in centre and cytoplasm is peripheral example – insect eggs
(v) Discoidal or Meiolecithal – Almost the whole of the egg is occupied by the yolk except a small disc, example : eggs of birds and reptiles

- On the basis of presence and absence of shell eggs are differentiated into cleidoic (surrounded with water proof shell e.g. birds and reptiles) and noncleidoic (shell absent)

FERTILIZATION IN HUMANS

- It is fusion of male and female gametes to form zygote. In human being fertilisation is internal. Human beings are viviparous
- Here the embryo is retained and nourished inside the uterus of the female by means of an attachment called placenta. At one time only a single ovum is released in human females from one of the two ovaries towards the middle of ovarian/ menstrual cycle. It passes into fallopian tubes and rests inside ampulla for some time. The journey time is 12-24 hours
- Human male produces 300-400 millions sperms per ejaculation. They are deposited in vagina during coitus. The process of deposition of sperms in the

female genital tract is called insemination. A number of them are demobilized or eat but a number of them remain functional and undergo capacitation (sperm activation) that provides them the ability to fertilise an ovum. Capacitation requires 6-10 hrs.

- Capacitation consists of three process

(i) Neutralisation of inhibitory factors present in semen

(ii) Weakening of covering membrane of acrosome head by dissolution of cholesterol

(iii) Entry of Ca^{2+} into sperms which changes sperm movement from undulation to whiplash motion

- The activated sperm being to pass into uterus and from there to oviducts. Viscous fluid secreted by female genital tract further enhances sperm motility. A number of sperms reach the ampulla part of oviduct where the egg rests temporarily
- Fertilization involves following steps:

(i) Approximation of sperm and ovum

Sperm can remain motile for 24-48 hrs. They swim at the rate of 1.5-3 mm/min. They are able to reach the ampulla part of female genital tract partly by contraction of uterus and fallopian tubes stimulated by prostaglandins (in male semen) and oxytocin (often formed in females). The movements are powerful within 5 minutes. After reaching an ovum, one sperm comes to lie against it. It releases lysine from its acrosomal region. Hyalouronidase and corona penetrating enzymes as well as dissolves cells of corona radiata. The sperm head now reaches zona pellucida where receptors protein fertilizing helps in attachment to specific protein of sperm. It is compatibility reaction.

(ii) Acrosome reaction

In contact with zona pellucida, acrosome covering degenerates. The contained enzymes are released. Acrosin or zona lysine dissolves zona pellucida in area of contact.

(iii) Egg reaction

A small protuberance or fertilization cone develops from the surface of ovum in the region of animal pole.

(iv) Penetration of sperm

Sperm head established contact with the lateral surface of fertilization cone. It produces a weak depolarization and ca^{2+} wave. Plasma membranes of the two, dissolve. Contents of head, neck and middle sperm enter ooplasm. Tail is left outside. Fertilization cone subsides. Cortical granules are extruded. They convert plasma membrane and deactivate sperm receptor of zona pellucida. A perivitelline space is created between it and zona pellucida. This prevents entry of a second sperm.

(v) Activation of ovum
Ovum undergoes meiosis II and extrudes a secondary polar body. It is now the actual ovum or female gametes.

(vi) Fusion of sperm and egg
The envelope of the sperm and egg pronuclei degenerates to form 'synkaryon'. The act is called karyogamy or syngamy. The proximal centriole brought by sperm helps form the spindle for the division of synkaryon (cleavage nucleus). Fertilized egg is also called zygote. It immediately begins cleavage.

SIGNIFICANCE OF FERTILIZATION

(i) It restores the diploid number of chromosomes, characteristics of species i.e. 46 in human being
(ii) Fertilization initiates cleavage

CLEAVAGE

- Cleavage is a series of rapid mitotic divisions of the zygote, characterized by absence of growth of daughter cells, which convert the single celled zygote into a multicellular structure called blastula (blastocyst)
- Cleavage differ from mitosis in the respect that

(i) There is no growth phase between successive division.
(ii) The size of cells gradually decreases
(iii) The metabolism becomes fast
(iv) There is rapid DNA replication
(v) High consumption of oxygen

- Types of cleavage

(i) Holoblastic: When whole of the egg is divided, it is found in microlecithal and mesolecithal egg. It may further be..
(a) Equal – When both the blastomers are equal Example – Amphioxus
(b) Unequal – When the blastomers are unequal in size. Example- frog
(ii) Meroblastic: When a part of the egg is divided. It is found in polylecithal eggs. It may be discoidal (e.g. birds) or superficial (e.g. insects)

- Planes of cleavage include meridional, vertical, equatorial and transverse. Patterns can be radial (sponges, coelenterates, some echinoderms like star fish) biradial, spiral (flatworms, annelids, non-cephalopod mollusks) bilateral (nematods, cephalopods, fishes, amphibians, reptiles, birds) and rotational (placemental mammals)

MORULA

Early cleavage produces a solid ball of cells called morula

BLASTULA

- Multicellular ball like embryo produced at the end of cleavage and usually having a fluid filled blastocoels, is called blastula
- It is of the following types

(i) Stereoblastula (solid blastula): It is blastula without blastocoels. E.g. Nereis
(ii) Coeloblastula : A blastula with a prominent blastocoels. e.g. frog
(iii) Discoblastula : A blastula having a many layered disc of blastomeres above the yolk. It develops as a result of meroblastic divisions in polylecithal eggs. E.g. Hen
(iv) Superficial blastula (Periblastula) : A blastula having a single layer of blastomeres around the central yolk. E.g. insects

GASTRULATION

- Sum total of all the processes which convert a solid or hollow ball of cells or many layered disc of blastula into two or three germinal layers of gastrula is called gatrulation
- Gastrulation takes place by the migratory or formative or morphogentic movements of blastomers from the surface of blastula to the proper position in the gastrula.
- These movements are classified into

(a) Epiboly: Growth of one part over another like prospective ectoderm over the rest except blastocoels.
(b) Emboly: Morphogenetic movements like migration of ectoderm, mesoderm and notochord cells from surface to interior. The emboly may occur by way of
   (i) Involution : Rolling of cells into interior
   (ii) Invagination : Infolding
   (iii) Ingression: New cells migrating into blastocoels

(iv) Delamination : Formation blastocoels is obliterated and a new cavity archenteron is formed which in future alimentary canal of the animal. Blastopore is opening of archenteron.

ORGANOGENESIS

The development of tissues and organs from the three germ layer is called organogenesis

MORPHOGENESIS

The assumption of shape, size and other morphological features by embryo is called morphogenesis

DIFFERENTIATION

It is the formation of different types of cells, which become different in size, form, chemical composition and perform different functions

FATE OF THREE GERMINAL LAYERS

Ectoderm

Central nervous system, nerves, retina, lens, cornea of eyes. Conjunctiva, ciliary and iridial muscles, lining of nasal chambers. Labyrinth, epidermis, cutaneous, glands, hair, nails, claws, hypophsis, adrenal medulla, salivary glands and enamel of teeth

Mesoderm

Dermis of skin, connective tissue, muscles, notochord, skeleton, blood, heart, blood vessel, adrenal cortex, urino – genitals system except part of urinary bladder, lining of coelom, spleen and eyes.

Endoderm

Digestive glands, liver, pancreas, middle ear, Eustachian tubes, lining of urinary bladder, respiratory system, adenophypophysis thymus, parathyroid and thyroid glands, lining of vagina and urethra, prostate.

FOETAL MEMBRANES

They are extra embryonic membranes that provide protection and nourishment to foetus. Foetal membranes are of four types

(i) Chorion – Outer foetal membrane that also takes part in formation of placenta.
(ii) Amnion – Inner foetal membrane that invests the embryo and forms a space called amniotic cavity. It is filled with fluid called amniotic fluid. Amnion protects the foetus from shock
(iii) Allantois – sac – like, develops from gut of embryo, supplies blood vessels to placenta. In reptiles and birds, it helps in respiration nutrition and excertion
(iv) Yolk sac – Membraneous sac attached to embryo near allantois, having yolk in egg laying animals and forms corpuscles in mammals till liver takes over

EMBRYO FORMATION IN HUMAN BEINGS

MORULA FORMATION

- Soon after fertilization, the zygot begins cleavage or segmentation. Cleavage consists of early mitotic divisions of fertilized egg without involving growth of daughter cells. There is rapid synthesis of new DNA and increased oxygen consumption. Surface –volume and nucleo-cytoplasmic ratio increases. The cells formed after cleavage are called blastomers. Cleavage is simple and holoblastic in humans as there is no yolk.
- The first cleavage is animal – vegetal axis or primary axis. It is slow and is completed within 30 hours of pertilization
- One of the two blastomers, is however slightly layer. Hnece, the first cleavage is holoblastic and unequal. Second cleavage is at right angle to the first one. It takes about 30 hours and completed slightly earlier in the larger blastomere so that a transitional 3-celled stage appers. Subsequent divisions are rapid and occur in different planes. They produce a solid ball of blastomers called morula. Phase of compaction ensues in 8-celed stage. Morula has almost the same size as the of fertilized egg due to presence of zona pellucida
- Morula has 16-32 cells. Th cells are compacted and of two types, outer slightly smaller peripheral cells with tight junctions than the inner mass of cells with ggap junctions. During the cleavage oung embryo descends in the fallopian

tube slowly due to feeble fluid produced by epithelial secretion and cilia. Ultimately it reach the uterus. It takes 4-6 days. Corona radiate dissolved away during this period.

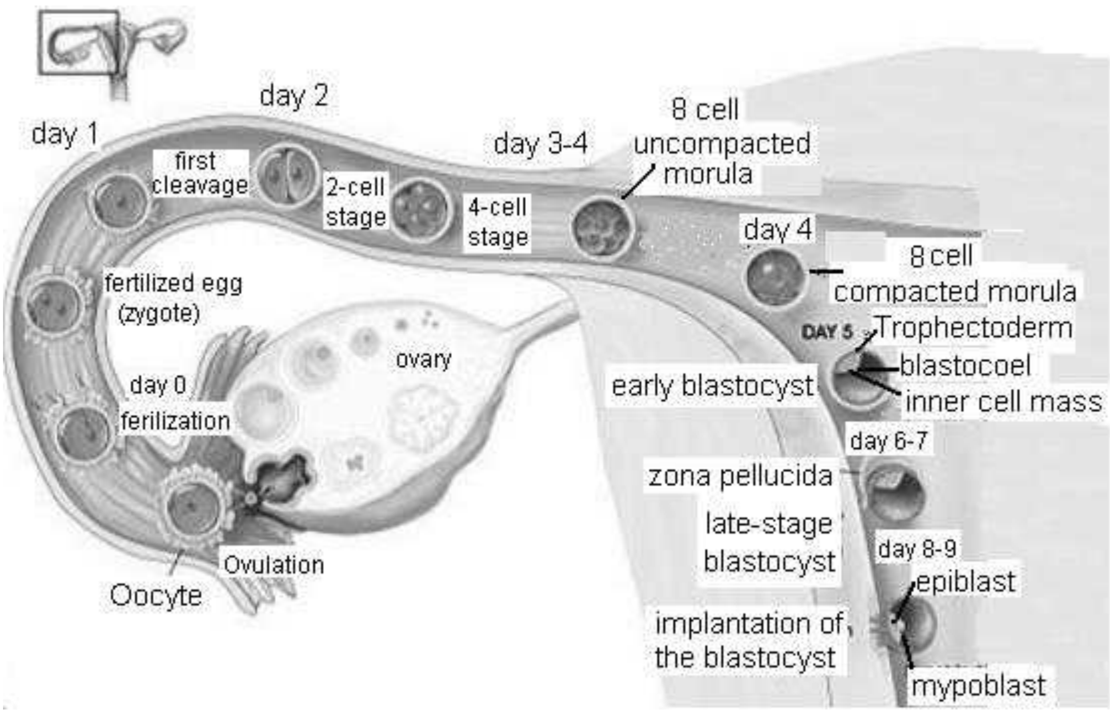
BLASTULATION

- In uterus, the endometrial cells become full of nutrients which are also secreted into uterine cavity. As the young embryo reaches uterus, its outer cells begins to absorb nourishment and grow while covered by zona pellucida
- The outer cells enlarge, flatten and form trophoblast. Trophoblast pours as fluid towards interior producing a cavity called blastocoels or blastocyst. It is equivalent to blastula of othe animals. The size of blastocyst is roughly three times the size of morula.
- Trophoblast then separates from inner cells except at one point called embryonic pole. The inner cells now occur at one side and called inner cell now occur at one side and called inner cell mass or embryonal knob as the latter is to form the body of embryo. Trophoblast cells in contact with inner mass are called cell of Rauber. Embryonic pole is also called animal pole. The opposite end of blastocyst is called abembryoic pole
- Blastocyst stage is completed after abour 5 days of fertilization. Trophoblast later becomes two – layered, outer synctiotrophoblast and inner cytophoblast. It secretes hCG (human chorionic gonadotrophin). Forms villi for implantation and later on produces chorion, amnion and foetal part of placenta

IMPLANTATION

- It is a choring or embedding of blastocyst into endomerium of uterus. Implantation begins about 7th day after fertilization of ovum. It takes about process to be completed
- Blastocyst comes in contact with the endometrium in the region of embryonal knob or embryonic disc
- The surfacea cells of trophoblast secrete lytic enzymes which causes corrosion of endometrial linning. They also give rise to figure – like outgrowths called chorionic villi and uterine tissue becomes interdigitated. Villi not only help in fixation but also absorption of nourishment

- The blastocyst sink in the pit formed in endometrium then get completed buried in the endometrium that grows around it. The embedded blastocyst forms villi all around it to obtain nourishment.
- Implantation causes nutrient enrichment, enlargement of cells and vascular endometrium. Vascular endometrium (deciduas of pregnancy) are stomal cells which have accumulated glycogen and lipid in their distended cytoplasm. The interglandular tissue increases in quantity.
- They may offer nutrition which is engulfed by the syntial trophoblast but they have been regulated as defensive mechanism
- Trophoblast covering secretes hormone called human chorionic gonadotropin (hCG). The hormone can be detected in the urine of woman within day after implantation
- hCG maintain the corpus luteum beyond its normal life. It continues to secrete pregnancy which prevents menstruation and maintains uterine lining in nutrient rich state.
- Progesterone induces cervical glands to secrete viscous mucus for filling the cervical canal to form a protective plug. By the 16th week of pregnancy, placenta produces enough progesterone and the corpus luteum regresse.



PLACENTA

- Placenta is a temporary organ found only in mammals during gestation period and it is composed of cells derived from two different organisms, the foetus and mother
- Placenta is connection between the foetal membranes and uterine wall.

Formation of placenta

- The outer surface of the chorion in human develops a number of finger like projections known as chorionic villi, which grow into the tissue of the uterus. These villi, penetrate the tissue of the uterine wall in which they are embedded to make up the organ known as placenta by means of which the developing embryo obtains nutrients, oxygen and gets rid of carbon dioxide and metabolic wastes
- A fully formed human placenta is reddish – brown disc. It foetal surface is smooth and has the umbilical cord. The allantois gives rise to umbilical cord. Umbilical cord has two umbilical arteries (small diameter) and two umbilical veins (large diameter)
- Umbilical arteries convey oxygen poor blood from the foetus to placenta and umbilical veins carries oxygen rich blood from the placenta to the foetus
- The blood of foetus in the capillaries of the chorionic villi comes in close contact with the mothers blood in the tissue between the villi, but are always separated by a membrane, through which substances must diffuse
- The maternal and foetal blood are not in direct contact in the placenta because
  (i) Two may be incompatible
  (ii) The pressure of maternal blood is far too high for the foetal blood vessels
  (iii) There must be a check on passage of harmful material into foetal blood

Functions of placenta

(i) Nutritive organs – Food materials from the mother's blood into the foetal blood through the placenta
(ii) Digestive organ – Trophoblast of placenta digests proteins before passing them into the foetal blood.
(iii) Respiratory organ – Oxygen diffuses from the maternal blood into the foetal blood through the placenta. Carbon dioxide diffuses from the foetal

blood into the maternal blood also through the placenta for elimination by the mother' lungs. Foetal haemoglobin has a greater affinity for oxygen than adult haemoglobin

(iv) Excretory organ – Nitrogenous waste such as urea, pass form the foetal blood into the maternal blood via placenta for elimination by mother's kidney

(v) Endocrine organ – Placenta secretes some hormone such as estrogens, progesterone, human chorionic gonadotropin (hCG), human placental lactogen (hPL) chorionic thyrotropin, chorionic corticotrophin and relaxin. The hCG stimulates and maintains the corpus luteum to secrete progesterone until the end of pregnancy. The hPL stimulates the growth of the mammary glands during pregnancy. Relaxin facilitates parturition by softening the connective tissue of pubic symphysis

(vi) Storage organ – The placenta stores glycogen for the foetus before liver is formed

PARTURITION

- It is the process of giving birth to a baby . The physical activities in parturition like uterine and abdominal contractions dilation of cervix and passage of baby are collectively called labour
- Labour is accompanied by localized sensation of discomfort or agony called labour pains.
- Parturation is controlled by complex neuroendocrine mechanism. Signals originate from fully formed foetus and placenta. They cause mild uterine contraction called foetal ejection reflex. It is accompanied by rise in estrogen to progesterone ratio, increase in oxytocin receptors in uterine muscles, increase in level of oxytocin secretion by both mother and foetus and stretching of uterian musculature

(i) Dilation stage

Uterine contractions begin from top. They occur once every 30 minutes. Contractions forces the baby towards cervix. The intervals between successive contraction decreases about every 1-3 minutes. Contractions are accompanied by pain caused by compression of blood vessels and uterine muscles

Oxytocin induce contraction and more oxytocin secretion. The strength of uterine contraction continues to increase due to stimulatory reflex. As the baby is pushed down in uterus, its head come to lie against cervix which therefore gets dilated and stretched, A similar dilation also occurs in vagina. The first stage of labour continues for 6-12 hours. It culminates in rupturing of amniotic membrane. The amniotic fluid flows out

(ii) Expulsion stage

The intensity of uterine and abdominal contractions increases. The foetus passes out through cervix and vagina with head in forward direction in normal deliveries. It causes intense labour pain. Expulsion stage takes about 20-60 minutes. Umbilical cord is tied and cut off close to navel

(iii) After birth

Within 10-45 minutes of the delivery of baby the placenta separates from uterus and is expelled out due to series of strong uterine contractions

In neonate there is a change in respiratory and circulatory system. The switch over is initiated by gaseous hormone nitric oxide (NO). Lungs expand and infant starts breathing. Blood flow through umbilical cord, formen ovale ceases. It starts passing through heart, aorta and pulmonary arteries

GESTATION PERIOD IN SOME MAMMALS

SrNO	Mammal	Days
1	Mare	335
2	Ass	365 -370
3	Cow	282-270
4	Cat	63
5	Dog	60-63
6	Elephant	624
7	Goat	148
8	Horse	335-340
9	Whale	330-365
10	Rats	22
11	Guinea pig	68
12	Lion	105-115
13	Monkey (Rhesus	164
14	Mouse	19-20
15	Human beings	266 -280 days
16	Rabbit	32
17	Sheep	148
18	Tiger	155
19	Swine (pig)	114

IMPORTANT DEVELOPMENTAL CHNAGES IN HUMAN EMBRYO

1. Week 1
- Fertilization
- Cleavage starts about 24 hours after fertilization
- Cleavage to form a blastocyst after fertilization
- More than 100 cells
- Implantation 6-9 days after fertilization
2. Week 2
- The three primary germ layers develops
3. Week 3
- Woman will not have period. These may be first sign of pregnancy
- Beginnings of backbone
- Neural tube develops, the beginning of brain and spinal cord
4. Week 4
- Heart, blood vessels, blood and gut start forming
- Umbilical cord developing
5. Week 5
- Brain developing
- ‘Limb buds’ a small swelling which are the beginnings of arms and legs
- Heart is a large tube and starts to beat, pumping blood. This be seen on a ultra sound scan
6. Week 6
- Eyes and ears start to form
7. Week 7
- All major internal organ developing
- Face, forming
- Eye have some colour
- Mouth and tongue develop
- Beginnings of hands and feet
- 2.5 cm long
8. By week 12
- Foetus fully formed with all organs, muscles, bone, toes and fingers
- Sex organs well developed
- Foetus reaches 7.5cm in height and about 14g weight
9. By week 20

- Hair beginning to grow, including eyebrows and eyelashes
- Fingerprints developed
- Fingernails and toenails growing
- Firm hand grip
- Between 16 and 20 weeks bay usually felt moving for first time

10. Week 24

- Eyelids open
- Foetus measures about 32 cm and weighs about 650gm

11. Week 26

    Has a good chance of survival if born prematurely

12. By week 28

- Baby moving vigorously
- Responds to touch and noise
- Swallowing amniotic fluid

13. By week 30
    Usually lying head down ready by birth
    Foetus is about 43cm long and its weight is about 1800gm
14. By week 40
    Birth
    Generally child is about 50cm long and weighs about 3300gm

LACTATION

- Production of milk in the female's breasts following the birth of a young one in mammals is called lactation
  Preparation of breast (mammogenesis)
  During pregnancy, the breast enlarges due to growth of mammary glands
  Synthesis and secretion from the breast alveoli (lactogenesis)
  Secretion and storage of milk begins after birth of the young one, usually within 24 hours under the influence of prolactin
  When the estrogen and progesterone are withdrawn following delivery, prolactin begins its milk secretory activity in previously fully developed mammary glands
  Ejection of milk
  The actual release of milk called milk letdown, requires the presence of oxytocin, which brings about contraction of smooth muscles of the ducts

within the mammary gland. Secretion of prolactin and oxytocin depends on suckling stimuli produced by the nursing infant on the nipples of breasts
Maintenance of lactation (galactopoiesis)
For maintenance of lactation, suckling is important
Milk pressure reduces the rate of production and hence periodic breast feeding is necessary to relieve the pressure which is in turn maintains the secretion.

- After birth, the breast first release is not milk, but colostrums for 2 or 3 days. It is a thin, yellowish, fluid called foremilk which is rich in protein, antibodies but low in fat.
- Human milk consists of water, fat, casein, lactose, mineral salts and vitamins. A nursing woman secretes 1 to 2 litres of milk per day

DEVELOPMENTAL DISPRDERS

AMNIONITIS

It is inflammation of amnion, usually resulting from premature rupture of amnion

ABORTION

It is giving birth to an embryo or foetus at the stage of about 20 weeks of gestation

TERATOGENY

Teratogens are certain agents or drugs that cause abnormal development in developing embryo/foetus. It may cause malformation in developing embryo.

ECTOPIC PREGNANCY

- The developmental site of foetus is other than the uterus like fallopian tube or cervix
- The growth of foetus may cause tube to rupture and bleed and my lead to miscarriage
- The condition is diagnosed by ultrasound and foetus may be removed by laproscopy before damage is done to fallopian tube.

- A plant cell has three physiological compartments – cell wall, protoplast and vacuole. Two membranes separate these compartments tonoplast around central vacuole and plasmolemma around protoplast and is attached to cell wall. Both membranes are selectively permeable. Central vacuole contains an osmotically active fluid called sap. Plant cell forms a living continuum called simpleast with the help of plasmodesmata which functions as cytoplasmic bridges between adjacent cells. A non-living continuum called apoplast also occurs in plants. It is formed of adjacent cell walls and intercellular spaces.

WATER POTENTIAL

- Chemical potential is free energy of one mole of a substance in system under constant temperature and pressure. All reactions and processes involve a decrease in chemical potential. Chemical potential of water is called water potential (Ψ_w) .
- The term water potential was first used by Slatyer and Jaylor (1960).
- Its value for pure water is taken as zero ($\Psi_w = 0$).
- $\Psi_w = \Psi_m + \Psi_s + \Psi_p$,
  Where Ψ_w is water potential.
  Ψ_m is matric potential.
  Ψ_s is solute potential.
  Ψ_p is pressure potential.

MATRIC POTENTIAL

- Matric potential (Ψ_m) expresses the adsorption affinity of water to colloidal substances and surfaces in plant cells.
- In herbaceous plants, the matric potential is almost negligible and it is therefore ignored. Thus $\Psi_w = \Psi_s + \Psi_p$

SOLUTE POTENTIAL OR OSMOTIC POTENTIAL

- It is the decrease in chemical potential of water due to occurrence of solute particles in it.
- The potential osmotic pressure which can develop in a system due to entry of water into it, is termed osmotic potential.
- Solute potential in a solution depends upon the total number of solute particles.
- Solute potential = - (Osmotic pressure) = - C.R.T

- Solute potential in the leaves of most temperate region crops, ranges from -20 to -10 bars. In leaves of xerophytes this value may be even less than -100 bars. Solute potential in leaf cell sap is more negative during the day and less negative at night.

PRESSURE POTENTIAL

- When a cell absorbs water the cell wall exerts pressure – wall pressure (wp). Hydrostatic pressure develops in the vacuole which is known as turgor pressure (TP) or pressure potential (Ψ_p). Ψ_p is equal and opposite to wp. It is usually positive. In plasmolysed cells it is zero and negative in xylem elements during rapid transpiration. In leaves +3 to +5 bars during a summer afternoon and is about +15 bars at night.
- At zero turgor $\Psi_p = 0$, the $\Psi_w = \Psi_s$. At full turgor Ψ_p and Ψ_a are equal but with opposite signs hence $\Psi_w = 0$. Mature cells show intermediate state between zero turgor and full turgor.

DIFFUSION

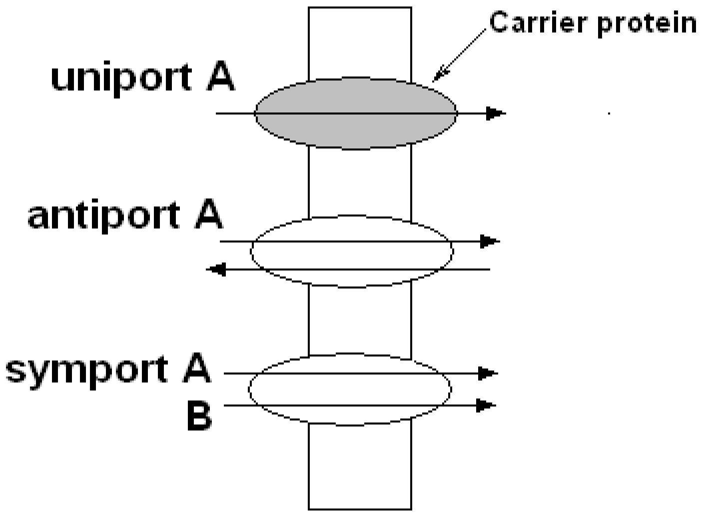
- Diffusion is the movement of particles of gases, liquids and solids from the region of higher concentration to lower concentration.
- Diffusion is due to random kinetic motion of particles. Different substances present in the same medium perform independent diffusion as per their own partial pressure or individual diffusion pressure
- Diffusion pressure is the pressure exerted by the tendency of particle of a substance to diffuse from area of its higher concentration to the region of its lower concentration.
- The diffusion pressure is directly proportional to the concentration or the number of diffusing particles in the system i.e. greater the concentration of diffusing particles, their diffusion pressure will also be greater and vice-versa.
- Diffusion will be more rapid when density of the diffusing substances and liquid as compared to solids. It also depends upon temperature, density of medium and diffusion pressure gradient.
- Diffusion will continue till a state of equilibrium is reached, osmosis is a type of diffusion. Transpiration, exchange of gases and a part of solute absorption are due to diffusion.

INDEPENDENT DIFFUSION

- A system may have two or more types of diffusing particles.
- Each diffusing particle exerts its own diffusion pressure called partial pressure. Each particle according to its partial pressure.
- Tendency of different substances to diffuse according to their own partial pressure or concentration is known as independent diffusion.

FACILITATED DIFFUSION

- A gradient must already be present for diffusion to occur. The diffusion rate depends on the size of the substances; smaller substances diffuse faster
- The diffusion of any substance across a membrane also depends on its solubility in liquids. Substances soluble in lipids diffuse through the membrane faster. Substances that have a hydrophilic moiety, find it difficult to pass through the membrane; their movement has to be facilitated.
- Membrane proteins provide sites at which such molecules cross the membrane. They do not set up a concentration gradient; a concentration gradients to diffuse even if facilitated by the proteins. This process is called facilitated diffusion
- In facilitated diffusion, special proteins help to move substances across membranes without expenditure of ATP energy. Facilitated diffusion cannot cause net transport of molecules from a low to a high concentration this would require input of energy.
- Transport rate reaches maximum when all of the protein transporters are being used.
- Facilitated diffusion is very specific, it allows cell to select substances for uptake. It is sensitive to inhibitors which react with protein side chains.
- The proteins form channels in the membrane for molecules to pass through some channels are always open; others can be controlled. Some are large, allowing a variety of molecules to cross,
- The porins are proteins that form huge pores in the outer membranes of the plastids, mitochondria and some bacteria allowing molecules up to the size of small protein to pass through.



PASSIVE SYMPORTS AND ANTIPORTS

- Two major types of transport proteins are known viz, carrier proteins and channel proteins. Carrier proteins bind the particular solute to be transported and deliver the same to the outer side of the membrane. Channel proteins allow diffusion of the solutes of appropriate sizes.
- Some carrier proteins allow transport only if two types of molecules move together. This is called cotransport. It is of two types.
- In symport method of cotransport, both molecules cross the membrane in the same direction at the same time.
- In antiport method of cotransport, both molecules move in opposite direction. When a molecule move across a membrane independent of other molecule, the process is called uniport.

FACTORS INFLUENCING DIFFUSION

- Rate of diffusion depends upon a number of factors. They are temperature, density of diffusing substance, density of medium, diffusion pressure and distance through which diffusion has to occur.
- Temperature – Increase in temperature increases the rate of diffusion. It is due to increase in kinetic energy of the diffusing particles.
- Density of substance – Heavier particles will diffuse at a slower rate as compared to lighter particles. Diffusion rate is inversely related to square root of relative density of the diffusing substance.
- As the density of gases is lower as compared to liquid, they diffuse more rapidly than liquids. Liquids similarly diffuse more rapidly than solids.

- Amongst gases, the lighter ones will show higher rate of diffusion. For example hydrogen diffuses faster as compared to oxygen.
- Density of medium – Diffusion is quicker, if the medium has lower density. It decreases with increase in density of the medium.
- Concentration or diffusion pressure – Rate of diffusion is proportional to the concentration or diffusion pressure of the substance. It is faster, if the difference in concentration or diffusion pressure is higher.
- Distance – Net diffusion will be high if the distance through which diffusion has to occur is small. It will be low if the distance is large.

IMPORTANCE OF DIFFUSION

- Diffusion keeps the cell walls of the internal plant tissues moist.
- Gaseous exchange during the process of photosynthesis and respiration takes place with the help of diffusion.
- The process of diffusion is involved in the respiration of water vapour.
- Aroma of flowers is due to diffusion of volatile aromatic compounds to attract pollinating animals.
- During passive salt uptake, the ions are absorbed by the process of diffusion.
- Diffusion helps in trans-location of food materials.

OSMOSIS

- It is the movement of water or solvent from a solution having its higher concentration to solution having its lower concentration separated by a semi permeable membrane
- Osmosis is influenced by temperature and pressure. A positive pressure applied over an osmotically active solution will reduce the entry of water into it. A pressure applied over external solution will enhance the passage of water into the internal solution. A perfect semi permeable membrane is essential for osmosis. However, osmosis cannot continue indefinitely. It stops after some time when the difference in chemical potential is counter balanced by hydrostatic pressure or pressure developed due to flow of water in confined solution.
- Reverse osmosis – It is expulsion of pure water from a solution through semi permeable membrane under the influence of external pressure higher than O.P. of water. Reverse osmosis is used in removing slats from saline water as well as extra-purification of water.

- Endosmosis – Osmotic entry of water into a cell or system as when placed in pure water or hypotonic solution is called endosmosis.
- Exosmosis – Osmotic withdrawal of water from a cell or system as when placed in hypertonic solution is called exosmosis.
- Isotonic solution – It is solution that has the osmotic concentration lower than that of another solution.
- Hypertonic solution – A solution having osmotic concentration greater than that of another solution.
- Semipermeable membrane – It is a membrane which allows the passage of solvent across it but prevents the passage of solutes. Example, animal bladder, parchment paper. Egg membrane.
- Permeable membrane – It membrane which allows the passage of both solute and solvent across it. Example, cell wall.
- Selective or differentially permeable membrane
  It is a membrane which is normally semi-permeable but allows selective semi-permeable but allows selective transport of certain solutes.

IMPORTANCE OF OSMOSIS

- Osmosis is responsible for absorption of water by roots.
- Osmosis is responsible for turgidity of plant organs.
- Osmosis is responsible for cell to cell movement of water.
- It is responsible for opening and closing of stomata.
- It is responsible for resistance of plant to drought, frost, etc.

OSMOTIC PRESSURE (O.P)

- It is maximum pressure which can develop in a system due to osmotic entry of water into it under ideal conditions.
- Osmotic pressure is also defined as the pressure required to completely stop the entry of water into an osmotically active solution across a semi-permeable membrane.
- It is measured in atmosphere, bars or pascals.
- Osmotic pressure is numerically equal to osmotic or solute potential but osmotic potential has negative sign where as osmotic pressure has a positive sign.
- Instrument used for measuring osmotic pressure is called osmometer.

FACTORS INFLUENCEING OSMOTIC PRESSURE

- Concentration of solute particles – Osmotic pressure is influenced by the ratio of solute and the solvent particles. More are the solute particles more would be osmotic pressure.
- Temperature – The osmotic pressure of solution increases with increase in temperature

PLASMOLYSIS

- The shrinkage of protoplast from cell wall due to exosmosis caused by hypertonic solution is called plasmolysis.
- Permanent plasmolysis causes death plasmolysis has here stages –

(i) Limiting: Cell size becomes minimum but cytoplasm does not withdraw from cell wall.
(ii) Incipient: Cytoplasm withdraws from the edges.
(iii) Evident: Cytoplasm withdrawn from cell wall except from one or more points.

- Limiting plasmolysis is used for measuring osmotic potential of plant materials. The common materials used for demonstrating plasmolysis are spirogyra.

IMPORTANCE OF PLASMOLYSIS

- Plasmolysis is the characteristic feature of living plant cells. All living plant cells plasmolyse when kept in a hypertonic solution.
- Pickles, meat and fish are preserved by salting. Jams and jellies are persevered by sweetening of sugars. Salting and sweetening create hypertonic solution in which the fungi and bacteria get killed by plasmolysis.
- Salting kills the weeds of tennis lawn by inducing plasmolysis in their cells.
- Plants are not allowed to grow in the cracks of the walls by the method of salting.

DEPLASMOYSIS

- Swelling of shrunken protoplast so as to come in contact with cell wall due to endosmosis caused by hypotonic solution is known as deplasmolysis.
- It can occur only immediately after plasmolysis otherwise the cell protoplast becomes permanently damaged.
- Turgid – It is a condition of being fully distended due to exosmosis.

DIFFUSION PRESSURE DEFICIENT (DPD)

- The term diffusion pressure and diffusion pressure deficient were coined by B.S.Meyer in 1938.
- When solute particles are added to it, the diffusion pressure of the solution gets lowered. The amount by which diffusion pressure of solution is lower than that of its pure solvent is known as diffusion pressure deficit.

IMIBITION

- Imbibition is the phenomenon of adsorption of water or any other liquid by the solid particles of substance without forming a solution.
- Imbibition is plant cells refers to the adsorption of water by hydrophilic – protoplasmic and cell wall constituents.
- I f a dry piece of wood is placed in water; it swells and increases in volume. Similarly, if dry gum or pieces of agar-agar are placed in water, they swell and their volume increases. These are the examples in plant systems are adsorption of after by cell wall, swelling and rupture of seed coats during germination, etc.
- The solid particles which imbibe water or any other liquid are called imbibate.
- During imbibitions, the water molecules get tightly adsorbed and becomes immobilized. They lose most of their kinetic energy in the form of heat. It is called heat of wetting.
- The swelling imbibant also develops a pressure called imbibant pressure.

CONDITIONS NECESSARY FOR IMBIBITION

- A water potential gradient should occur between imbibant and liquid imbibed.
- There should be some force of attraction between imbibant and imbibed liquid for imbibitions to occur.
- Adsorption is the property of colloids and hence the materials which have high proportion of colloids, are good imbibants. It is for this reason, the wood (plant material) is good imbibants, because it contains proteins, cellulose and starch as colloidal substances.

FACTORS INFLUENCING IMBIBITION

- Looseness of imbibant shows more imbibitions while compactness less.
- Imbibition rises with rise in temperature.
- It decreases with rise in pressure.

- It also decreases with electrolytes.
- Imbibition either decreases or increases depending upon the charge of imbibant.

IMPORTANCE OF IMBIBITION

- Imbibition plays an important role in absorbing and retaining water.
- Absorption of water by young cell is mostly through imbibitions.
- Water is absorbed by the germinating seeds through imbibitions.
- Breaking of the seed in germinating seeds is due to greater imbibitional swelling of the seed kernel as compared to seed covering.
- A seedling is able to come out of soil due to development of imbibitions pressure.
- Jamming of wooden frames during rains is caused by swelling of wood due to imbibitions.
- It was used in breaking the rocks and stones.
- Fruits of many plants come in develop matric potential in addition to their osmotic potential in order to maintain inflow of water even under conditions of water scarcity.
- Imbibition is dominant in the initial stage of water absorption by roots.
- Since the imbibition is not dependent on metabolic activity of cell, it can occur under anaerobic conditions.
- The water moves into ovules which are ripening into seeds by the process of imbibitions.

ABSORPTION OF WATER

- Aerial parts of plants can absorb only a small quantity of water from atmosphere when it is saturated.
- Most of the water absorption occurs from soil through roots. For this, the roots must be metabolically active, respiring aerobically and continuously growing.
- Roots are usually restricted to that area of soil which lies well above the water table.
- Water table is the depth at which the earth’s crust is saturated with water.
- Usually water absorption occurs in plant through roots, but sometimes through shoots also.
- The zone of rapid absorption is characterized by the presence of root hairs. Root hairs help in absorption of water from soil by increasing the surface area

of root. Maximum absorption of water occurs through root hair zone. Some amount of water absorption occurs by zone of elongation but no absorption takes place at root cap and meristematic zone.

- A root hair is the unicellular tubular prolongation of the outer wall of the epiblema.
- It is generally delicate and short lived.
- The cell wall of root hair is composed of two distinct layers
- The outer layer, which is composed of pectic substances, helps to adhere soil particles. The inner layer is made up of cellulose.
- The cell wall is permeable both source and solvent molecules. It surrounds plasma membrane and a thin layer of cytoplasm.
- For long distance, plants have developed a mass or bulk flow system which operates through development of pressure difference between source and sink.
- In mass or bulk flow all the substances dissolved or suspended in solution travel at the same pace. Long distance bulk movement of substances that occurs through conducting or vascular tissues, xylem and phloem.
- Xylem translocation is mainly from roots to aerial parts. It passes water with mineral salts, some organic nitrogen and hormones.
- Phloem translocates organic substances and inorganic solutes first from leaves to all other parts of the plant and storage organs.
- Storage translocates organic nutrients to those parts which require the same as newly formed leaves and fruits.
- Translocation operates due to positive hydrostatic pressure gradient as in phloem or a negative hydrostatic pressure gradient as in xylem.
- Water absorption takes place by two methods – passive absorption and active absorption.

PASSIVE WATER ABSORPTION

- It is the common method of water absorption (96% of the total). The driving force for passive water absorption develops in the aerial parts through transpiration.
- Transpiration produces negative pressure or tension in xylem channels. The rate of water absorption closely follows the rate of transpiration. Root hair cells function as tiny osmotic systems as they have a, D.P.D of 3-8 bars while D.P.D of soil water is 0.1-0.3 bars. Root hair cells absorb water from soil which causes a decrease in their D.P.D as compared to adjacent cortical cells. As a

result cortical cells absorb water from root hair cells. They in turn lose water to inner cortical cells absorb water from root hair cells. They in turn lose water to inner cortical cells, the latter to endodermal pericycle and xylem parenchyma cells. Xylem channels have the maximum D.P.D or lower water potential Therefore, water passes into them. In this way water travels from soil to xylem along the gradient of D.P.D / suction pressure.

ACTIVE WATER ABSORPTION

- The force for this type of water absorption resides in the root. Active water absorption requires energy.
- The energy is used for

(i) Direct absorption and pumping activity of cells
(ii) Maintenance of bioelectric potential in the root cells.
(iii) Maintenance of high salt content in xylem channels.

- Active water absorption is manifested by root pressure. Root pressure is a positive pressure that is found in the sap contained in xylem channels of the root in certain plants and in certain seasons probably due to active water absorption. It shows a diurnal rhythm being maximum in early morning. Root pressure is exhibited by the exudation of sap if the stem is cur. Pressure can be measured by means of manometer.

FACTORS AFFECTING WATER ABSORPTION

- External or environmental factors.

(i) Available soil water: It is optimum at field capacity. Water absorption decreases above it. It begins to decline and stop of PWP.
(ii) DPD of soil water: Normal DPD of soil water is 0.1 – 0.3 atm. Above 1 atm, the rate of water absorption begins to decline. Near 4at,. Water absorption falls below requirement. Halophytes are exceptional.
(iii) Soil air: Oxygen content of soil air is generally less than that of atmosphere while carbon dioxide content is higher. Rate of water absorption begins to decline below 15% oxygen and 1% carbon dioxide.
(iv) Transpiration: It creates a force for passive absorption of water. When transpiration is very high, the rate of water absorption declines due to development of root-soil resistance and concentration of root.
(v) Soil temperature: optimum soil temperature for water absorption is 15-25^{O} C. A higher or lower temperature can reduce water absorption.

- Internal or plant factors

(i) Extent of root system: The amount of water absorption is directly dependent on the extensiveness of the root system, especially the number of rootlets and their root hairs.

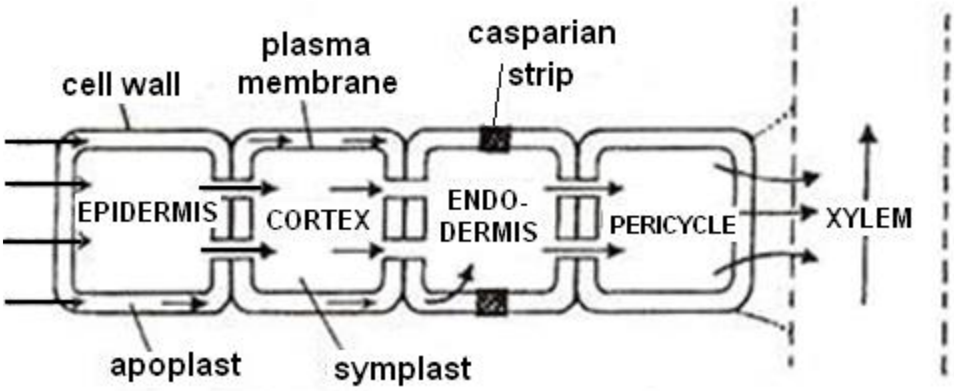
(ii) Growth and metabolism of root: Root hairs have a short life span. Continued water absorption depends upon growth of root branches and formation of new root hairs.

(iii) Depth of root system: Deeper roots are less efficient than the upper ones.

(iv) Resistance: Water absorbed by root hairs travels to root interior and from there it rises upwardly. The rate of this transfer is inversely related to degree of internal resistance.

PATHWAYS OF WATER MOVEMENTS IN ROOTS

- There are two pathways of water passage from root hairs to xylem inside the root, apoplast and symplast.
- In apoplast pathway water passes from root hairs to xylem through the walls of intervening cells without crossing any membrane or cytoplasm.
- It provides least resistance to movement of water.
- It is interrupted by the presence of impermeable lignosuberin casparin strips in the walls of endodermal cells.
- In symplast pathway water passes from cell to cell through their protoplasm facing plasmalemma (cell membrane) at least at one place. It is also called transmemebrane pathway.
- It does not enter cell vacuoles
- The cytoplasm of adjacent cells are connected through bridge call palsmodesmata.
- Symplastic movement is aided by cytoplasmic streaming of individual cells.
- It is, however, slower than apoplastic movements.
- In mycorrhizal association large number of fungal hyphae extend to sufficient distance into the soil and have a large surface area.
- These hyphae are specialized to absorb both water and minerals and provide them.



Pathways of water movement inside the root

ASCENT OF SAP (TRANSLOCATION OF WATER)

- The passage of absorbed water from root to the aerial parts of the plant is known as ascent of sap.
- It occurs the lumen of tracheary elements or vessels and tracheids with the rate of about 75cm/min
- Many theories have been put forward to explain the upward movement of water, the important ones are:
- Root pressure theory
- Transpiration pull or cohesion – tension theory.
- Vital force theories.

ROOT PRESSURE THEORY

- Root pressure theory was proposed by Priestly (1916)
- Root pressure is defined as a pressure developing in the tracheary element of xylem due to metabolic activities of roots.
- The pressure is caused due to diffusion pressure gradient and is maintained by the activity of living cells.
- The root pressure is therefore, referred to as an active process, which is confirmed by the following:
- The pressure is not observed if the roots are placed in hypertonic or isotonic solutions.
- Oxygen supply and some poisons also effect the root pressure without affecting semi permeability of protoplasm.
- Living roots are essential for it to occur.
- It is believed that root pressure is largely responsible for ascent of sap in herbaceous plants.

- The pressure develops more in certain seasons which favours optimum metabolic activity and reduce transpiration.
- The magnitude of root pressure is about 2 bars.

PHYSICAL FORCE THEORIES

- As sap can rise upwards even in the absence of living cells, physical phenomena were thought to operate in the ascent of sap. Example, capillarity, imbibitions.
- Capillary force theory: The theory was put forward by Bohm (1863). According to this theory, xylem channels functions as fine capillary tubes wherein water rises up automatically due to force of surface tension. Water is attracted to walls of the capillary tubes due to phenomenon of adhesion. As the water passes up the wall of capillary tube, the cohesive force existing amongst the water molecules causes pulling of water in the form of a thin column. Capillary rise will continue till the force of surface tension is counter-balanced by the downward pull of gravity.
- The force of capillary is small. It can raise water to a maximum height on one metre in a tube having a diameter of 30μm found in xylem vessels. Capillary cannot be useful in gymnosperms which are devoid of vessels. They possess tracheids which have closed ends.
- Atmospheric pressure theory: According to this theory, the ascent of sap is due to the atmospheric pressure. During active transpiration, a vacuum is created in the tissue. As a result, the water is forced below.
- According to Boehm's concept, upward movement of water is due to the joint force of capillarity and atmospheric pressure. However the atmospheric pressure theory was criticized as this pressure can raise water upto the height of about 30 feet. Hence it could not be operative in tall parts.
- Imbibition theory: This theory was proposed by Sachs (1878). According to this theory, the upward movement of water in stem is due to the force of imbibitions. This theory was rejected as large quantity of water moves through the lumen of xylem which can be checked by artificially blocking the lumen by gelatin or oil.
- Transpirational pull or cohesion-tension theory : This theory was originally proposed by Dixon and Jolly in 1894 and further improved by Dixon in 1914. This theory is based on the following features.
- Cohesive and adhesive properties of water molecules to form an unbroken continuous water column in the xylem.

- Transpirational pull or tension exerted by this water column
- Cohesion force: Water molecules are healed together by strong cohesion force which is due to hydrogen bonds amongst them. This is another force of adhesion which holds water to the walls of xylem vessels.
- Continuous water column: A continuous column of plat. The continuity of water column is maintained in the plants because of cohesive force of water molecules. Dixon described this water column in the stem as a net or rop. Water column is present in tracheary elements. These tracheary elements from this continuous system through their unthickened areas. Since, a large number, no breakage in the continuity of water occurs for the blockage of one or few of them.
- Transpiration pull: According to this theory, due to transpiration, the water column inside the plant occurs under tension. This is called 'transpiration pull'. On account of this tension, the water column is pulled up passively from below to the top of the plant. A tension of one atmosphere is sufficient to pull water to a height of about 10 metres.
- During transpiration in plants, water is lost in form of water vapour, from the mesophyll cells to exterior, through stomata.
- As a result the turgor pressure of these cells decreases and the diffusion pressure deficient increases. Now these cells take water from adjoining cells decreases. This process is repeated and ultimately water is absorbed from nearest xylem vessels of leaf. As there is a continuous water column inside the xylem elements, a tension or pull is transmitted down and finally transmitted to root, resulting in upward movement.
- So, this theory suggests that the transport of water takes place at low pressure and high tension. However, under this condition, the dissolved gases in xylem sap comes out of solution and they form bubbles due to low solubility. This phenomenon is known as 'cavitation'. It may occur during water stress. These bubbles definitely prevent the transport of water. As this condition, an alternative route for the transpiration stream would be needed. This theory was criticized due to the fact these bubbles may break up the water column. However, it is revealed that even in extreme dry conditions these air bubbles could not enter in water column and if they entered, they do not block the whole system.

VITAL THEORIES

- According to vital theories, upward movement of water takes place due to activity of living cells of plant bordering xylem.
- Godlewski's relay pup theory: According to Godlewski's (1984) ascent of sap takes place due to rhythmatic change in the osmotic pressure of rhythmatic change in the osmotic pressure of living cells of xylem parenchyma and medullar rays and are responsible for bringing about a pumping action of water in upward direction. Living cells absorb water due to osmosis from bordering vessels and finally water is pumped into xylem vessel due to lowering of pressure in living cells. Thus, a staircase type of pressure in living cells. Thus, a staircase type of movement occurs. Hanse (1887) supported the theory and showed that if flower part of the shoot is killed upper leaves were affected.
- Criticism: Theory was discarded due to following reasons:
- Strasburger (1893), Overton (1911) and MacDougal (1966) showed that transport of water was independent of living cells. They found that water continued to rise even after living cells were killed at high temperature and poison treatments.
- Xylem structure does not support the Godlewsk's theory. For pumping action living cells should be in between two xylem vessels and not on the lateral sides as found.
- Pulsation theory: Sir J.C.Bose (1923) said that living cells of inner most layer of cortex, just outside the endodermis were in rhythmatic pulsations. Such pulsations are responsible for pumping the water in upward direction. He inserted a fine needle into a stem of Desmodium. The needle was connected to galvanometer and an electric circuit. The fine needle touched the innermost layer of cortex oscillations turned violent indicating that cells in this layer were pulsating i.e. expanding and contracting alternately. According to Bose, the pulsatory cells pump the water into vessels.
- Criticism: However, this theory was criticized by several workers including Shull (1923) and Benedict (1927). The living cells do not seem to be involve in the ascent of sap because when a plant is placed in poisonous liquid, like picric acid, even then water continues to rise upward in plant.

TRANSPIRATION

- Loss of water in the vapour state from the aerial parts of plants is known as transpiration.
- Transpiration is similar to evaporation in the loss of water vapour but differs from the same in

(i) Formation of water vapour internally.
(ii) Being controlled by a number of plant factors
(iii) Occurrence of it even when the air is saturated.
(iv) Influence of light

- 98-99 % of water absorption by a plant is lost through transpiration. Over 90% of the transpiration occurs through leaves and is called foliar transpiration. A minor amount of transpiration occurs through barks of plants and is called bark transpiration.

CUTICULAR TRANSPIRATION

- It is the loss of water in the vapour from the general surface through the layer of cuticle. Cuticular transpiration is appreciable only in case the cuticle is thin as in mesophytic plants growing in humid areas. Commonly, it is 3-10% of the total. Cuticular transpiration continues through day and night.

STOMATAL TRANSPIRATION

- It is the loss of water in the vapour form stomata present on the surface of leaves and lesser extent on the surface of flowers and young stems. It is the major form of transpiration constituting 50-97% of total. It, however, occurs only when stomata are open.

LENTICULAR TRANSPIRATION

- This is lose of water in vapour form from lenticles or aerating pores present in the bark of stem. It is hardly 0.1% of the total.

STOMATA.

- They 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 whole surface area of the leaf.

- Number of stomata on a leaf is about 1,000 to 60,000 in per sq.cm. The size of stomatal pore (fully open) measures about 3-12μm in length.
- Each stomata is surrounded by two small specialized green epidermal cells called guard cells. Guard cells are small in size, therefore, rapidly influenced by turgor changes. They are kidney-shaped in outline and joined at their ends.
- Guard cells contain chloroplasts while the same are generally absent from other epidermal cells. In some plants the guard cells are surrounded by a group of specialized epidermal cells known as accessory or subsidiary cells. In Poaceace, members of Cyperaceae and many palms the guard cells are dum-bell shaped with thin end walls and thick middle parts. In other guard cells are reniform or kidney shaped. Their outer wall are thinner and more elastic while the inner walls are thick and less elastic. They grow out into one or two pair of ledges to protect stoma from water drops. Guard cells are connected with other epidermal cells through plasmodesmata.

TYPES OF STOMATA

There are four categories of stomata.

(i) Barley or cereal type : The guard cells are dum-bell shaped. Stomata are found equally on both surfaces (amphistomatic leaf). They usually remain open during the day for a few hours e.g. maize, wheat and other cereals
(ii) Leucerne or alfalfa type: They open during day and close during night under mesophytic conditions. E.g. pea, apple, radish, grapes, turnip, mustard
(iii) Potato type : Stomata are present on both the surface, more on lower surface than on upper surface. Under mesophytic conditions, the stomata can remain open throughout the day and night, but close down for different periods and at various time for different periods and at various time under conditions of less water availability e.g cucurbits, portulaca, tulip, onion, banana, potato.
(iv) Equisetum type: The stomata remains open and seldom close. E.g. amphibious plants or emergent hydrophytes.

GUARD CELL PHOTOSYNTHESIS THEORY

- This theory was proposed by von mohe (1856). During day time, photosynthesis occurs in guard cells because they contain chloroplast. The soluble sugar formed by this process decreases the water potential of the guard cells and hence resulting in stomatal opening. However, very small amount of soluble sugar has been extracted from the guard cells which are insufficient to affect the water potential.

- During day time at lo CO_2 concentration, pH of guard cells rises. Some organic acid chiefly the malic aid is build up during this period in guard cells. The formation of malic acid would produce proton that could operate in an ATP-driven-proton-K^+ exchange pump, moving protons into the adjacent epidermal cells and K^+ ions into the guard cells. This helps in decreasing water potential of the guard cells and results into the opening of stomata. The reverse process would occur in dark and would lead to closing of stomata.

STARCH HYDROLYSIS THEORY (CLASSICAL THEORY) [Sayre, 1923]

- Guard cells contain starch which is hydrolysed to form glucose under high pH and reduced carbon dioxide concentration. Glucose increases osmotic concentration and hence D.P.D. of guard cells.
- Guard cells absorb water from epidermal cell, swell up and create pore. Closing of stomata is caused by polymerization of glucose to form starch and reduction of osmotic concentration of guard cells. The guard cells lose water to epidermal cells, contract and close the pore.
- Objections:
  (i) Glucose does not occur in detectable quantity in the guard cells of open stomata.
  (ii) Starch and sugar inter-conversion is too slow to account for rapid stomatal opening and closing.

MALATE OR K^+ ION PUMP HYPOTHESIS (MODERN THEORY) [Levitt, 1974]

- Rise in pH of guard cells causes hydrolysis of starch to form phosphoenol pyruvate. The latter combines with carbon dioxide with the help of PEP case (Phosphoenol pyruvate carboxylae) forms oxalic acid which gets changed into malic acid.
- H^+ ions pass out of the guard cells actively while K^+ ions of epidermal cells pass into guard cells. K^+ combines with malate and passes into small vacuoles. Cl^- ions also absorbed from outside to maintain electro-neutrality. The ions exert an osmotic potential. It results in absorption of water from adjacent cells. Development of turgor and hence opening of stomata. Cytokinins and cyclic AMP are required. During closure movement, K^+ ions are pumped out of guard cells and malate is changed back to starch. It reduces osmotic concentration of guard cells. Water is lost. Turgidity of guard cell decreases and pore is closed. Abscisic acid or ABA promotes closure.

- Evidences
  (i) Guard cells of the opened stomata posses abundant K^+ ions
  (ii) At the time of stomatal opening starch is changed to organic acids.

FACTORS AFFECTING STOMATAL OPENING

1. Light: Most stomata open in light and close in darkness. Light intensity required for stomatal opening is quite low. Even moonlight is sufficient in some cases. Both blue and red light stimulate stomatal opening though blue light is slightly more effective.
   Succulents and some other plants are exceptions to this. Here stomata remains closed during day time. They open only during dark e.g. Agave, opuntia, pineapple.
2. Carbondixoide : Low carbon dioxide concentration induces stomatal opening while high carbon dioxide causes stomatal closure.
3. Oxygen : It is essential for stomatal opening.
4. Humidity: In dry weather, stomata tend to close while in humid environment they remain open for longer period.
5. Plant Hydration: Water deficit in plants causes stomatal closure due to formation of ABA and lowering of water potential in epidermal cells.
6. Hormones: Abscisic acid brings about closure of stomata. It is produced during water stress. Cytokinins are required for keeping stomata open.
7. pH: Acidic pH induces stomatal closure while rise in pH causes stomatal opening.
8. Mechanical shock: It causes stomatal closure.
9. Temperature: Rise in temperature induces stomatal opening while fall in temperature causes closure. At 38^o-40^o C stomata open even in darkness.
10. Potassium : Opening of stomata is due to influx of K^+ while closure depends upon efflux of K^+ from guard cells.

FACTORS AFFECTING TRANSPIRATION

- EXTERNAL FACTORS

i) When relative humidity is high, the rate of transpiration decreases, because the atmosphere is more saturated with moisture. It retards the diffusion of water vapour from the intercellular spaces of the leaves to the outer atmosphere through the stomata.
ii) Transpiration increases with the increase in temperature. High temperature opens stomata even in dark

iii) Light increases with the rate of transpiration because in light, stomata open.
iv) Transpiration is less in still wind because water vapour accumulates around the transpiring organs and reduce the DPD of air. Rate of transpiration increases with the wind velocity.
v) A decrease in amount of available soil water, reduces absorption causing reduction in the rate of transpiration.

- Internal factors

i) The more of leaf surface area, the more is the rate of transpiration.
ii) An increase in root/shoot ratio causes an increase in the rate of transpiration.
iii) Mucilage and solutes decrease the rate of transpiration by holding water tenaciously.
iv) Structural features
(a) Sunken stomata: Help in reducing the rate of stomatal transpiration. The rate of transpiration is further decreased, if they are situated in grooves and sometimes protected by hairs.
(b) Thick cuticle: The thinner the cuticle, the greater is the rate of cuticalar transpiration. Therefore, in xerophytes, thick cuticle is developed by plants. The presence of wax coating exposed parts also reduces cuticalar transpiration.
(c) Leaf modification: Leaf spines, scale leaves, phyllode, phylloclade, prickles are all modifications of leaf and help in reducing transpiration.
(d) Mesophyll: Compact mesophyll cells reduce transpiration, because of fewer intercellular space. Loose mesophyll increases transpiration because of larger intercellular spaces.

MEASUREMENT OF TRANSPIRATION

1. Potometer: It is an instrument for measurement of the rate of transpiration by shoots through measuring the rate of their water absorption.
2. Prometer: An instrument that gives a rough idea about the degree of stomatal opening.
3. Cobalt chloride paper test: Dry cobalt chloride is blue while the moist one is pink. A filter paper slip can be dipped in 3-5% cobalt chloride and dried. It appears blue. The slip is placed over leaf surface and protected from atmospheric humidity by a glass slide or transparent tap. Change in colour of the filter paper slip from blue to pink indicates transpiration.

ADVANTAGES OF TRANSPIRATION

1. It plays an important role in the upward movement of water, i.e. ascent of sap
2. It helps in absorption and translocation of minerals salts.
3. Rapid evaporation of water from the aerial parts of the plant through transpiration brings down their temperature. Thus, it prevents them from excessive heating. This is also known as cooling effect.

ANTITRANSPIRANTS

- They are substances that are employed for reducing the rate of transpiration. It is done by –
  (i) Chemical which reduces the degree of stomatal opening. E.g PMA (Phenyl mercuric acetate). Salicylic acid and ABS (abscisic acid).
  (ii) Formation of ultra –thin surface film of silicon emulsion over leaf surface. It is more permeable to gases than water vapour.
- Importance
  Benefits of transpiration includes cooling of surface area, increased development of mechanical tissues, better development of fruits, increased absorption of salts etc. Its drawbacks include reduced growth, reduced yield, modification and wilting. However, transpiration cannot be checked completely because it will occur to a smaller or larger degree. Whenever stomata open for gaseous exchange. Therefore, it is regarded as necessary evil.

GUTTATION (Bregerstein, 1887)

- Loss of water in the liquid state from uninjured parts of plants is known as guttation. It is usually occurs from the tips and margin 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. Cucurbita. Potato, tomato and many grasses.
- In the regions of guttation, the leaves posses special pores called hydathodes. Hydathods or water pores are permanently open pores as their guard cells are immobile. Internally a hydathode leads to a loose parenchymatous tissue called epithem. A vein ends below. Root pressure usually causes the flow of sap from the vein to epithem and then hydathode. Guttated water contains minute quantities of both inorganic and organic substances.

- Photosynthesis is simply defined as " formation of carbohydrates from CO_2 and H_2O by illuminated green cells of plants, O_2 and H_2O by being the byproducts". In other words, capture of photons of light by green plant cells and conversion of their radiant energy into chemical form of energy is called photosynthesis.

$$6\ CO_2 + 12\ H_2O \xrightarrow[\text{radiant energy}]{\text{Chlorophyll}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

IMPORTANCE OF PHOTOSYNTHESIS

(i) Synthesis of organic food.
(ii) Non-photosynthetic or heterotrophic organisms depend upon for organic food. Plants are, therefore called produces. Other are called consumers.
(iii) It converts radiant or solar energy into chemical energy.
(iv) Fossil fuels are products of photosynthetic activity of past plants.
(v) All plant products of photosynthetic activity of past plants.
(vi) It absorbs CO_2 from atmosphere which tends to increase due to respiration of organisms and combustion.
(vii) It evolves oxygen which is consumed in respiration and combustion of respiratory substrate and formation of ozone in stratosphere for filtering out harmful radiations.
(viii) Productivity of crop depends upon rate of photosynthesis.

LANDMARKS IN PHOTOSYNTHESIS

1. STEPHAN HALES (1727) : Father of plant physiology pointed out that green plants require sunlight to obtain nutrition from air.
2. JOSEPH PRIESTLY (1771): An English clergyman and chemist, showed that the plants purify air which becomes foul by the burning of candles and respiration by mice.
3. INGENHOUSZ: A Dutch physician in 1779 demonstrated that light is necessary for purification of air by plants.
4. JEAN SENEBIER (1782): He showed that the presence of noxious gas produced by animals and by plants in darkness (CO_2) stimulated production of "purified air" (O_2) in light.
5. NICHOLAS THEODORE de SUSSURE (1804): He showed that the total weight of the organic matter produced and oxygen evolved by the green plants in presence of sunlight was greater than the weight of fixed air (CO_2), consumed by them during this process. He concluded that besides fixed air (CO_2), water must constitute the raw material for this process.
6. PALLETIER AND CAVENTION (1818): They discovered and named green colour of leaf as chlorophyll which could be separated from leaf by boiling in alcohol.
7. JULIUS ROBERT MAYER (1845): He observed that the green plants utilize light energy and convert it into chemical energy of organic matter.

8. JULIUS VON SACHS (1854): Showed that the process of photosynthesis takes place in chloroplasts and results in the synthesis of starch. He also showed that chlorophyll is confined to chloroplast.
9. GG STOCKS (1864): Obtained pure fraction of chlorophyll –a and b and detected the presence of chlorophyll – c.
10. ENGELMANN (1888): Plotted the action spectrum of photosynthesis.
11. FF BLACKMAN (1905): Noted that photosynthesis is a two step process. A dark reaction also occurs along with photochemical reaction. He also proposed the law of limiting factor.
12. WILLSTATTER AND STOLL (1913, 1918): Showed detailed account of chemical composition and functioning of chlorophyll.
13. WARBERG (1920): Flash light experiment with chlorella as useful material for photosynthesis experiments.
14. VAN NEIL (1931): Showed that the photosynthetic bacterial fixed CO_2 in the presence of H_2S. He postulated that the plants evolve O_2 by splitting H_2O not CO_2.
15. EMERSON AND ARNOLD (1932): Recognised light reaction consists of two distinct photochemical process. They showed that about 2500 chlorophyll molecules are required to fix one molecule of CO_2 in photosynthesis.
16. ROBIN HILL (1937): Isolated chloroplast suspended in water in presence of suitable hydrogen acceptor which evolve oxygen in presence of light. He demonstrated that the source of O_2 evolved during photosynthesis is water and not CO_2.
17. RUBEN AND KAMEN(1941): Used radioactive oxygen O^{18} and proved that oxygen evolved was part of water.
18. ARNON, ALLEN AND WHATLEY(1954): Demonstrated that fixation of CO_2 by chloroplast using $C^{14}O_2$.
19. MELVIN CALVIN(1954): Traced the path of carbon in photosynthesis using unicellular algae chorella. Melvin calvin gave C_3-cycle and was awarded Nobel Prize in 1960 for the discovery
20. PARK AND BIGGINS(1961): Discovered quantosome 100 Angstrom thick and stated that it contains about 230 chlorophyll molecules.
21. HATCH AND SLACK(1967): Discovered C_4 pathway for fixation of CO_2
22. HUBER, MICHEL AND DISSENHOFER (1985): Crystallised photosynthesis reaction centre of bacterium Rhodobacter and got Nobel Prize in 1988.

RAW MATERIALS FOR PHOTOSYNTHESIS

- In green plants including algae, photosynthesis takes place in chloroplasts of the cells. During this process, solar energy is trapped and synthesis of carbohydrates takes place from carbon dioxide and water. This sunlight, carbon dioxide, water, chloroplast are important components necessary for plants to derive the process of photosynthesis.

SUNLIGHT

- Photosynthesis is a light dependent process. The literal meaning of world “Photosynthesis” is “ the synthesis, with the help of light”. To drive photosynthesis in plants, sunlight provides solar energy. Only 0.2% of the light energy, incident on earth is actually used by photo autotrophs.
- Light is the visible radiation which represents a very small portion of the total electromagnetic spectrum of radiation, emitted by the sun. Visible light (approx. between 400nm to 700 nm) causes the physiological sensation of vision of man. Visible light is actually a combination of several colours of different colours viz. Violet (400nm to 425 nm), blue (425nm to 490nm), green (490 – 550 nm), yellow (550 -585 nm), organge (585 – 640 nm) and red (640 – 700 nm)
- The most effective regions of visible light spectrum responsible for maximum photosynthesis in plants are blue and red regions of which red light is most effective. On the other hand, green light is least effective. Photosynthesis cannot take place beyond the range of visible spectrum.

CARBON DIOXIDE

- In land plants, carbon dioxide is obtained from the atmosphere through the stomata. Small quantities of carbonates are also absorbed from soil through the roots. Hydrophytes get their carbon dioxide supply from the aquatic environment as bicarbonates. The latter are absorbed by hydrophytes through their general surface.

WATER

- In the process of photosynthesis, the source of liberated oxygen in water. Photosynthetic land plants absorb a large amount of water from the soil through the root hairs-present on their roots. But relatively very small amount of this absorbed water is used in the process of photosynthesis. Aquatic photosynthesis plants absorb water through their body surface.
- As mentioned earlier, Van Niel (1931) hypothesized that the pototosynthetic organisms require a source of hydrogen. He proposed that oxygenic photosynthesis is an oxidation reduction reaction where hydrogen of water reacts with carbon dioxide to form organic compounds
- 1937, Robin Hill demonstrated that in absence of carbon dioxide, isolated chloroplasts of stellaria media produced oxygen when they were illuminated in presence of hydrogen acceptor. Here ferricyanide is reduced to ferrocyanide by photolysis of water. This is Hill reaction and can be represented as

$$\underset{\text{(hydrogen acceptor in oxidised state)}}{2A} + 2H_2O \xrightarrow[\text{chloroplast}]{\text{light}} \underset{\text{(reduced product)}}{2AH_2} + O_2$$

- The hydrogen acceptor is often called as Hill oxidant or Hill reagent. In plants, $NADP^+$ (Nicotinamide adenine dinucleotide phosphate) acts as a hydrogen acceptor.

$$2NADP^+ + 2H_2O \xrightarrow[\text{chlorophyll}]{\text{light}} 2NADPH + 2H^+ + O_2$$

- In 1941, by using non-radioactive heavy isotope of oxygen (O^{18}), Ruben and Kamen proved that during photosynthesis, oxygen comes from the water.

$$CO_2 + 12\,H_2\,{}^{18}O \xrightarrow[\text{chlorophyll}]{\text{light}} C_6H_{12}O_6 + 6\,H_2O + 6\,{}^{18}O2$$

CHLOROPLASTS

- Chloroplasts (Chloros = green, plastos = moulded) are the green plastids which occur in all the green parts of the plants.
- They are the actual sites of photosynthesis.
- The chloroplasts contain chlorophyll and carotenoid pigments which are responsible for trapping light energy essential for photosynthesis.
- Majority of the chloroplasts of the green plants are formed in the mesophyll cells of the leaves.
- They are lens shaped, oval, spherical, discoid or even ribbon like organelles having variable length (5- 10 mm) and width (2 -4 mm).
- The chloroplasts are double membrane bound, each membrane are 9-10 mm in thickness. The space limited by the inner membrane of the chloroplast is called the stroma. It is the site of dark reaction.
- A number of organized flattened membranous sac called the thylakoids are arranged in stacks like piles of coins called grana. Thylakoids lying outside the grana are called stroma, thylakoids or the intergrana thylakoids
- Each granum may contain 20 to 50 thylakoid discs. There may be 40 – 60 grana per chloroplasts.
- The major function of thylakoids is to perform photosynthetic light reaction (photochemical reaction)
- The pigments and other factors of light reaction are usually locataed in thylakoid membranes.

- Cyanobacteria and other photosynthetic bacteria do not possess chloroplasts. However, the photosynthetic pigments which lie freely in the cytoplasm. There photosynthetic pigments are also different from those of eukaryotes.
- Thylakoids possess four types of major complexes; photosystem I, photosystem II, cy b_6 – f comples and coupling factor (ATP synthetase)
- Photosystem II is thought to mostly occur in the appressed or partition to mostly occur in the appressed or partition regions of granal thylakoids while photosystem I lies in the non-appressed parts as well as stroma thylakoids.

PHOTOSYNTHETIC PIGMENTS

(i) Chlorophylls

It is a green pigment which traps solar radiation and convert light energy to the chemical energy. Generally, it is of two types.

(a) Chlorophyll –a ($C_{55}H_{72}O_5N_4Mg$): It participates directly in the light reactions of photosynthesis has a head called a porphyrin ring with a magnesium atom at its centre. Attached to the porphyrin is a hydrocarbon tail, which interacts with hydrophobic regions of proteins in the thylakoid membrane.

(b) Chlorophyll-b ($C_{55}H_{70}O_6N_4Mg$): It differs from chlorophyll-a only in one of the functional group bonded to porphyrin. This diagram simplifies by placing chlorophyll at the surface of the membrane; most of the molecules are actually immersed in the hydrophobic core of the membrane.

(ii) Carotenoids

These are yellow, brown and orange pigments, which absorb light strongly in blue-violet range. These are called shield pigments, because they protect chlorophyll from photo ocidation by light intensity and also from oxygen produced during photosynthesis. Along with chlorophyll-b, the cartenoids are also called as accessory pigments, because they absorb energy and give it to chlorophyll-a. carotenoids are two types:

(a) Carotenes: Carotenes consists of an open chain conjugated double bond system ending on both the sides with ionone rings. They are hydrocarbons with molecular formula $C_{40}H_{56}$ carotenes are orange in colour. The red colour of tomato and chillies is, because of carotene call lycopene. The common carotene is β-carotene which is converted to vitamine-A by animals and humans

$$\underset{\beta\text{ - carotene}}{C_{40}H_{56}} + 2H_2O \longrightarrow \underset{\text{vitamin- A}}{2C_{19}H_{27}CH_2OH}$$

(b) Xanthophylls: Also known as carotenols. These are similar to carbon, but differ in having two oxygen atoms is the form of hydroxyl, carboxyl group attached to the ionone rings. Their molecular formula is $C_{40}H_{56}O_2$. The yellow colour of autumn leaves is due to lutein and a characteristics xanthophylls of brown algae is fucoxanthin.

(iii) Phycobilins

Phycobilins consist of four pyrrol rings and lack Mg and phytol tail. The phycobilin pigments are of two types.

(a) Blue – Phycocyanin, allophycocyanin

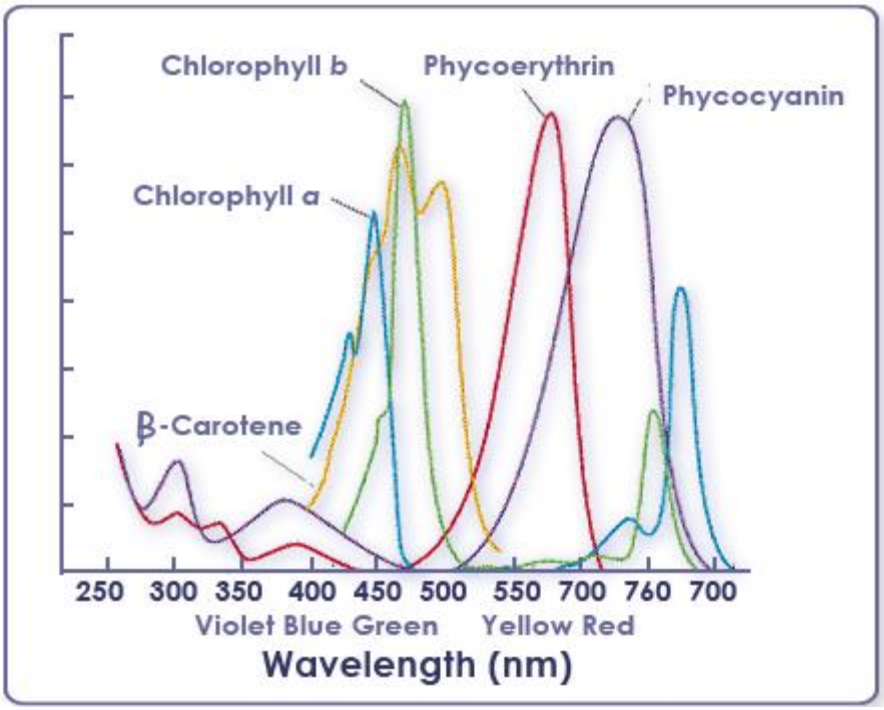
(b) Red – phycoerythein

These pigments are useful in chromatic adaptations. Phycoerytherin transfer energy to phycocyanin which in turn transfer energy to carotenoids which is ultimately received by chlorophyll –a.

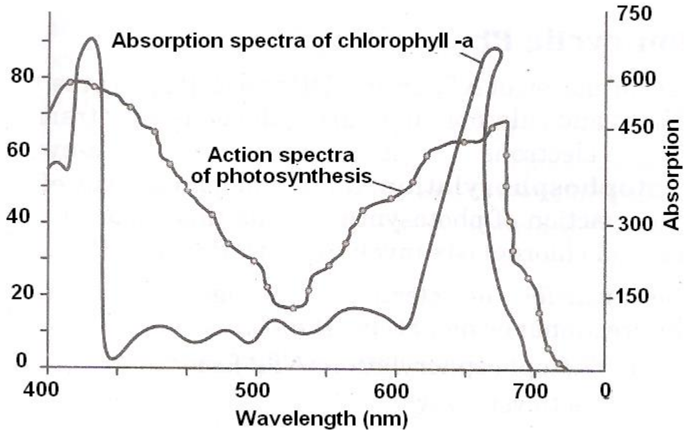
- The chlorophylls, carotenoids and phycobilins together form a complex of pigment in thylakoid membrane. These complexes work for the absorption of light and its transfer to a reaction center. These complexes are called photosynthetic unit or photosystem or pigment system. These system show clear division of labour. Some pigments called as accessory pigments such as carotenoids act to receive the light. They basically harvest the light molecules towards a reaction center thus, also called as Light Harvesting complexes (LHC). Chlorophyll-a act as reaction center and perform further reaction of photosynthesis.

ABSORPTION SPECTRUM AND ACTION SPECTRUM

- The graphic representation of curve depicting the various wavelength of light absorbed by a substance is known as absorption spectrum. Chlorophyll mostly absorb light radiations in blue (more) and red parts of light spectrum (430 to 662 nm for chlorophyll a, 455 and 604 nm for chlorophyll b)



- Action Spectrum: It is a graphical representation of curve depicting the rate of photosynthesis in various wavelengths of light.
- Fluorescence: It is property of almost immediate emission of long wave radiation by substances after attaining excited state on receipt of light energy e.g. Chlorophyll
- Phosphorescence: the delayed emission of long-wave radiations from an activated molecule is called phosphorescence. It continues for some time after removal of irradiation source.



PHOTOSYNTHETIC UNIT

- It is the smallest group of photosynthetic pigment molecules which can pick up light energy and convert it into chemical form. A photosynthetic unit has 250-400 pigment molecules. It has a photocentre of chlorophyll a molecules surrounded by harvesting molecules differentiated into core molecules and antenna molecules
- Antenna molecules are meant for absorbing radiation energy of different wavelengths. On absorbing a photon of light, the pigment molecule enters excited state. In this state the electrons move into outer orbital. The excited state lasts for 10^{-9} seconds. In this period the excited antenna pigment molecule transfer its energy to a core molecule through resonance. If this does not happen, the energy is lost as fluorescence. The core molecules pass over their energy to trap centre or photocentre. The frequency of excitation is very high. It is met by collaboration of core and antenna molecules. Each time the trap centre or photocentre gets excited, it expels an electron and becomes oxidized. An electron is required to convert it to normal state.

PHOTOSYSTEM I (PS I)

- It is a photosynthetic pigment system along with some electron carriers that is located on both the nonappressed part of grana thylakoids as well as stroma thylakoids.
- PS-I has more of chlorophyll a
- Chlorophyll b and carotenoids are comparatively less.

- Photosystem I has a reducing agent X which is special chlorophyll P_{700} molecule, FeS centre B or ferredoxin, plastoquinone, cytochrome complex and plastocyanin.
- It takes part in both cyclic and non-cyclic photophosphorylation.
- PS-I can carry on cyclic phosphorylation independently.
- Normally it drives an electron from photosystem II to $NADP^+$

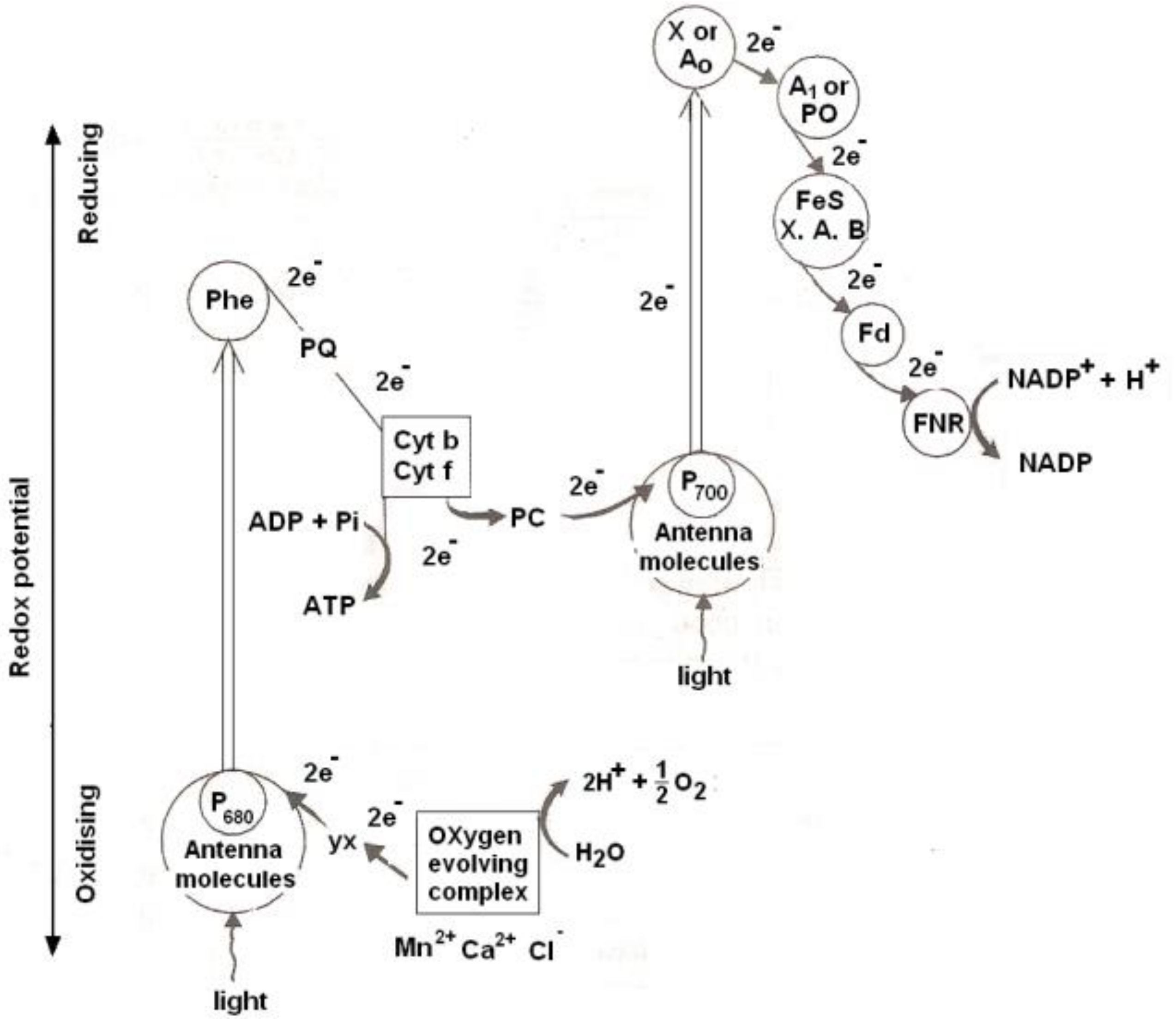
PHOTOSYSTEM II (PS II)

- It is a photosynthetic pigment system alongwith some electron carriers that is located in the appressed part of grana thylakoids.
- PS –II has chlorophyll a,b and carotenoids.
- Chl a and Chl b contents are equal.
- Carotenoid content is higher as compared to that of PS I
- The photocentre is a special chlorophyll a molecule called P_{680}
- It is surrounded by other chlorophyll a molecules, chlorophyll b and carotenoid molecules
- PS II also contains Mn^{2+}, Cl^-, quencher molecules Q, plastoquinon (PQ), cytochrome complex and plastocyanin.
- It picks up electron released during photolysis of water.
- The same is extruded on absorption of light energy.
- As the extruded electron passes over cytochrome complex, sufficient energy is released to take part in the synthesis of ATP from ADP and inorganic phosphate.
- This photophosphorylation is non-cyclic.
- PS II can operate only in conjugation with PS I

NON – CYCLIC PHOTOPHOSPHORYLATION

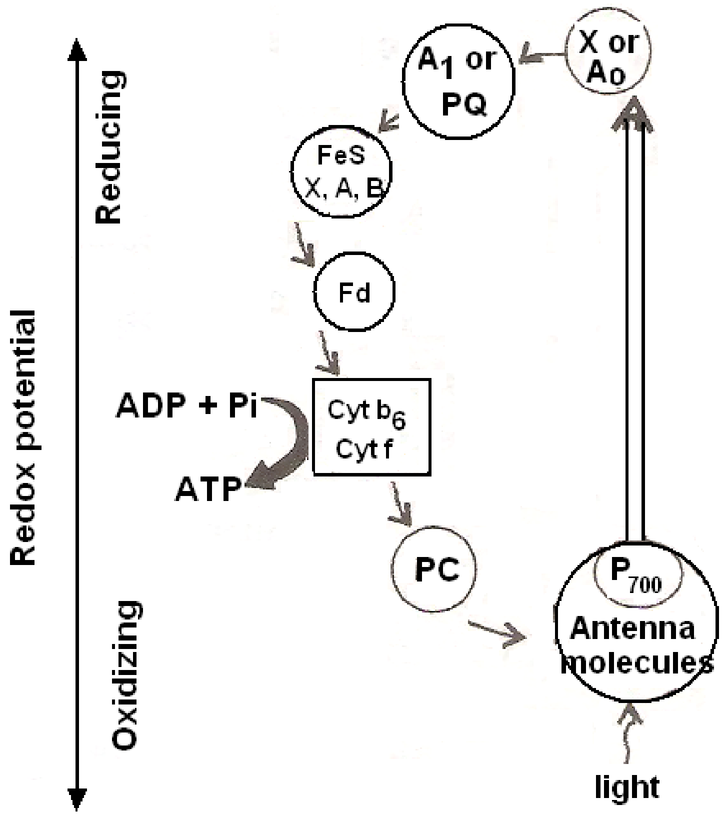
- It is the normal process of photophosphorylation in which the electron expelled by the excited photocentre does not return to it.
- Non-cyclic photophosphorylation is carried out in collaboration of both photosystem I and II.
- Electron released during photolysis of water is picked up by photocentre of PS II called $P_{680.}$
- The same is extruded out when the photocetre absorbs light energy.
- The extruded electron has an energy equivalent to 23 kCl / mole
- It passes through a series of electron carriers phaeophytin, PQ. Cytochrome $b_6{}^-f$ complex and plastocyanin.
- While passing over cytochrome complex, the electron loses sufficient energy for the synthesis of ATP.

- The electron is handed over to photocentre P_{700} of PS I by plastocyanin. P_{700} extrudes the electron after absorbing light energy. The extruded electron passes through special chlorophyll P_{680} molecules, Fe-S, ferrodix, to finally reach $NADP^+$
- The latter then combines with H^+ with the help of NADP – reductase to form NADPH.
- This is called Z scheme due to its characteristics zig-zag shaped based on redox potential of different electron carriers.
- Non-cyclic photophosphorylation or Z-scheme is inhibited by CMU and DCMU.
- DCMU (Dichlorophenyldimethyl urea) is a herbicide which kills the weed by inhibiting CO_2 fixation as it is strong inhibitor of PS II



CYCLIC PHOTOPHOSHORYLATION

- It is a process of photophosphorylation in which an electron expelled by the excited photocentre is returned to it after passing through a series of electron carriers.
- It occurs under conditions of low light intensity, wavelength longer than 680nm and when CO_2 fixation is inhibited.
- Absence of CO_2 fixation results in non-requirement of electrons for formation of NADPH
- Cyclic photophosphorylation is performed by photosystem I only.
- Its photocentre P_{700} extrudes an electron with gain of 23 kcal/mol of energy after absorbing a photon of light.
- After losing the electron the photocentre becomes oxidized.
- The expelled electron passes through a series of carriers including P_{700} chlorophyll molecules, plastoquinone (PQ), FeS complex, ferrodix (Fd) cyt b_6 – f and plastocyanin before returning to photocentre.
- Over the cytochrome complex (cyt b_6-f), the electron creates a proton gradient for synthesis of ATP from ADP and inorganic phosphate.
- Halobacteria or halophile bacteria also perform photophosphorylation but ATP thus produced is not used in synthesis of food. These bacteria possess purple pigment bacteriorhodopsin attached to plasmamembranes. As light falls on the pigment, it creates a proton pump which is used in ATP synthesis.
- Cyclic photophosphorylation is the most effective anaerobic phosphorylation mechanism.



CHEMIOSMOTIC HYPOTHESIS OF ATP FORMATION

- The view was propounded by Peter Mitchell in U.K. in 1961 in the case of mitochondria and chloroplast.
- Mitchell's chemiosmotic theory was confirmed by G.Hind and Andre jagendorf at cornell university in 1963.
- According to this view, electron transport, both in respiration and photosynthesis produces a proton gradient (pH gradient)
- The gradient develops in the outer chamber or inter-membrane space of mitochondria and inside the thylakoid lumen in chloroplasts.
- Lumens of thylakoid becomes enriched with H^+ ion due to photolytic splitting of water.
- Primary acceptor of electron is located on the outer side of thylakoid membrane.
- It transfer its electrons to a H-carrier. The carrier removes a proton from matrix while transporting electron to the inner side of membrane.
- The proton is released into the lumen while the electron passes to the next carrier.
- NADP reductase is situated on the outside of thylakoid membrane.
- It obtains electron from PS I and protons from matrix to reduce $NADP^+$ to NADP + H^+ state.
- The consequences of the three events is that concentration of proton decreases in matrix or stroma region while their concentration in thylakoid lumen rises resulting in decrease in pH.
- A proton gradient develops across the thylakoid.
- The proton gradient is broken down due to movement of protons through transmembrane channels, cF_o of ATPase (cF_o – F_1 particle).
- The rest of the membrane is impermeable to H^+, cF_0 provides facilitated diffusion of H^+ or protons.
- As the protons move to the other side of ATP, they bring about conformational changes in cF_1 particle of ATPase or coupling factor.
- The transient cF_1 particles of ATPase enzyme from ATP from ADP and inorganic phosphate.
- Therefore, ATP synthesis through chemiosmosis requires a membrane, a proton pump, a proton gradient and cF_0 – cF_1 particle or ATP-ase
- One molecule of ATP is formed when $3H^+$ used by the ATP synthase.

LIGHT REACTION (Photochemical phase).

- It occurs inside the thylakoids, especially those of grana regions.
- Photochemical step is dependent upon light. The function of this phase is to produce assimilatory power consisting of reduced co-enzyme NADPH and energy rich ATP molecules.
- Photochemical phase involves photolysis of water and production of assimilatory power.
- The phenomenon of breaking up of water into hydrogen and oxygen in the illuminated chloroplast is called photolysis of water.

- Light energy, an oxygen evolving complex (OEC) and an electron carrier are required.
- Oxygen evolving complex was formly called Z-enzyme
- It is attached to the inner surface of thylakoid membrane.
- The enzyme has four Mn ions. Light energized changes in Mn (Mn^{2+}, Mn^{3+}, Mn^{4+}) removes electrons from OH^- component of water forming oxygen.
- Liberation of O_2 requires two other ions Ca^{2+} and Cl^-.
- Electron carrier transfer the released electrons to P_{680}

$$4H_2O \rightleftharpoons 4H^+ + 4OH^-$$

$$4OH^- \xrightarrow[Mn^{2+},\ Ca^{2+},\ Cl^-]{\text{oxygen-evolving complex}} 2H_2O + O_2 + 4e^-$$

- The electron released during photolysis of water are picked up by P_{680} photocentre of photolystem II.
- On receiving a photon of light energy the photo-centre expels an electron with a gain of energy (23 kcal/mole).
- It is the primary reaction of photosynthesis which involves the conversion of light energy into chemical form.
- The phenomenon is also known as quantum conversion.
- The electron extruded by the photocentre of photosystem II is picked up by the quencher phaeophytin.
- From here the electron passes over a series of carriers in a downhill journey losing its energy at every step.
- The major carriers are plastoquinone (PQ) cytochrome b-f complex and plastocyanine (PC).
- While passing over cytochrome complex, the electron loses sufficient energy for the creation of proton gradient and synthesis of ATP from ADP and inorganic phosphate by the process of photophosphorylation.
- From plastocyanin the electron is picked up by the trap centre P_{700} of photosystem I.
- On absorbing a photon of light energy, P_{700} pushes out the electron with a gain of energy.
- The electron passes over carriers, FeS, feredoxine and NADP-reductase.
- The latter gives electron to $NADP^+$ for combining with H^+ ions to produce NADPH.

$$NADP^+ + 2e^- + H^+ \xrightarrow{\text{NADP reductase}} NADPH$$

- NADPH is a strong reducing agent. It constitutes the reducing power which is also contains a large amount of chemical energy.

DARK REACTION (Biosynthetic phase)

- Dark reaction of phorosynthesis occurs in presence of or absence of light i.e. independent of light.
- Dark reaction occurs in stroma fraction of the chloroplast.
- Dark reaction is purely enzymatic reaction and is slower than light reaction of photosynthesis.
- Dark reaction was first of all established in detail by Dr. Calvin, Benson and J.Bassham and for this work they were given Nobel prize (1961).
- The techniques used for studying different steps were radioactive tracer technique using ^{14}C chromatography and autoradiography and the material used were chlorella and scenedesmus. These are microscopic, unicellular algae and can be easily maintained in laboratory.
- Dark reaction is also named as Blackman's reaction.

C_3- PATHWAY OR CALVIN CYCLE

- The details of the step involved in the dark reaction were discovered by Professor M. Calvin and hence the dark reaction known to be called as Calvin cycle.
- This is the major pathway for the fixation of carbon dioxide in green plants. It represents phase II i.e. dark reaction. It takes place in the stroma of the chloroplasts.
- The reactions are enzyme. Controlled and temperature dependent. After the fixation of carbon dioxide, the first stable compound formed is 3-carbon phosphoglyceric acid (PGA). Hence, it is also called the C_3 – pathway.
- Calvin cycle can described under three stages:
  (a) Carboxylation of RUBP:
    - In this process there is fixation of atmospheric CO_2 into a stable organic compound with the help of enzyme RuBP, Carboxylase-oxygenase or RuBisCO

$$\text{Ribulose-1,5-biphosphate} + 6CO_2 + 6H_2O \longrightarrow \text{3 phosphoglyceric acid (3PGA)}$$

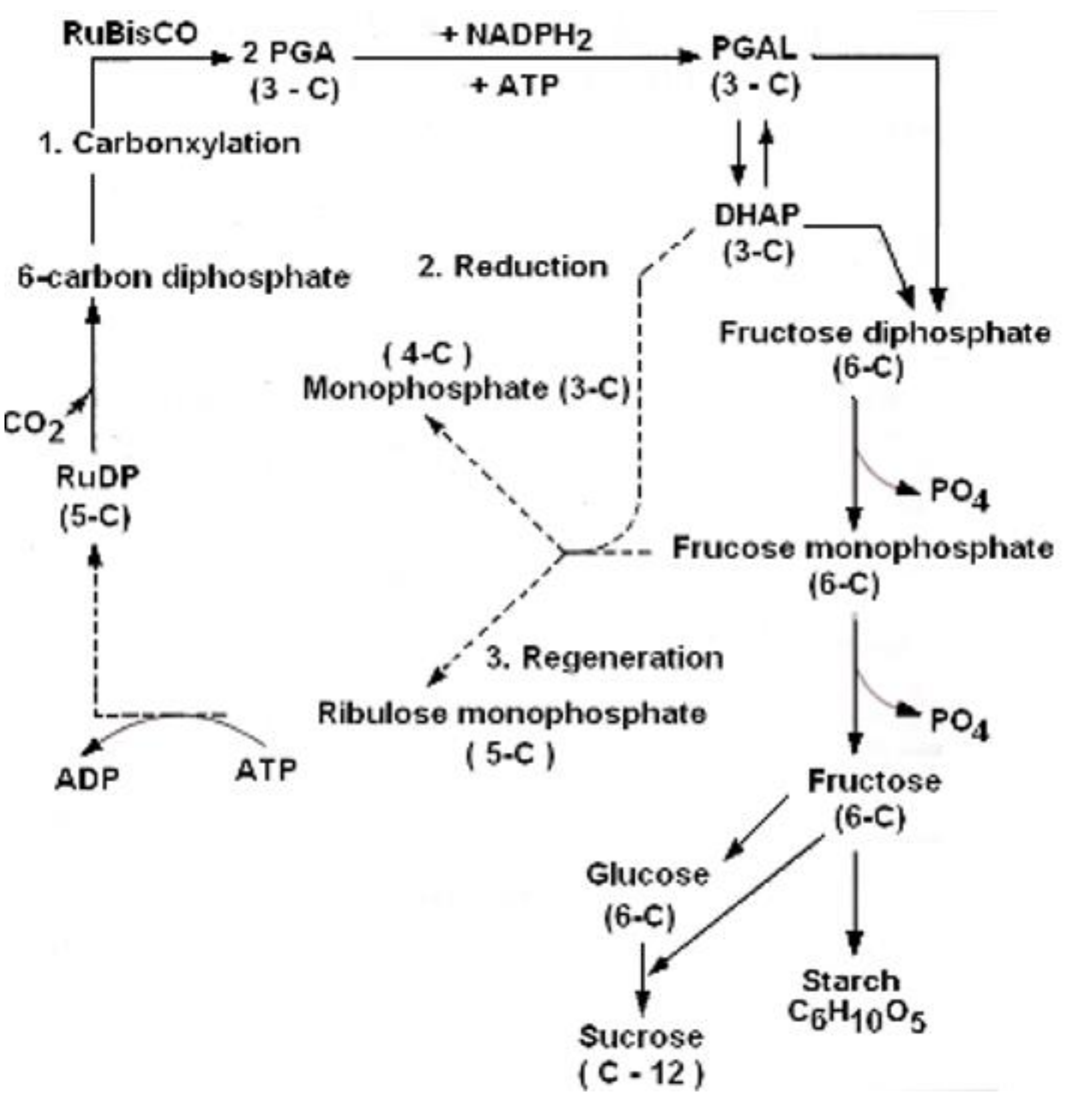
  (b) Reduction of CO_2
    - The 3-C PGA then undergoes reduction with the help of the assimilatory power to form 3-c phosphoglycerladehyde (PGAL). $NADPH_2$ provides the hydrogen and ATP supplies energy for the reduction. Enzyme trisephosphate dehydrogenase catalyses the reaction.
    - Some molecules of PGAL are converted into another triosephosphate called Dihydroxy Acetone Phosphate (DHAP) in presence of enzyme phosphor triose isomerase.

- The formation of sugars (end products of photosynthesis), the 3-C triose phosphates (PGAL 3-C and PHAP 3-C) to form 6-C hexose sugar fructose 1,6-biphosphate in the presence of enzyme aldolase.
- Fructose biphosphate is the diphosphorylated first to fructose monophosphate and then to fructose (6-C) in the presence of enzyme phosphotase. Some fructose monophosphate molecules may be isomerised into glucose monophosphate by the enzyme isomerase and then into glucose (6-C). The hexose sugar may be further converted to sucrose ($C_{12}H_{22}O_{11}$) or to starch $(C_6H_{10}O_5)_n$ and are stored in storage cells.

(c) Regeneration of RuBP

- The 5-C RuBP is constantly required for the fixation of CO_2 in the calvin cycle. It is regenerated through another chain of reactions.
- Some molecules of triosephosphate and fructose monophosphates are used from the calvin cycle for the formation of RuBP to be used again to combine with CO_2
- The net reaction of calvin cycle can be represented by
  6RuBP + 6CO_2 +18ATP +12NADPH → 6RuBP + $C_6H_{12}O_6$ + 18ADP +12 $NADPH^+$ + 18 Pi
  Balnce sheet of calvin cycle

IN	OUT
6CO_2	1 glucose
18 ATP	18 ADP
12 NADPH	12 NADP



C_4 – PATHWAY OR HATCH AND SLACK PATHWAY

- In some plants, the first stable product, after the fixation of CO_2, is 4-C dicarboxylic acid called oxaloacetic acid (OAA), such plants are called C_4 plants and path of carbon) dark reaction) is called C_4 – pathway.
- It was first noticed by Kortschak (1964) in the photosynthesis of sugarcane leaves. However details of the C_4 – pathway, were worked out by Hatch and Slack (1966). Therefore, it is called Hatch and slack pathway.

ANATOMICAL PECULIARITIES OF C_4 – PLANTS

(a) The leaf mesophyll consists of compactly arranged cells.
(b) It is not differentiated into palisade and spongy mesophyll as in C_3 plants
(c) The vascular bundles (veins) in the leaves are surrounded by a distinct bundle sheath of radially enlarged parenchyma cells.
(d) The chloroplast in leaf cells are dimorphic i.e. granal and agranal chloroplast

- Chloroplasts in mesophyll cells are smaller and possess grana.
- Chloroplasts in the bundle sheath cells are larger and without grana.

This type of leaf anatomy in C_4-plants is called as Kranz anatomy

IMPORTANT STEPS IN C_4 – PATHWAY

(a) First part reactions are completed in the stroma of the chloroplasts in mesophyll cells.
(b) Second part, reactions are completed in the stroma of the chloroplasts in bundle sheath cells.

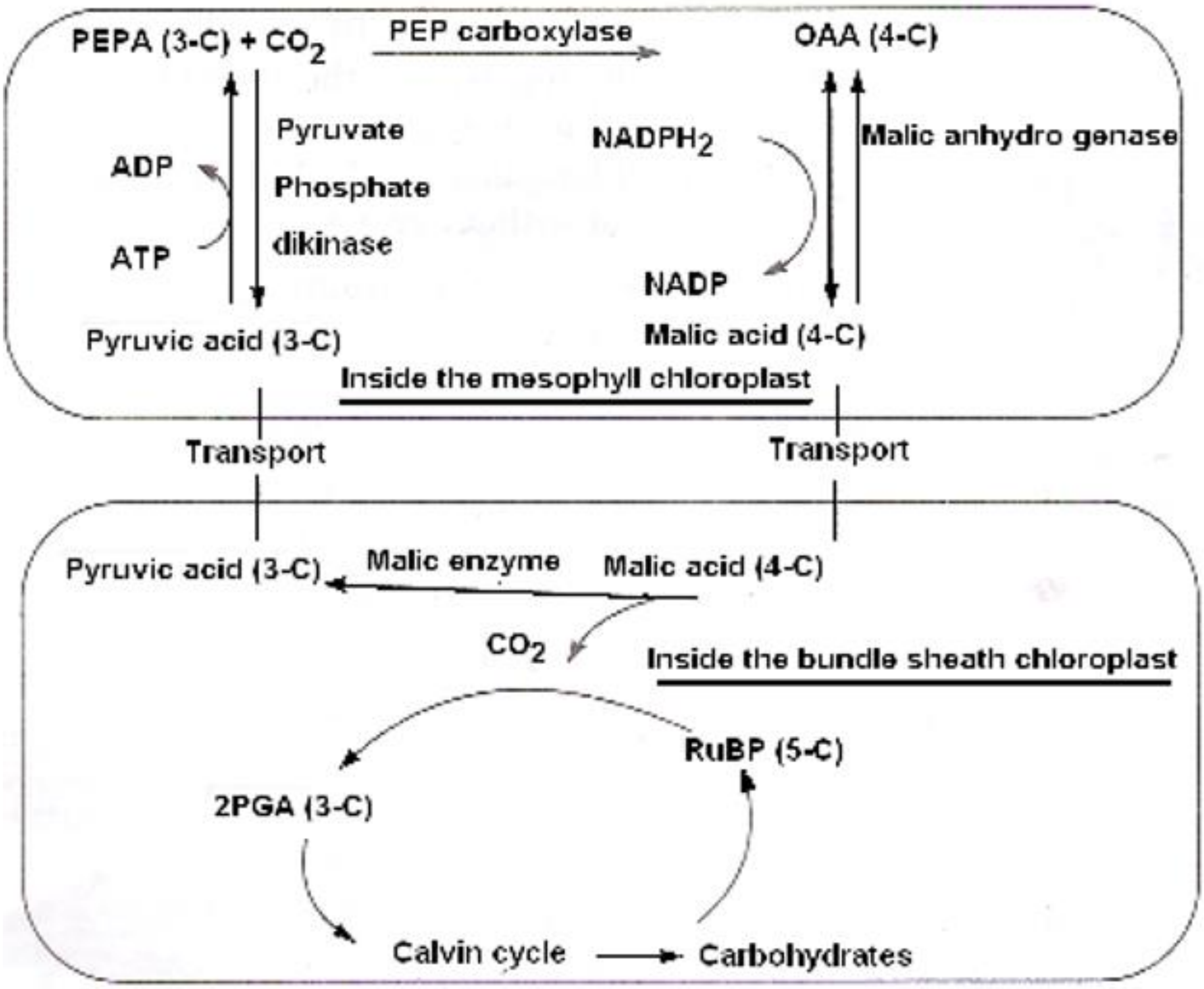
Part I (in mesophyll cells)

- First CO_2 fixation: In this pathway, the first CO_2 acceptor is 3-C phosphoenol Pyruvate (PEP), CO_2 first combines with 3-C PEP to form 4-C OAA (oxaloacetic acid). As DAA is a dicarboxylic acid pathway.
- 4-C OAA is converted into 4-C malic acid or 4-C aspartic acid and transported to bundle sheath cells.

Part II (in bundle sheath cells)

- In the chloroplasts of bundle sheath cells, 4-C malic acid undergoes decarboyylation to form CO_2 and 3-C pyruvic acid.
- Second CO_2 fixation: The CO_2 released in decarboxylation of malic acid combines with 5-C RuBP (Ribulose 1,5-biphosphate) to form 2 molecules of 3-C PGA. Further, the conversion of PGA to sugar is the same as in the calvin cycle.
- The pyruvic acid produced in decarboxylation of malic acid is transported back to the mesophyll cells. Here, it is converted to phosphoenol pyruvic acid (PEPA) and again made available for the C_4-pathway.

- In C_4 pathway when carbon dioxide fixation take place, an additional 2 molecules of ATP per molecule of CO_2 fixed are also required to convert pyruvic acid to phosphoenol pyruvic acid. Thus in C_4 cycle in all 30ATPs are required for fixing 6 molecules of carbon dioxide.



CAM (Crassulacean Acid Metabolism) PATHWAY

- In the member of crassulaceae, cactaceae, agavaceal, orchidaceae, CO_2 fixation occurs during night only.
- In succulents belonging to the above families the stomata remain closed during day time in order to reduce transpiration and the stomata open during night.
- In CAM plants OAA is formed due to carboxylation as in C_4 plants.
- Like C_4 plants, OAA is reduced to make malic acid in CAM plants and is accumulated in the vacuole.
- Absorption of CO_2 during night and its storage as organic acid (malic acid) is called acidification.

$$PEP + HCO_3^- \xrightarrow{\text{PEP carboxylase}} OAA + H_3PO_4$$

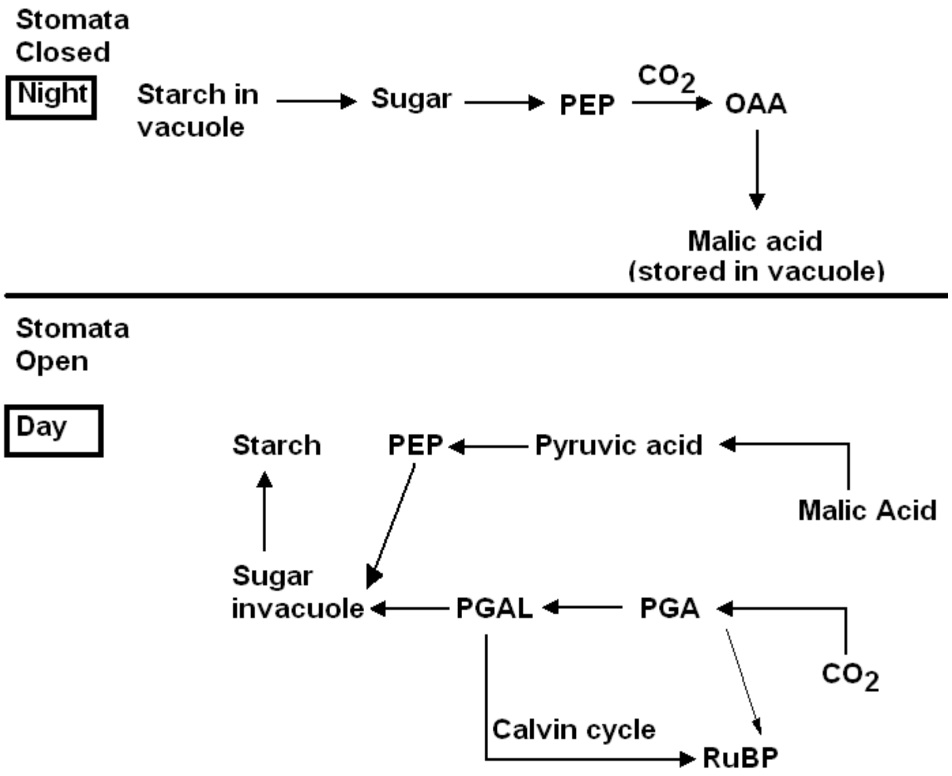
$$OAA + NADPH \xrightarrow{\text{dehydrogenase}} \text{malic acid} + NADP^+$$

- During day time malic acid undergoes oxidative decarboxylation nad CO_2 is released.

- Liberation of CO_2 from an organic acid during day time is called deacidification.

$$\text{malic acid} + NADP^+ \xrightarrow[\text{enzyme}]{\text{malic}} \text{pyruvate} + CO_2 + NADPH$$

- The diurnal acidification and deacidification during the night and day time respectively is called CAM
- In C_4 plants, initial carboxylation and final carboxylation is separated by space but in CAM plants, they are separated by time.
- All reactions of CAM occurs in mesophyll cells.
- Chloroplasts are absent in bundle sheath cells of CAM plants
- CAM pathway is important for the survival of succulents



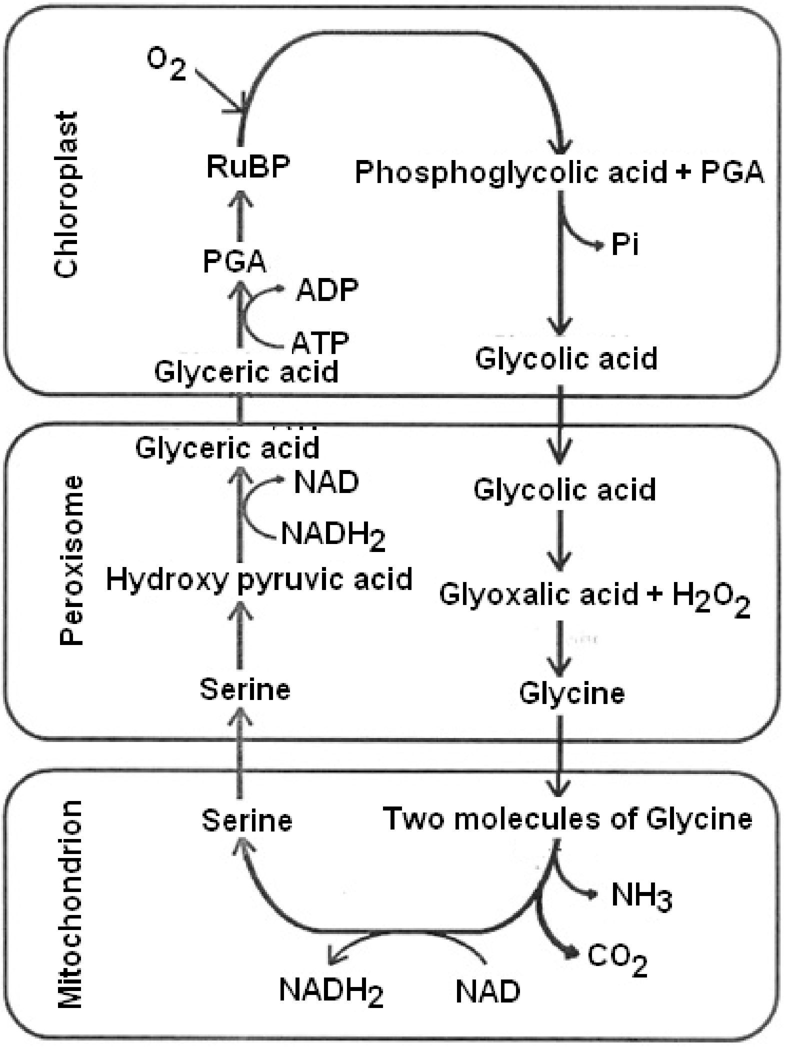
NUMBER OF ATP AND NADPH REQUIRED FOR $1CO_2$ FIXATION

PATHWAY	ATP	NADPH
C_3 cycle	3	2
C_4cycle	5	2
CAM	6.5	2

PHOTORESPIRATION

- It was first observed by Otto Warburg (1920) that presence of high O_2 concnetration and high temperature decreases the rate of photosynthesis. Later it was demonstrated by Dicker and Tijo (1959) in tobacco.

- RuBisCO is most abundant enzyme and it has affinity to both CO_2 and O_2. In C_3 – plants, when there is higher O_2 concentration and temperature, O_2 binds with RuBisCO instead of CO_2 and form one molecule of phosphoglycerate and phosphoglycolate in pathway called photorespiration, so there is neither synthesis of sugars, nor of ATP. Instead it results in the release of CO_2 with the utilization of ATP. In photorespiratory pathway there is no synthesis of ATP and NADPH.
- The process can be understood in the following steps.
  1. Oxygen binds with RuBP oxygenase to form phosphoglycolate in chloroplast which gets converted to glycolate and transported to peroxisomes.
  2. In peroxisome it forms glyoxylate and then glycine.
  3. Glycine then enters mitochondria and looses NH_4 and CO_2 in a reaction and it form serine.
  4. Serine is transported to perioxisomes and in a series of reaction it form glycerate which gets converted to PGA and then RuBP is the chloroplast.
  5. So, here we can see, there is no fixing of CO_2 instead CO_2 is given off along with NH_4. Thus it reduces the rate of photostnthesis in C_3 plants



PRINCIPLE OF LIMITING FACTORS (Blackman, 1905)

- When a process is conditioned as to its rapidity by number of separate factors, the rate of process is limited by the pace of the slowest factor. In other words, at one time only one factor limits the rate of the process. It is called limiting factor. A limiting factor is that factor which is deficient to such a extent that increase in its value directly increases the rate of the process.

FACTORS AFFECTING PHOTOSYNTHESIS

- The light reaction totally depends on the availability of light, water, pigments etc and the dark reaction depends on the temperature and available CO_2
  EXTERNAL FACTORS
  - Light: In photosynthesis light is converted to chemical energy in the food formed.
  (i) Light intensity – Light intensity required to get the optimum value differs with different species. Usually with increase in light intensity increase in rate is noticed. The value of light saturation at which further increase in photosynthetic rate is not accompanied by an increase in CO_2 uptake is called light saturation point.
  (ii) Light quality- Blue and red light of the spectrums is said to be the best for the photosynthesis. The maximum photosynthesis is shown to occur in the red part of the spectrum with the next peak in blue part. The green light has inhibitory effect.
  (iii) Light duration – Generally photosynthesis is independent of light duration. It is more in intermittent light than continuous light.
  - Carbon dioxide: Carbon dioxide is present in low concentration and form about 0.03% of total atmosphere CO_2 is natural limiting factor of photosynthesis. It the concentration of CO_2 is increased from 0.03% to 1%, the rate of photosynthesis increases, If concentration of CO_2 exceeds 1% rate of photosynthesis decreases due to closer of stomata.
  - Water: Water deficiency may decrease the rate. Less availability of water may further check the rate by closing the stomata there by affecting the entry of CO_2.
  - Temperature: The optimum temperature for photosynthesis is $15^{O}C$ to $35^{O}C$. if the temperature is increased too high, the rate of photosynthesis is reduced due to denaturation of enzymes involved in the process. Photosynthesis occurs in conifers at high altitude at $35^{O}C$. Some algal in host springs can undergo photosynthesis even at $75^{O}C$. When other factors are not limiting rate of photosynthesis gets doubled for every $10^{O}C$ rise in temperature untile an optimum is reached.
  - Oxygen: Excess of O^2 may become inhibitory for the process. Enhanced supply of O^2 increase the rate of respiration simultaneously decreasing the rate of

photosynthesis. An increase in oxygen concentration decreases photosynthesis and the phenomenon is called Warbrug effect.

- Mineral elements: Some mineral elements like Fe, Mg, Cu, Mn, Cl etc are associated with synthesis of chlorophyll and important reactions in photosynthesis like photolysis of water. So, absence of these elements decreases the rate of photosynthesis.

INTERNAL FACTORS

- Chlorophyll: Chlorophyll is an important internal factor for photosynthesis since it absorbs the radiant energy of light. Light initiates the mechanism of photosynthesis by transferring its electrons and getting excited. Emerson (1929) found direct relationship between the chlorophyll content and the rate of photosynthesis. The chlorophyll deficient mutants are albinos. They can't synthesize carbohydrates by photosynthesis, so they cannot survives.
- Leaf anatomy: Photosynthesis also depends upon the anatomy of leaf. If the assimilatory surface by palisade parenchyma is extensive there will be increased photosynthesis.
- Leaf age: In immature leaf the rate of photosynthesis is at minimum level. A mature leaf shows phosynthetic rate at maximum. When leaf becomes old, the rate decreases.
- End products: The end products of photosynthesis are carbohydrates. Accumulation of carbohydrates decreases the rate of photosynthesis. If the carbohydrates are translocated rapidly the rate of photosynthesis increases.
- Protoplasmic factors: These factors include the hydration of protoplasm and also the enzymatic activity. If there is an appreciable decrease in the hydration of the protoplasm the process of photosynthesis is inhibited because the enzymes gets denatured.

BACTERIAL PHOTOYNTHESIS

- It is an oxygenic (without evolution of O_2) because water is not employed as hydrogen donor. Instead H_2 H_2S and other compounds are employed. Trap centre is usually B_{890} of bacterio-chlorophyll a. It absorbs radiations between 870-890 nm of infra-red range. Though both cycles and non-cyclic photophosphorylations occur there is only one photosystem. Assimilatory power consists of ATP and NADH.

CHEMOSYNTHESIS

- It is the manufacture of organic food from inorganic raw materials like carbon dioxide and a hydrogen donor with the help of energy obtained from exergonic reactions.

Chemosynthesis is performed by certain bacteria. They are able to manufacture food in the absence of light.

- The organism carrying out chemosynthesis are called chemoautotrophs. Many of the chemoautotrops aare also able to obtain nourishment as saprotrophs and are thus actually facultative chemoautotrophs. They oxidize the inorganic substances present in their substrate. The energy is trapped and used in synthesis o organic compounds from inorganic raw materials. Chemoautotrops do not have a light trapping mechanism. They, however perform Calvin cycle reactions of carbon assimilation.

$$6\,CO_2 + 24\,H + \text{energy} \xrightarrow{\text{enzymes}} C_6H_{12}O_6 + 6\,H_2O$$

Some common chemoautotrophs are nitrifying bacteria, sulphur bacteria, iron bacteria, methane bacteria, hydrogen bacteria and carboxy bacteria.

TRANSLOCATION OF ORGANIC NUTRIENTS

- It is the movement of organic nutrients from the region of source or supply to the region of sink or utilisation. Phloem (sieve tubes / sieve cells) is the pathway for this translocation as found out by
  (i) Steam girdling.
  (ii) Stem girdling
  (iii) Sieve tube puncturing
  (iv) Radio autography
  (v) Sieve tube analysis
- Important theories about the mechanism of translocation of organic nutrients are:
  (a) Cytoplasmic / Protoplasmic Streaming Hypothesis
  Ina sieve tube element, organic solutes pass to all parts by cytoplasmic streaming while they pass from one element to another through diffusion.
  (b) Transcellular streaming hypothesis
  Sieve tubes possesses tubular transcellular strands which shows persistalis and hence take part in translocation of organic nutrients.
  (c) Mass flow hypothesis
  Organic region of high osmotic concentration to the region of low concentration in a mass flow due to occurrence of pressure gradient. It is most widely accepted theory.

- Sexual reproduction is the process of development of new organisms through the formation and fusion of gametes.
- The flower is the main structure concerned with reproduction, The reproductive organs or the sporophylls are produced within the flowers. The sporophylls are of two types microsporophylls (stamen) and megasporophylls (carpel)
- Stamen is distinguished as filament, anther and connective.
- Carpel is distinguished as ovary bearing ovule, style and stigma
- The whole process of sexual reproduction in flowering plants can be divided into three steps

i) Pre-fertilization
ii) Double fertilization
iii) Post-fertilization

PRE-PERTILISATION : STRUCTURE AND EVENTS

The pre-fertilisation events can be studied under following points

i) Pollen grain formation
ii) Embryo sac formation
iii) Pollination
iv) Pollen pistil interaction

POLLEN GRAIN FORMATION

Male reproductive unit (Stamen)

- A stamen is the male reproductive unit of angiosperms. It consists of an anther and a filament. The anther is bilobed and the lobe encloses four pollen sacs or microsporangia. Each pollen sac contains number of pollen grains. The four pollen sacs in a dithecous anther appear to lie in the four corners of anther
- The wall of anther consists of four layers of cells
- An anther dehisces by slits to liberate pollen grains

Anther development

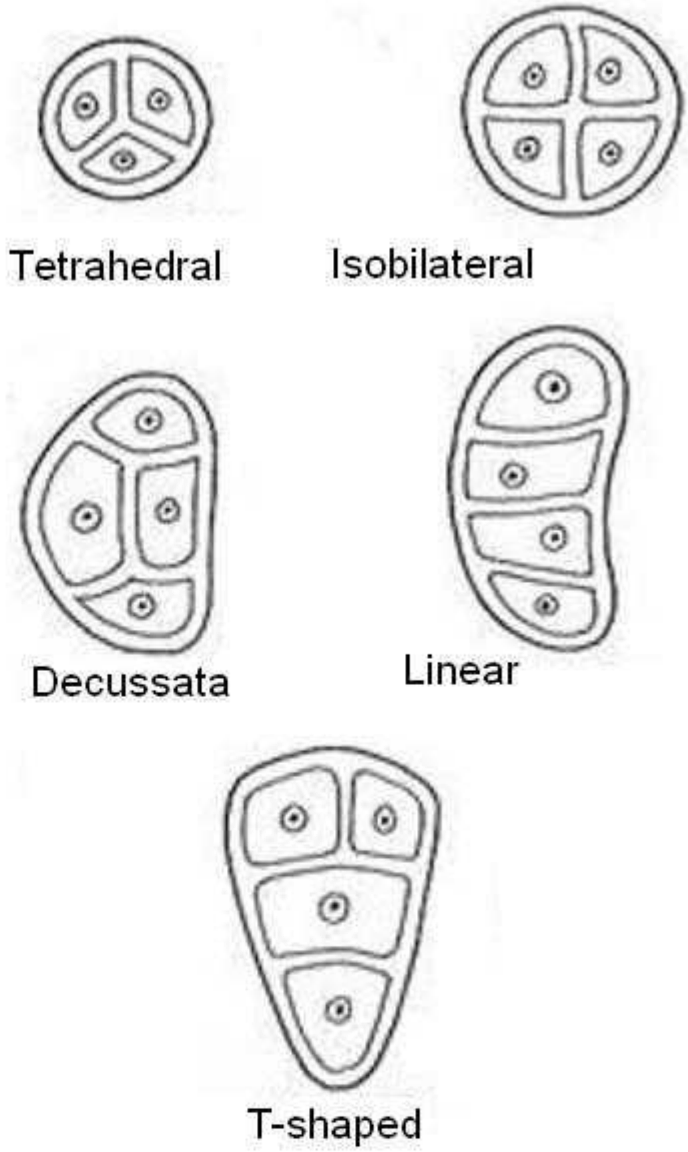
- The anther initiates its development in the form of a homogenous mass of a meristematic cells surrounded by epidermis. It becomes four lobed and four longitudinal rows of aechesporial cells are differentiated. Each of these cells divides to form a primary parietal cell and a primary sporogenous cell. The parietal cell divides several times to form the anther wall and the sporogenous cell divides a few times to form the microscopes or pollen mother cells (PMC). The innermost layer of cell wall in contact with the PMC's form the tapetum which plays a significant role in pollen development. The layer below the epidermis later becomes the endothecium.

Wall layers of anther

- Epidermis – one cell thick and protective in function
- Endothecium – Second wall layer usually single layered. Cells have a cellulose thickening with a little pectin and lignin. It help in anther dehiscence
- Middle layers – The number of middle layer ranges from 1-6. The middle layer degenerate at the maturity of the anther
- Tapetum – This is the innermost layer of anther wall which surrounds the sporogenous tissue. Tapetal cells are nutritive. They are multinucleated and polyploidy. In these cells the ubisch bodies which is deposited in the exine of microscope wall. The tapetum is of two types
  - (i) Secretary / glandular – The tapetal cells remain in situ all through the development of microscope and finally they degenerate.
  - (ii) Amoeboid / periplasmodial – The radial wall of tapetum cell break up releasing the protoplast into the pollen chamber. All such protoplast now fuse to form the periplasmodium.

Microsporogenesis

- The formation and differentiation of microspore is called microsporogenesis. The PMCs divide meiotically each forming generally tetrahedral tetrads, Cytokinesis may be successive or simultaneous.
- Successive type is advanced type. Tetrad are of five types, tetrahedral, isobilateral, decussate, T shaped, linear tetrahedral is most common
- In successive type, the cell wall is formed after meiosis –I as well as meiosis –II thus an isobilateral pollen tetras is formed. It is a characteristic feature of monocot
- In simultaneous type, each nuclear division in microspore mother cell is most followed by cell wall formation



- The microspores separate from the tetrahedral configuration and get surrounded by a two layered wall, outer exine and inner intine. The pollen grains are the first cells of the male gametophyte.
- The tapetum get used up, the anther becomes dry structure and pollen are liberated by dehiscence of the anther.
- Mostly, all the four nuclei in a tetrad remain functional to form four microspores. However, in cyperaceae only one functions and therefore only one microspore instead of four is formed by one meiosis. In some cases, all the four pollens remain attached forming compound pollen grains e.g. Juncus jatropha. In family asclepiadaceae and orchidacae, all the microspores in a sporangium adhere together in a single mass called pollinium.

Pollen grain

- Pollen grains may be oval, ellipsoidal, triangular, lobed or even crescent shaped. It is generally round with size of 25 - 30μm
- Pollen grain is haploid, unicellular body with single nucleus. Therefore is an outer wall and 2-3 celled interior.
- Wall or sporoderm is made of two covering, outer thick exine of sporopollenin and inner thin intine of pecto-cellulose
- The outer layer exine is thick and sculptured or smooth. It is cuticularised and cutin is of special type called sporopollenin which is resistant to chemical and biological decomposition so pollen wall is preserved for long periods. It also possess proteins for enzymatic and compatibility reactions.
- Exine is differentiated into inner endexine and outer ektexine. Ektexine is further divided into inner continuous foot layer, middle discontinuous baculate layer and outermost discontinuous tectum.
- Tectum is helpful for identifying pollen grain and referring them to their family, genus or species.
- Exine is absent over certain areas called germ pores when circular or it is called germ furrow when elongated
- In insected pollinated pollen grain, exine is covered with yellowish, viscous and sticky substance called pollenkitt. Pollenkitt act as an insect attractant and protects the pollen from UV rays
- Intine is thin and elastic. It is made up of cellulose and pectin. It emerges out as the pollen tube from the germ pores during germination
- Internally pollen grains have cytoplasm which is rich in starch and unsaturated oils. Uninucleated protopeast becomes 2-3 celled at the later stages of development.
- In calotropis and orchids, the pollen of each anther lobe formed a characteristics mass called pollinium
- Pollen grains can be monoclopate (having one germ pores),bicolpate(two germ pores) and triclopate (3 germ pores).
- The branch of study of pollens is called palynology

Development of male gametophyte

- Size of nucleus in pollen grain increases and it divides mitotically to produce a bigger vegetative cell or tube cell and smaller generative cell
- Pollination can occur in two celled (tube + generative) or three-celled (tube + two male gametes)

- However, in plants such as cereals, the male gametes while the pollen is still within the anther. In those cases, where pollen is shed at two celled stage, the generative cell divides after pollen has landed on stigma.
- The cytoplasm contents of generative cell do not possess much of stored food material. Vegetative cell contains fat, starch and protein granules.

Pollen products

(i) Pollen food supplements : Pollen grain contains abundant carbohydrates and unsaturated fat. They are used in form of tablets and syrups for enhancing vital body functions. Pollen consumption increases performance and used by athletes and given to race horses

(ii) Pollen creams : Pollen grain protect themsevles from UV rays. Thus they are used in creams, emulsions for providing smoothness and protection to skin.

Pollen viability

The period for which pollen grains remain viable or functional is called pollen viability. It depends upon temperature, humidity. Pollen grains remain viable in 30 minutes. Pollen grain can be cryopreserved in liquid nitrogen (temp – $196^{O}C$) and used as pollen banks.

Pollen allergy

Pollen grain produce severe allergy. It causes have fever and common respiratory disorders are asthma, bronchitis. Carrot grass (Parthenium hysterophorus) that came in India along with imported wheat is major source of pollen allergy besides harming internal body organs.

FEMALE REPRODUCTIVE UNIT (Pistil)

- The pistil or gynoceium of a flower is the female reproductive unit
- A carpel or pistil has a stigma or receptive region for pollen grains, a stalk or style and basal swollen region or ovary. Ovary contains one to several ovules
- Ovule is integumented megasporangium which on fertilization ripens into a seed. It is oval and whitish.
- The ovule is attached to placenta by means of a stalk called funiculus or funicle. The point of attachment of funicle to the ovule is known as hilum. A raphe (ridge) is formed by the fusion of funiculus with the body of ovule.

— The actual megasporangium equivalent is a parenchymatous tissue called nucellus. It may be thin (tenuinucellate, e.g. compositae) or massive (crassinucellate e.g casuarinaceae)

— On the basis of number of integuments, ovules are of following types

(i) Unitegmic – With one integuments, higher dicots e.g. composital, gymnosperms

(ii) Bitegmic – Ovules with two integuments (monocots and primitive dicots like cruciferae and malvaceae)

(iii) Tritegmic – With three integuments (Asphodelus)

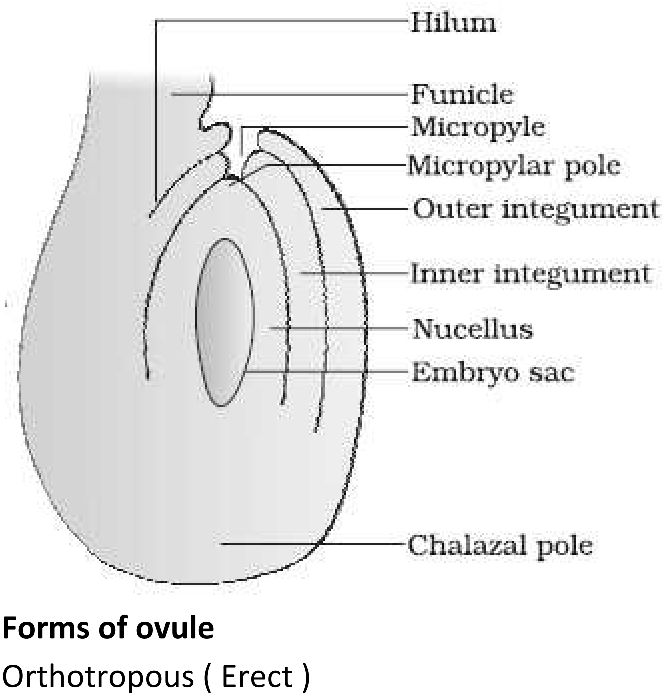
(iv) Ategmic – Without integument (Santalum, Loranthus, Ziriosoma and olax)

— Place of origin of integuments is called chalaza, A pore is present in the integuments at one end. It is known as micropyle. The inner region of integument may provide nourishment to developing embryo sac and it is called endothelium. Outer side of each integument as well as nucellus possesses cuticle.

— In castor bean (Ricinus) proliferation of the integumentary cells at micropylar region is called caruncle. It performs two functions

I. It acts as water absorbing pas and helps in seed germination

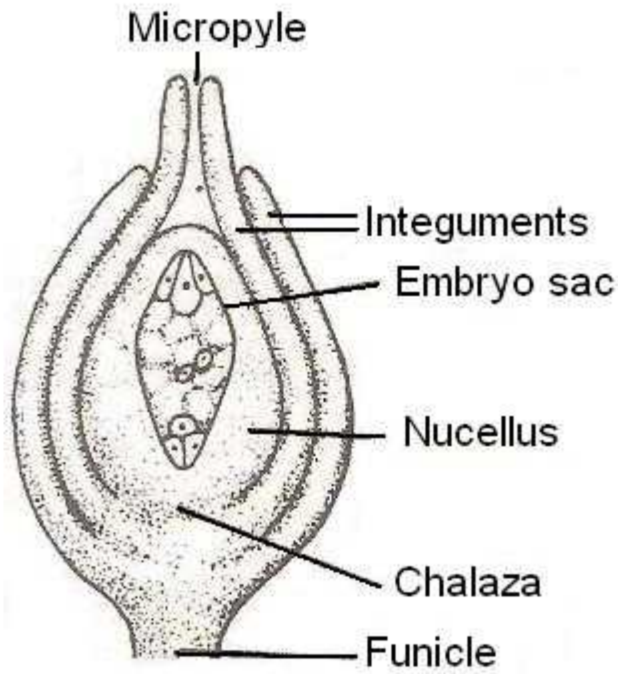
I. It is made up of sugary substance and thus seed dispersal occurs by ants.



Forms of ovule

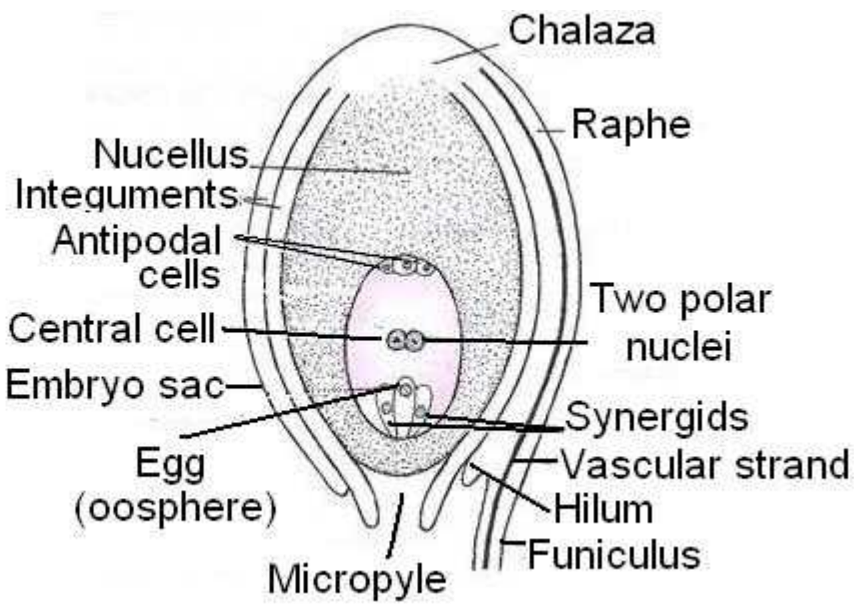
1. Orthotropous (Erect)

The body of the ovule lies straight and upright over the funicle. Hilum, chalaza and micropyle occurs on the same line. E.g. Polygonum

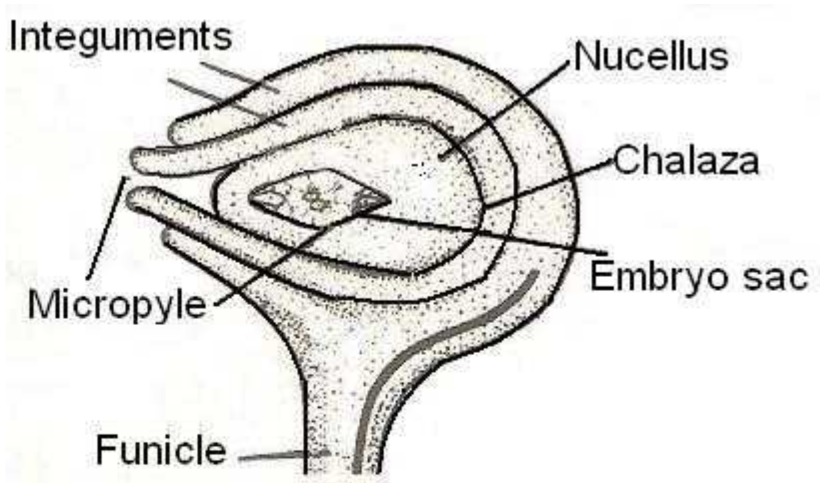


Orthotropous ovule

2. Anatropous (Inverted)
The body of ovule is inverted and gets fused with funicle forms ridge called raphe. Hilum and micropyle are nearby with chalaza on opposite sides. It is the most common type of ovule. E.g. Ranunculus

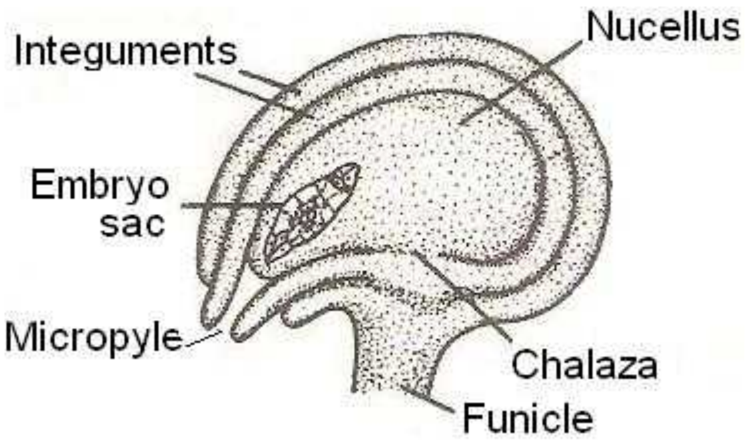


3. Hemianatroppous
   The body of ovule is placed at right angle (90^o) to the funicle e.g. Malpighiaceae.



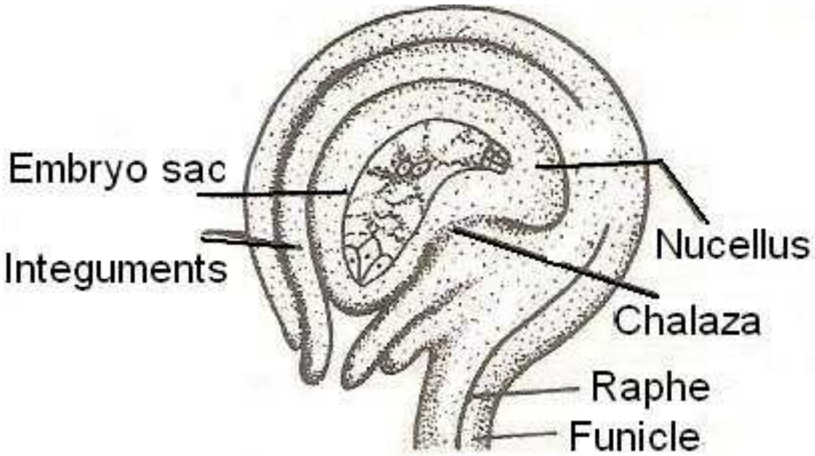
Hemianatropous ovule

4. Campylotropous
   The body is curved but embryo sac is straight. Hilum, chalaza and micropyle come nearby e.g. Caspells, Capparis, Chenopodiaceac



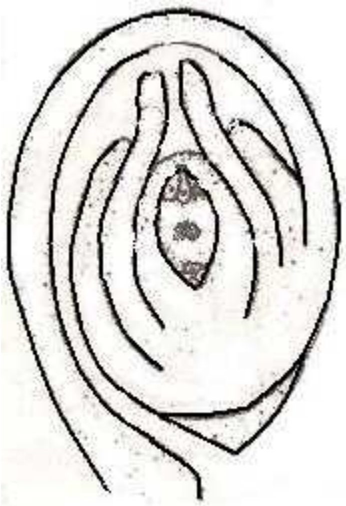
Campylotropous ovule

5. Amphitropous
   Both body of ovule and embryo sac are curved e.g. crucifers



Amphitropous ovule

6. Circinotropous
   The ovule turns at morethan 360^{O} angle so funicle becomes coiled around the ovule. Example opuntia.


Circinotropous Ovule

Megasporogenesis

— The process of formation of megaspores from megaspore mother cell is called megasporogenesis. Ovules generally differentiate a single megaspore mother cell (MMC) in micropylar region of the nucleus. It is a large cell containing dense cytoplasm and prominent nucleus. The MMC undergoes meiotic division. Meiosis results in the production of four megaspores

— In a majority of flowering plants, one of the megaspores is functional while the other three degerate Only the functional megaspore develops into the female gametophyte. This method of embryo sac formation from single megaspore is termed monosporic development

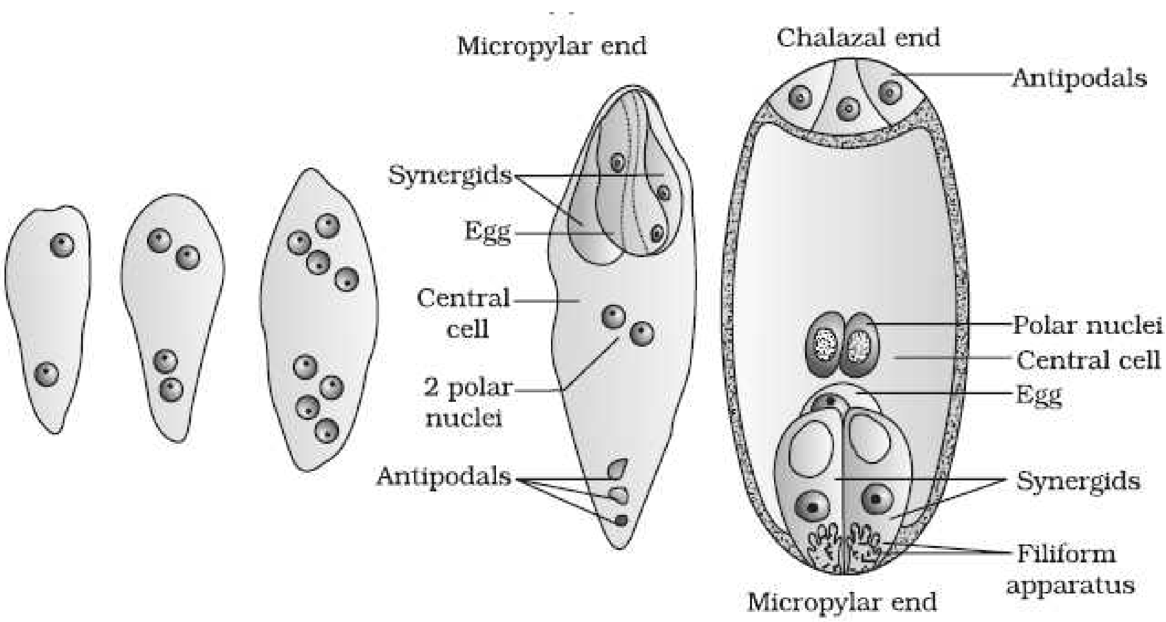
Formation of embryo sac

— The nucleus of the functional megaspore divides mitotically to form two nuclei which move to the opposite poles, forming the two nucleate embryo sac. Two more sequential mitotic nuclear division results in formation of four nucleate and later eight nucleate stages of embryo sac.

— These mitotic division are strictly free. i.e. nuclear divisions are not followed immediately by cell wall formation. After the eight nucleate stage, cell walls are laid down leading to the organization of the typical female gametophyte or embryo sac.

— Six of eight nuclei are surrounded by cell walls and organized into cells, the remaining two nuclei, called polar nuclei are situated below the egg apparatus in the large central cell

— Three cells are grouped together at the micropylar end and constitute the egg apparatus. The egg apparatus consists of two synergids and one egg cell. The synergids have special cellular thickenings at the micropylar tip called filiform apparatus, which play an important role in guiding the pollen tubes into the synergid. Three cells are at chalazal end and are called the antipodals. Thus a typical angiosperm embryo sac, at maturity, though eight nucleate is seven celled.



Pollination

— Pollination refers to the process of transfer of pollen grains from anther and their deposition on stigmatic surface of the flower

— Pollination is of two types self pollination and cross pollination

Self pollination

Self pollination is the transfer of pollen grains from anthers to the stigma of same or genetically similar flower

Self pollination is of two types : autogamy and geitonogamy

1. Autogamy

   It is a self pollination which occurs between anther and stigma of the same flower.

   a) Chasmogamous devices

      When the flower expose their mature anther and stigma to the pollinating agents.

      In Lilac the stigma lies exactly below the anthers

   b) Cleistogamy

      The flowers remain close so there is no alternative self pollination.

      Examples: Pisum, Lathyrus, commelina, benghalensis

   c) Bud pollination

      Anthers and stigma of bisexual flowers mature before opening of bud and thus self pollination takes place at the time of bud stage e.g. pea, wheat etc.

2. Geitonogamy
   It is transfer of pollen grain from anther of one flower to stigma of another flower of same plant or genetically similar plants

   Advantages of self pollination
- It maintains purity of the race
- The plant does not need to produce large number of pollen grains
- It ensures seed production
- Self pollination eliminates bad recessive characters.

   Disadvantages of self pollination
- Variable and hence adaptability to changed environment reduced.
- Vitality decreases and ultimatey leads to degeneration.

Cross pollination

- It is defined as the deposition of pollen grains from anther of a flower to the stigma of a different flower of another plant of same or different species. It is also known as allogamy
- In Xenogamy, pollination takes between two flowers of different plants (genetically & ecologically)

Devices for cross pollination

1. Dicliny: There are two types of flowers, male and female. The plants may be monoecious or dioecious
2. Dichogamy: Anther and stigmas mature at different times
   (i) Protandry: Anthers mature earlier. E.g, Salvia, clerodendron, sunflower, rose
   (ii) Protogny : Stigmas mature earlier. E.g. plantago, magnolia, mirabilis
3. Self sterility : Pollen grains are incapable of growing over the stigma of the same flower e.g. Tobacco, some crucifers. Quicker growth of pollen on another plant than pollen of same plant is called prepotency (e.g. apple)
4. Heterostyly: Flower have two or three heights of styles and stamens. Primula and Jasminum have two types of flower (dimorphic heterostyly) , pin-eye (long style and short stamen) and thrum-eye (short style and long stamens) Some plants have trimorphic (3) hetrostyly e.g. Lythrum, oxalis.

5. Herkogamy : It is the presence of natural or physical barrier between androecium and gynoecium which help in avoiding self pollination. In calotropis stignui, gynoecium is fused with pollinium and form gynostegium

Advantages of cross pollination

— Cross pollination introduces genetic recombinations and hence variation in offspring.
— Cross pollination increases the adptability of the offspring towards changes in environment.
— The defective character of race is eliminated and replaced by better character.

Disadvantages of cross pollination

— Plants have to produce a large number of pollen grains
— The very good character are likely to be spoiled
— As external agency is involved chance factor is always there

Agents of pollination

Anemophily (wind pollination) characteristics

(i) Pollens are very light. They may have air sac or wings
(ii) Flowers are small and are colourless, odouless
(iii) Pollen grains are dry
(iv) Anthers have long filament and are abundant
(v) Stigmas are sticky and feathery.
Examples : Date palm, coconut, grass, willow, maize, jowar, cannabis, mulberry.

Hay fever is allergic reaction due to presence of pollen in air

Hydrophily (water pollination) characteristics

(i) Flowers are small and colourless, odourless, nectarless
(ii) Stigma is long, sticky and unwettable

Water pollination is of two types

(a) Epihydrophily (on surface of water e.g. Vallisneria)
(b) Hypohydrophily (inside water) e.g. zostera, ceratophyllum. Pollen grains are without exine and often elongated. Vallisneria is dioecious. Male plants

produces a large number of male flowers, which after breaking, rise upwards in closed state and open on surface of water. The female plant produces flowers that brings it on surface of water with the help of long pedicels. After pollination, the female flower is brought down into water

Entomophily (Insect pollination) characteristics

(i) Flowers are coloured. Bluish-purplish – violet – yellow flowers attracts bees while reddish flowers attract butterflies and wasps.
(ii) Flowers commonly posses an aroma or scent
(iii) Visiting insects are fed by either nectar and pollen
(iv) Pollen grains are sticky due to pollenkitt
(v) Stigmas are sticky

Ornithophily (Bird pollination)

- Pollination by birds is common is coral tree, bottle brush and silk cotton tree
- Two types of long –beasked small birds take place pollination – sun birds and hummingbird
- Other birds are Bulbul, parrot, crow etc
- Ornithophilous flower are large and strong with abundant nectar and edible part. Example Bombax, agave, Butea, Bignonia

Chiropterophily (Pollination by bats)

- The flowers they pollinate are large dull coloured and produce strong aroma
- Chiropterophilous flower produce abundant pollen grains and secrete more nectar than the orinthophilous flower.
- Bats carry out the pollination in Adansonia and kigelia

Malacophily (pollination by snails)

Snails perform pollination Arisaema (snake orcobra plants)and some arum lilies

Myrmecophily (pollination by ants)

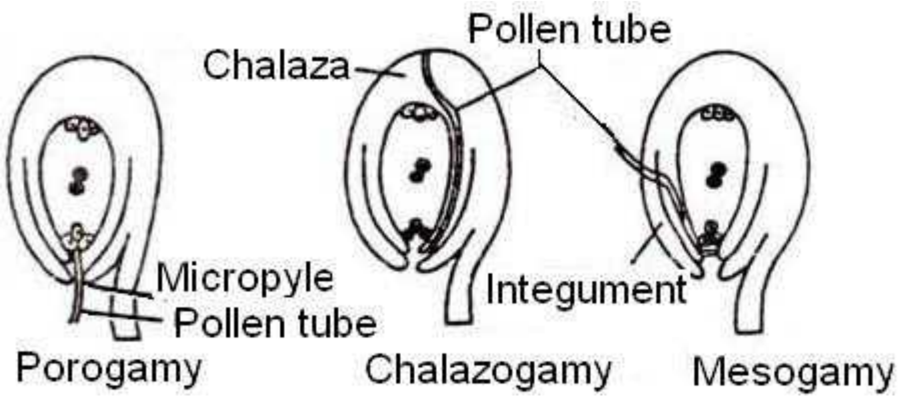
- Plants pollination by ants are called myrmecophytes examples some members of family rubiaceae.

Significance of pollination

- Pollination leads to fertilization and production of seeds and fruits, which ensure continuity of plant life
- It stimulates growth of ovary.
- It results in production of hybrid seeds
- The seeds and fruits are also a source of nutrition

Post pollination events

- The nucleus of the pollen grain divides to produce vegetative and generative cells. A short outgrowth called germ tube, emerges from the pollen and secrete enzymes which digests the tissues of stigma and continues to grow as pollen tube
- The generative nucleus divides to form two male nuclei, which become surrounded by cytoplasmic masses and appear as distinct male gametes
- The pollen tube grows through the stigma and passes into the tissues of style.
- Depending upon the region of entry into ovule. These are:-
  - i) Porogamy : The entry of pollen tube into the ovule through micropyle e.g. ottelia
  - ii) Chalazogamy: The entry of pollen tube into the ovule through chalaza e.g. Casuarina
  - iii) Mesogamy: The entry of pollen tube through funicle or integuments e.g. cucurbita.
- Generally pollen tube enters the ovule through micropyle and enters synergids through filiform apparatus. Filiform apparatus guides the entry of pollen tube.



Pollen – pistil interaction

- Only the compatible pollen of the same species are able to germinate. Germination is connected with compatibility incompatibility reaction between proteins present over the pollen grains and stigma.
- Plant breeders are able to obtain hybrid between different species.
- If the female parent bears bisexual flowers, removal of anthers from the flower bud before the anther dehisces using a pair of forceps. This step is referred to an emasculation.
- Emasculated flowers have to be covered with a bag of suitable size, generally made up of butter paper, to prevent contamination of its stigma with unwanted pollen. This process is called bagging.

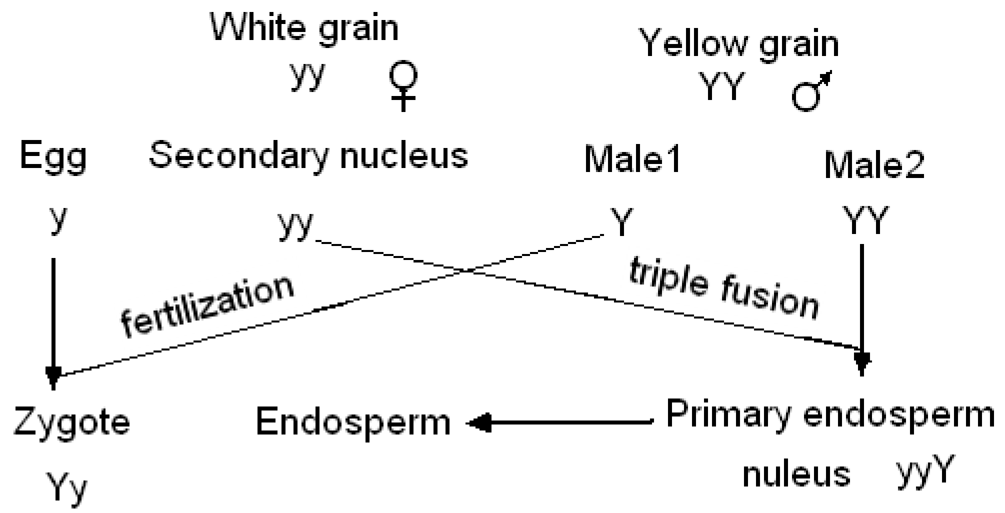
DOUBLE FERTILIZATION

- Fertilization is defined as the fusion of male and female gametes to form the zygote which eventually develops into an embryo.
- Two male gametes are discharged into embryo sac through pollen tube. One of the male gametes fuse with the egg, resulting in the production of diploid zygote. This is called syngamy or also called generative fertilization
- The second male gametes fuses with two polar nuclei, producing a triploid primary endosperm nucleus. This is called triple fusion and is also known as vegetative fertilization.
- In an embryo sac there occur two sexual fusion – one in syngamy and other in triple fusion. This phenomenon is called double fertilization.

POST FERTILIZATION : STRUCTRE AND EVENTS

Endosperms

- Endosperm is a nutritive tissue formed from vegetative fertilization. Endosperm is meant for nourishing the embryo. It is generally triploid
- Since endosperm develops fully in the fertilized ovule, it may show the effect of genes present in the male gamete. The phenomenon is called xenia.
- The direct or indirect effect of pollen on structure inside embryo sac except embryo has been termed by Focke 1881 and limited to endosperm part. It is seen in Zea mays (maize) alone.



— The metaxenia may be defined as the effect of pollen on the seed coat or pericarp lying outside the embryo sac

— Depending upon its mode of development endosperm is of three types

1. Nuclear endosperm

— Primary endosperm nucleus divides to form a large number of free nuclei

— A central vacuole appears and massive peripheral multinucleate cytoplasm is formed. Wall formation occurs and central vacuole disappears. Example maize, wheat, rice.

— In coconut there is an outer multicellular solid endosperm and inner free nuclear liquid endosperm in the centre.

2. Cellular endosperm

— Wall formation occurs after every division of primary endosperm nucleus, so that endosperm is cellular from the beginning e.g. Datura, balsam, Petunia

3. Helobial endosperm

   First division produces two cells within each of which free nuclear division occur but ultimately they may also become cellular. E.g. Eremurus, Asphodelus.

Functions of endosperms are

(i) In plants with albuminous seeds the endosperm reserves support early seedling growth.

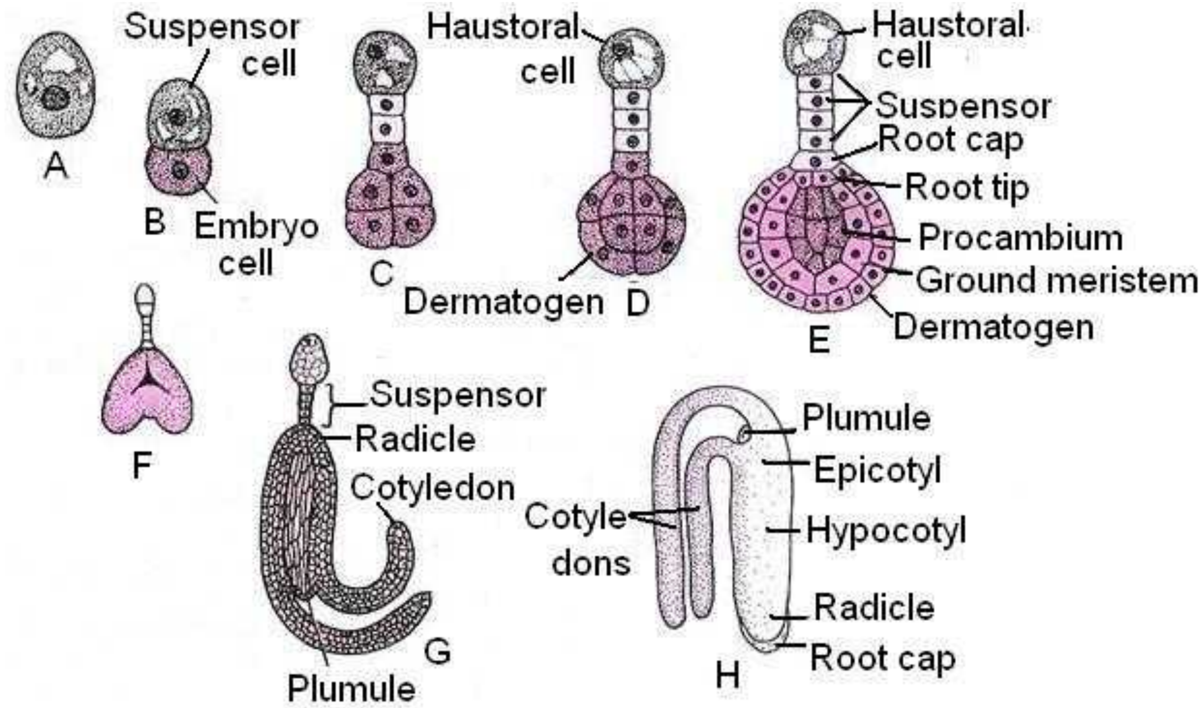
(ii) Endosperm provides nutrition to developing embryo

(iii) Liquid endosperm of coconut contains auxins, cytokinins and GA and induces cytokinesis. When added to basic nutrient medium. Coconut milk also induces the differentiation of embryo and plantlets from various plant tissues

(iv) Zeatin, a very potent cytokinin is extracted from the young endosperm of maize.

Embyrogeny (embryo formation)

— It is the development of mature embryo from zygote or oospore
— Early development produces a pro embryo which has an axial symmetry. Embryo passes through globular stage.
— Development of embryo is endoscopic or on inner side because of presence of suspensor.
— Dicot embryogeny (crucifer / onagrad type)
— Zygote divides into two unequal cells, larger suspensor cell towards micropyle and a smaller embryo cell towards antipodal region.
— The suspensor undergoes transverse division forming 6-10 celled suspensor. The first cell of suspensor is called haustorium and last cell (towards embryo cell) is called hypophysis. It forms radical.
— Embryo cell divides twice. Vertically and once transversely to produce a two tired eight called embryo. The epibasal (terminal) tier forms two cotyledons and a plumule while the hybobasal (near the suspensor) tier produces only hypocotyls. It is initially globular than becomes heart shaped and further assumes typical shape.
— A typical dicotyledonous embryo consists of an embryonal axis and two cotyledons. The part of embryonal axis above the level of cotyledons is called epicotyle. It terminates with the stem tip, called plumule (future shoot)
— The part below the level of cotyledons is called hypocotyls which terminates in the root tip called radical (future root) The root tip is covered with root cap.

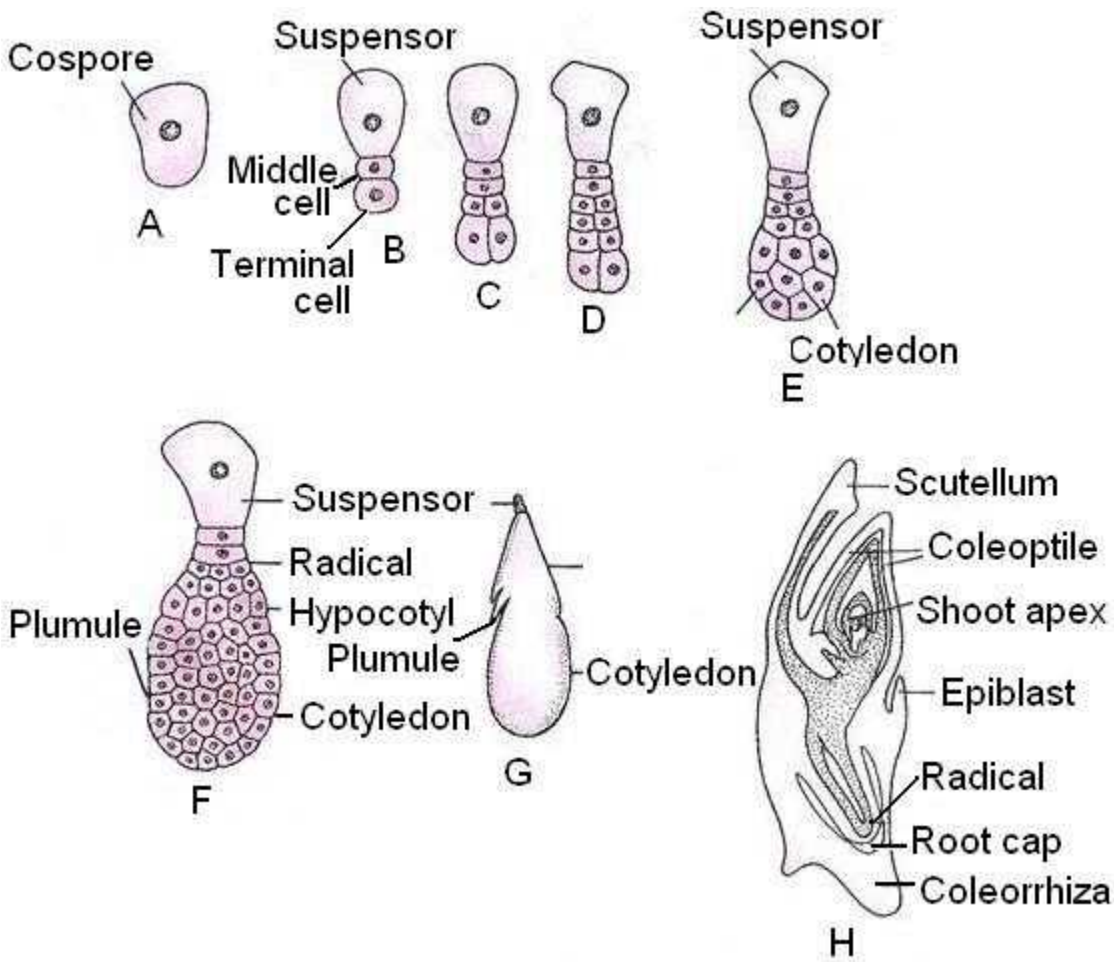


In caspella bursa pastoris, the elongating cotyledons curve due to curving of the ovule itself. In orchids, orboanche and utricularis, the embryo does not show differentiation of plumule, cotyledon and radical.

— Monocot embryogeny (sagittaria type)

— The zygote divides transversely producing a vesicular suspensor cell towards micropylar end and embryo cell towards the chalazal end. The embryo cell divides transversely again into a terminal and middle cell. The terminal cell divides vertically and transversely into globular embryo. It forms a massive cotyledon and a plumule. Growth of cotyledon pushes the plumule to one side. Remains of second cotyledons occurs in some grasses. It is called epiblast. The single cotyledon of monocots is called scutellum. It is shield shaped and appears terminal.

— The middle cell gives rise to hypocotyls and radical. It may add a few dells to the suspensor. Both radical and plumule develop covering sheats called coleorhizae and coleoptiles respectively. They appear to be extensions of scutellum.



Transformation of parts of flower

	BEFORE FERTILIZATION	AFTER FERTILIZATION
1	Calyx, corolla, androccium, style, stigma	Wither off
2	Ovary	Fruit
3	Ovary wall	Pericarp
4	Ovule	Seed
5	Integuments	Seed coats
	Outer integuments	Testa
	Inner integuments	Tegmen
6	Micropyle	Micropyle
7	Funicle	Stalk of seed
8	Nucellus	Perisperm
9	Egg cell	Zygote
10	Synergids	Disintegrate and disapper

Formation of seed and fruit

Fruit

Ripened ovary or fertilized ovary is called fruit. Wall of the ovary forms fleshy or dry fruit wall called pericarp. Fleshy fruit or pericarp is having three layers – epicarp, mesocarp and endocarp

Pericarp

— It is the covering of fruit that develops from ovary wall
— It is a part of fruit and is dry or fleshy
— It is protective covering and nutrition

Seed

— Ripened ovules are known as seeds
— Integuments of ovule forms seed coat. Outer integuments form testa and tegmen develops from inner integuments
— In some case like litchi, ingadulce (Pithecolobium, Asphodelus, Trianthema) a sort of third integuments or aril is present, which covers an additional covering of seed
— Some seeds like castor (ricinus communis) have a spongy outgrowth near the micropyle, which is known as caruncle and it absorbs water during seed germination.
— Funiculus (stalks of ovule) forms stalk of seed. Ultimately, stalk withers and leaves a minute scar called hilum.
— Smallest are found in orchids which are lightest in plant kingdom and are called dust seeds. Fresh weight of each orchid seed is 20.33μg
— Largest seeds are double coconut (Zodoicea maldivica) which are bilobed and each seed is having a weight of 6kg
— Depending upon the persistence of endosperm the seeds are classified as
  i) Non-endospermic or ex-albuminous: Food stored in endosperm is completely exhausted by developing embryo. Example : Seed of gram, pea, bean, orchid.
  ii) Endospermic or albuminous: Endosperm grows vigorously and is not exhausted by the developing embryo cotyledons are thin here Examples: Seed of wheat, barley, castor, poppy etc

Importance of seeds

- Evolutionary achievement: Seed is an evolutionary achievement. It provides protection to embryo
- Seeds colonise in new areas and spread its species because of dispersal
- Seeds has sufficient food reserve that nourishes the germinating embryo
- Being products of sexual reproduction, seeds have number of variation and variation helps in adaptation to varied environment.
- Germination and sowing of seeds by human gave rise to agriculture and it helped in development of civilization, science and technology.

Seed viability

- It is the period of time for which the seeds retain the ability to germinate. Seed viability is determined genetically as well as environmentally.
- Environmental conditions which can alter viability are humidity and temperature.
- Genetically seed viability ranges from a few days (e.g. oxalis) one season (e.g. Birch), 2-5 years (most crop plants) to 100 years (e.g. Trifolium). Seed viability has been found out to be more than 1000 years in Lotus. 2000 years old seeds of Phoenix dactylifera excavated from king Herod's palace near Dead sea have been found viable. Similarly 10,000 year old seeds of Lupins arcticus (Lupine) excavated from Arctic Tundra not only germinated but also produced plants that flowered
- Viability of the seed is tested by its (a) respiration (b) germination
- Respiring seed turns colourless triphenyl tetrazolium chloride into pink tripheyl formazan

i) Apomixis

[Gk . apo – without ,mixis – moarriage; Winklwr 1908]

- It is the formation of new individuals by asexual methods which mimic sexual reproduction including seed formation but do not involve fusion of gametes or sex cells.
- Normal type of sexual reproduction having two regular features, i.e. meiosis and fertilization, is called amphimixis.

- The organism reproducing through apomixes is called apomicts. Apomixis is controlled by gene and individual; are genetically similar to the parent producing i.e. are clone and members of a clone are called ramets.

  It occurs by following methods:

  a) It is mode of apomixis in which seeds are formed but are asexual in nature as the embryo develops directly without gametic fusion.
  b) The term sporophytic budding is used if embryo develops adventitiously from diploid cells of nucellus or integument, e.g. mango, orange, opuntia, onion.

ii) Parthogenogenesis

[Gk. Parthenos – virgin; genesis – descent, Owen 1848]

- It is the development of a new individual from a single gamete without fusion with another gamete.
- Depending upon the ploidy of the gametes, there are two types of gametes, there are two types of parthenogenesis – haploid and diploid
- In haploid parthenogenesis, the embryo sac and its egg are haploid
- In diploid parthenogenesis, the embryo sac as its contained egg is diploid. It undergoes parthenogenesis and forms diploid embryo. Diploid parthenogenesis is generally accompanied by failure of meiosis during megasporogenesis as well as direct formation of embryo sac from a nucellar cell, e.g. Poa, apple, rubus

iii) Apogamy (Gk. Apo – without, gamos – arriage)

- It is formation of sporophyte or embryo directly from cells of gametophyte.
- In higher plants, only diploid apogamy is successful, that is, the gametophytic cell forming the sporophyte is diploid. In lower plants, haploid apogamy is equally successful.

Polyembryony

- The phenomenon of having more than one embryo is called polyembryony.
- Occurrence of polyembryony due to fertilization of more than one egg cell is called simple polyembryony.
- Formation of additional embryos from different parts of ovule like synergids, antipodal, nucellus, integuments etc.

Example – Citrus, groundnut, onion, opuntia, mangifera

- Polyembryony was first discovered by Leeuwenhoek (1719) and was confirmed by Schnarf (1929). Polyembryony is more common in gymnosperm than in angiosperm
- There are two types of polyembryony false and true embryony
- In false embryony, more than one embryos arise in different embryo sac in the ovule; whereas in true, more than one embryos are formed in the same embryo sac
- The cause of polyembryony may be:
  - Cleavage of proembryo e.g. family orchidaceae.
  - Development of many embryos from other cells of embryo sac except egg. E.g. Argemone
  - Formation of many embryos due to presence of more than one embryo sac in same ovule e.g. citrus
  - Formation of many embryos from the structure outside the embryo sac e.g. mango, opuntia
- Polyembryony is practically important because genetically uniform parental type seedlings are obtained from nucellar embryos
- Nucellar embryos are superior to those obtained by vegetative propagation because nucellar embryo seedlings are disease free and maintain their superiority for long time.

Parthenocarpy : (Gk. Parthenos – virgin, karpos – fruit; Noll 1902)

- It is formation of fruit without fertilization. Parthenocarpic fruits are seedless e.g. apple, pear, banana, pineapple etc
- Technically, fruit having seeds (pseudoseeds) with an asexual embryo are also parthenocarpic fruit
- Parthenocarpy is of three types: genetic, environmental and chemically induced

— Genetic parthenocarpy:
Parthenocarpy is due to genetic alteration caused by mutation or hybridization. It is also called natural parthenocarpy. E.g. banana, apple, pineapple, varieties of grapes, pear

— Environmental parthenocarpy:
Low temperature, frost and fog have been known to induce parthenocarpy in a number of plants examples: pear, olive, capsicum, tomato

— Chemically induced parthenocarpy :
Spray or paste of auxins and gibberellins in low concentration of 10^{-6} – 10^{-7} M has been found to induce parthenocarpy in several plants.
Example: tomato, citrus, strawberry, blackberry, fig etc.

Importance of parthenocarpic fruits

- They do not contain seeds which have to be removed before eating fruits.
- Fruits can be developed inside the green houses where pollinators are not available.
- Quicker food processing.

Disease is a condition of disturbed or deranged functioning of the body caused by infection, defective diet, heredity, environment or deprived condition of brain. Health is a state of complete physical, mental and social well being.

TYPES OF DISEASE

1. Congential disease
   Diseases contracted before birth due to defective heredity (chromosomal abnormalities and gene mutations), physiological disturbance or transplacemental transmission, e.g. haemophilia colour blindness, sickle cell anaemia, Down's syndrome, klinefelter's syndrome.
2. Acquired disease
   Diseases contracted after birth due to infection, defective diet, hypersensitivity, injury, addiction, degeneration, cancer, depression etc. Acquired diseases are broadly differentiated into two types, communicable or infectious and non-communicable or non-infectious. Communicable diseases are of several type like deficiency disease, degenerative or organic disease, allergies, mechanical psychological, cancer, metabolic disorders, physical disorder.
3. Infectious disease (communicable disease)
   They are diseases due to pathogens that can be transferred from one individual to another e.g. Viral, bacterial, protozoans, fungal, helmintic other organisms, sexually transmitted etc.
4. Deficiency disease
   Disease caused by absence or deficiency of an essential element e.g. anemia, goiters, kwashiorkor, beri-beri
5. Degenerative disease
   Diseases caused by ageing resulting in malfunctioning or decreased efficiency e.g. hypertension, atherosclerosis
6. Allergies
7. Mental disorders
8. Occupational disease
9. Addiction
10. Cancer and AIDS

CAUSES OF DISEASE / DISEASE AGENTS

Disease agent is an organism, substances force or disturbance which causes disease due to excessive presence, deficiency or absence

1. Pathogens / Biological agents
   They are biological entities which causes infectious disease. Example virus (mumps, chicken pox, small pox), mycoplasma (acute leukemia, bronchitis), Chlamydia (trachoma) rickettsia (typhus, trench fever), bacteria (cholera, tetanus), spirochaetes (syphilis) ,fungi (ringworm, thrush, moniliasis, pulmonary aspergillosis), protozoa (giardiasis, sleeping sickness), helminths (filariasis, ascariasis, taeniasis), other organisms (scabies)
2. Nutrient agents
   Deficiency of vitamins (beri-beri, scurvy, night blindness), minerals (anemia, rickets), carbohydrates, fats and protein (maramus, kwashiorkor) or excess of food (obesity)
3. Chemical agents
   (i) Endogenous: Excess presence of urea and uric acid, reduced secretion of ADH (diabetes insipidus) or insulin (diabetes mellitus)
   (ii) Exogenous : Pollutants(pneumoconiosis) allergens (allergy)
4. Physical agents
   Heat (e.g. stroke), cold (frost bite), radiations, sound (impaired hearing , electricity, pressure, humidity etc.
5. Mechanical Agents
   Fractures, sprains, dislocations, injury, chronic friction
6. Genetic agents
   Excess or deficiency of chromosomes, mutations harmful alleles e.g. colour blindness, albinism. Haemophilia, Turner's syndrome
7. Degeneration
   They include old age change like peptic ulcers, hypertension, atherosclerosis
8. Social and personal inconsistencies: They lead to mental disorder.

INFECTION

Infection is invasion, establishment and growth of pathogens in a host contamination is occurrence of harmful organism or their products in articles of use. E.g. milk, food, water, garments. Infestation is occurrence of animal parasites or ectoparasites like lice on or inside the body of an individual.

KOCH'S POSTULATES

Robert Koch studied diseases and pathogens of anthrax (Bacillus anthracis) in 1876, tuberculosis (mycobacterium tuberculosis) in 18982 and cholera (vibrio choleras) in 1883. He gave forth germ theory of disease and proposed four criteria for establishing an agent of infectious disease. They are called Koch's postulates

1. Pathogenic organism occurs in abundance in patients suffering from diseases.
2. Pathogen can be separated and cultured.
3. Healthy persons injected and cultured pathogen contracts disease.
4. Pathogenic organism is recoverable from the newly diseased individual.
   However, viruses cannot be grown in pure artificial cultures.

RESERVOIR OF INFECTION

It is the place or organism where a pathogen resides without causing any infection e.g. air, soil, water, animals (reservoir hosts) and some human beings called carrier. Carrier is an animal or healthy human host which harbor the pathogen without being harmed and passes the same to another susceptible individual. Many cook passed typhoid to several thousand individuals. She has been appropriately called typhoid Mary.

TRANSMITION OF INFECTIOUS DISEASE

1. Direct Transmission
   An intermediate agent is absent
   i) Direct contact with infected persons. The diseases are called contagious e.g. ringworm, syphilis
   ii) Droplet Infection: Transmission is from an infected person to healthy person in mist emitted from nose, lungs and mouth while sneezing, splitting, talking and coughing. E.g. influenza, common cold and diphtheria.
   iii) Contact with soil: Soil born pathogens enter the host through injured or exposed part. E.g tetanus
   iv) Animal bite: Rabies is spread through bite of dog / cat
   v) Transplacemental Transmission: Mother transfer virus of German measles and bacterium of syphilis through placenta.
2. Indirect Transmission:
   An intermediate agent is required
   i) Vectors : Vectors are living agent for transferring pathogens e.g. housefly, mosquito, tse-tse fly, sandfly. Mosquitoes are vectors of

malaria, encephalities, filarial, yellow fever, dengue etc. Housefly is vector of cholera, dysentery, typhoid, diarrhea, conjunctivitis.

ii) Vehicle born: An article of food, water ice carries the pathogen for transmission e.g. cholera, typhoid, dysentery.

iii) Air borne: Dust and air current spreads disease.

iv) Tomite borne: Articles handled or coming in contact with patients are cause of disease transmission, e.g. door handles, taps, crockery, currency, garments.

v) Unclean hands: They transfer germs to healthy person, food, utensils etc.

RESISTANCE TO INFECTION

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. Degree of virulence depends upon invasiveness and toxigencity. Infective dose is the maximum number of pathogenic organism that can result in the production of disease. Infection depends upon the presence of infective dose, virulence of pathogen, natural resistance and immunity. Host has three line of defense against invasion by pathogens. They are nonspecific and specific defense mechanism

VIRAL DISEASES

VIRAL HEPATITIS

- Viral hepatitis is commonly called jaundice viral hepatitis is common in Eastern Europe, Africa and Asia. In early stage the liver is enlarged and congested. In later stage the liver becomes small, yellowish or green
- The symptoms in early phase includes-fever, anorexia, nausea, vomiting, epigasric discomfort pains in muscles and joints
- The urine is dark and stool is pale. Leukopenia is followed by lymphocytosis. Splenic enlargement is sometimes present. Jaundice increases for 1-2 weeks
- There are six varieties of hepatitis. These are Hepatitis A, known as infectious hepatitis is a benign. Usually it is not fatal but in rare case its fatal rate is 0.1%. It is spread by ingestion of contaminated water and food
- Hepatitis B, called as serum hepatitis is versatile one. Blood and body secretions such as saliva, sweat, semen, tears, breast milk are vehicle of transmission

- Hepatitis C has been known to cause 90 to 95% of cases of transfusion associated hepatitis.
- Hepatitis D, called delta hepatitis. HDV is defective virus for which NBV is the helper. Thus, hepatitis D develops when there is concomitant hepatitis B infection
- Hepatitis E, is an enterically transmitted and is water born infection. A characteristic feature of hepatitis E infection is the high mortality rate among pregnant women
- Hepatitis G is caused by hepatitis GB virus

Preventive measures

The control measures for infectious hepatitis are

- ✓ Sanitary disposal of excreta
- ✓ Prevention of contamination of water, food and milk
- ✓ Control of flies
- ✓ Screening of kitchens and latrines
- ✓ Personal cleanliness and also that of food handlers
- During epidemic,, boiled or chlorinated water should be taken
- To control semen hepatitis, person having hepatitis should not be accepted as blood donors pregnant women having serum hepatitis can transmit the disease to infants.

DENGUE FEVER

- Dengue fever is caused by an RNA containing arbo virus of feavi virus group which also causes yellow fever. Thus, the virus which causes dengue fever is a mosquito born flavi-ribo virus
- The virus of dengue fever is transmitted by the bite of tiger mosquito, Ades aegypti during day time. Aedes aegypti is primarily a day time feeder and mainly bites in the morning or late in the afternoon in covered areas. The Aedes aegypti female prefers to lay its eggs in artificial, rather than natural containers, that have fairly clean water and are located around human habitation
- Incubation period is 3-8 days

Classical dengue fever

- It is an acute viral infection caused by at least 4 stereotypes of dengue virus. The reservoir of infection is both man and mosquito. The transmission cycle is man-mosquito-man. Aedes agypti is the main vector. The illness is characterized by an incubation period of 3 to 10 days

Symptoms

(i) Abrupt onset of high fever
(ii) Several frontal headache
(iii) Pain behind the eyes which worsens with eye movement
(iv) Muscle and joint pains
(v) Loss of sense of taste and appetite
(vi) Measeles like rash over chest and upper limbs
(vii) Nausea and vomiting

Dengue haemorrhagic fever

- Dengue haemorrhagic fever (DHF) is a severe form of dengue fever, caused by infection with more than one dengue virus. The severe illness is thought to be due to double infection with dengue viruses – the first infection probably sensitizes the patient, which the second appear to produce an immunological catastrophe

Symptoms

(i) Bleeding from the nose, mouth, gums and skin bruising
(ii) Sever and continuous stomach pains
(iii) Frequent vomiting with or without blood
(iv) Pale cold or clammy skin
(v) Excessive thirst (dry mouth)
(vi) Rapid weak pulse
(vii) Difficulty in breathing
(viii) Restlessness and constant crying

Prevention

- No vaccine for dengue fever is available. Eliminate mosquito breeding places by covering small water containers, water tanks, changing the water of cooler every week and where Aedes mosquito breed. Wear cloths which cover arms and legs. Use mosquito repellents, repellent cream and sleep in mosquito – net

YELLOW FEVER

- Yellow fever is a zoonotic disease caused by an arbovirus. It is a haemorrhagic disease transmitted by an infected Aedes aegypti. It affects principally monkeys and other vertebrates in tropical America and Africa.
- Yellow fever is characterized by headache, fever, vomiting, rupture of veins in kidney, spleen, liver, etc. In severe cases, the skin of the sufferer becomes yellow from jaundice, hence the name yellow fever
- Max Theilder in 1951 got Nobel Prize for the development of vaccine for yellow fever

CHIKUNGUNYA

- It is a temporarily debilitating disease caused by Alpha virus and spread through mosquitoes, Aedes aqypti and Aedes albopictus
  Symptoms
- The patient has maculopapular (strain and eruptions) rash of limbs and trunk and arthritis of multiple joints
- There is fever which lasts for about two days which is accompanied by conjunctivitis and photophobia. Even after disappearance of fever, headache, insomnia and arthritis continue for 5-7 days

Treatment

- Chloroquine phosphate has been found to reduce the impact of the disease.

Prophylaxis

Protection against Aedes mosquitoes by use of long sleeves, full pants, socks, windows and doors with wire gauze screens and mosquito repellents are preventive measures. There should be no stagnant water nearby

COMMON COLD

- Common cold is caused by 100 types of Rhino virus and small bacterium Dialister pneumosintes

Symptoms

- Virus infects nose and upper respiratory passage causing inflammation of mucous membranes
- There is irritation of nasal tract, nasal congestion, flow of mucus, sneezing, sore throat, hoarseness, cough, tiredness, head ache and slight fever
  Treatment : It cures automatically after 3-7 days

MUMPS

- Mumps is caused by Parmyxovirus (RNA virus) or myxovirus parotiditis. Virus generally affects the children between the age of 5 and 12 years
- It is highly infectious and spreads through droplet infection or direct contact with the mucus membranes of mouth.
- Incubation period is about 12-26 days

  Symptoms
- Mumps causes inflammation of the parotid glands behind ears. It also affects testes and ovaries in adults leading to sterility.

  Treatment
- One attack gives a lifelong immunity
- There is no specific medicine for mumps
- MMR vaccine is used against measles, mumps and German measles (rubella)

MEASLES (Rubeola disease)

- Measles is highly infectious childhood disease occurring between 3-6 years of age
- It is caused by Rubeola virus which is passed out in the secretions of nose and throat of the infected person as droplets or in articles soiled by these secretions. The incubation period is of 10days

  Symptoms
- Eruptions of small spots in the form of rash all over on face and body along with itching
- Inflammation of respiratory passage from mouth to bronchi, sometimes may effect conjunctiva

  Treatment
- Single attack gives a lifelong immunity
- Edmonston B vaccination is also available to provide active immunity
- Antibiotics and sulpha drugs are effective in measles

CHICKEN POX

- Chicken pox is caused by Varicella zoster virus a DNA virus, which is passed out in the discharges of the respiratory tract of the infected person directly as droplets or through contaminated articles used by the patient.
- Incubation period is of 14-21 days

  Symptoms

- Dew-drop like rash (pox) at stomach and chest, spreading later on face and the whole body characterize it. Also high fever, itching, aches and uneasiness occurs
  Treatment
- Boric acid, calamine and benzyl benzoate reduces itching and tendency to scratch.
- One attack give a lifelong immunity
- No vaccine available so far

SMALL POX

- It is an eruptive viral disease which has been completely eradicated through widespread compulsory vaccination. The last case was reported in Somalia in 1977.
- WHO declared the planet free from small pox in 1980. The disease is caused by brick shaped DNA virus called Variola Virus
- Infection starts from oral, nasal, vesicular discharges, pustules and scabs. Incubation period is 12 days

Symptoms

- The disease begins with headache, backache, chill, high fever, rashes appearing on third day of illness as reddish spots which change in to papules and finally scabs in third week
- The spots appear first on the hair line, then face and over rest of the body but fewer on the trunk. The scab fall down leaving permanent pox mark, complications include blindness
- Death could occur

Treatment

Vaccine for small pox was developed by Edward Jenner and gives active immunity

TRACHOMA

- Trachoma is caused by chlamydia trachomatis.
- It is spread through direct contact with the discharge from infected eyes.
- It causes ulceration of cornea and conjunctiva of the eye.
- In acute case it lead to blindness.

Symptoms

- It is caused by development of granules.
- There is inflammation pain and watering of the eye.

Treatment

Sulpha drug and specific antibiotics help to cure the disease

POLIMYELITIES

- Poliomyelities is caused by enterovirus, polio virus (RNA virus) who is 10μm in diameter
- It enters the body through food and water and multiplies in the ells of the intestinal wall and spreads in nervous system through blood
- Incubation period is 7-14 days

Symptoms

- It produces inflammation of the nervous system
- There is inability of bending the head forward stiffness of neck, paralysis of skeletal muscles, fever, headache, chilliness and pain all over the body

Treatment

- Oral polio drops on 6^{th} , 10^{th} and 14^{th} week of the child.
- Booster shots before the age of 3 and 4 years give immunity
- A person who recovers from polio has a life time immunity
- Vaccine for polio are killed Salk's vaccine and live Sabin's oral vaccine

INFLUENZA (FLU)

- Orthomyxo virus, a spherical RNA virus having a lipid envelope causes influenza
- Influenza is epidemic, endemic and pandemic
- Endemic influenza is caused by Haemophilus, influenza, a gram (-)ve bacteria
- Avian flu is a viral disease caused by H5N1 virus, first reported in China
- Incubation period is 18 hours to 72 hours

Symptoms

It is characterized by discharge from the nose, sneezing, sore through, cough, muscle pain, headache, chill and fever fro 4-5 days.

Treatment

Vaccination is available but a high risk

RABIES (Hydrophobia)

- Rabies is primarily a disease of carnivores like dogs, cats etc. It is caused by Rabies Virus (Rhabo virus or Lyssa Virus)
- It enters human body with saliva of an infected animal generally by bite or scratch of dog or a cat
- The virus destroys the brain and spinal cord

Symptoms

- It is characterized by scare of water in victim and biting behaviors.

Other symptoms are anxiety, irritability, fatigue, loss of appetite, sensitivity to light and sound, saliva from the mouth, headache, fever and inability to swallow fluids due to chocking throat

Treatment

Treatment of rabies was discovered by Louis Pasture. It involves a series of 14 injections given after the bite of dog. It is antirabies serum.

July 6 is marked as world Rabies Day

BACTERIAL DISEASES

TUBERCULOSIS OR T.B.

- T.B. is caused by mycobacterium tuberculosis and infects any part of the body. It could be bones, brain or lunges and lymph nodes. Lung T.B. is most common. The bacterium releases a toxin tuberculin which destroy tissues it infects
- It spreads through sneezing, coughing, contaminated food water or cloths
- Incubation period is 3 to 6 weeks or may be years

Symptoms

- Constant cough and in severe cases sputum wille blood, pain in chest. While coughing, loss of body weight and gradual weakening of the body, low grade fever throughout the day are the symptoms of lungs T.B.

Treatment

- Sputum, tuberculin, X-rays and gastric analysis are carried out to diagnose tuberculosis

- Direct observation treatment (DOT) is a programme under WHO for treatment of T.B. across the world
- Some of the antituberculosis drugs are streptomycin, rifampicin, isoniazid, thiatozone, PAS (Paraamino salicylic acid) etc.
- BCG (Bacillus Clamette Guerin) vaccine for T.B. was obtained from bovine bacillus by Calmette and Guerin in 1921

DIPHTHERIA

- It is an acute infectious disease produced by gram (+) rod-shaped bacterium corynebacterium diphtheria
- Diphtheria has three forms-gravis, intermedius and mitis. Infection occurs mostly in children of 2-5 years
- It is spread through droplets method by kissing, coughing, sneezing and contaminated articles
- Incubation period is 2-5 days
- Portal of entry is upper respiratory tract through implantation may occur anywhere.
- Exotoxin produced by pathogen causes epithelial necrosis of nose (nasal diphtheria), throat tonsils (pharyngeal diphtheria) and laryngotrachea (laryngotracheal diphtheria)

Symptoms

- Fever, sore throat, epithelial necrosis by endotoxin and oozing of semi-solid material in the throat which develops into a grey false but tough membrane
- The membrane chocks the air passage sometimes, bacterium infects the heart leading to fatal heart blockage

Treatment

- Schick test the presence of antitoxin and the sate of hypersensitivity to diphtheria toxin
- Diphtheria antitoxin can neutralize the toxins produced only if given within 24 hours of appearance of symptoms.
- DPT- vaccine: Diptheria, pertussis and tetanus vaccine is given as immunization within six weeks of birth.

WHOOPING COUGH OR PERTUSIS

- Whooping cough is caused by Gram (-) non motile coccus Bordetella pertussis is a common childhood disease affecting the respiratory system
- It spreads by droplet infection or by direct contact.
- It has an incubation period of 1-16 days

Symptoms

- It causes constant cough leaving the child breathless, tired and red in face
- Later the voice becomes hoarse and the cough gives a whoop or loud crowing sound while inhaling
- The child usually vomits and there is frothy discharge from his mouth and nose

Treatment

- Immunization of disease is done by DPT vaccination within six weeks of birth. Three doses at one month interval at the age of 3 to 4 month

CHOLERA

- Cholera is water borne disease
- This is caused by the bacterium vibrio cholerae or comma infecting intestines and digestive tract
- It is spread through contaminated food and drinks
- The causative bacterium secretes cholera toxin enterotoxin which induces excessive secretion of an isotonic electrolyte solution by the intestinal mucosa
- Incubation period varies from a few hours to 2-3 days

Symptoms

- Cholera is mainly characterized by sudden onset of profuse, effortless, rice-water like stools, vomiting and rapid dehydration, loss of minerals and muscular cramps

Treatment

- Fluid and slat lost is restored by Oral Rehydration Solution (ORS). It is water with a small amount of sugar and salt
- Cholera vaccine is effective for six months only

Prophylaxis

- Proper sanitation and hygienic conditions are the best methods of prevention

DIARRHOEAL DISEASES

- Diarrhoeal diseases are a group of diseases caused by different bacteria e.g. E.coli, shigella, campylobacter, salmonella, clostridium.
- This is spread through food poisoning, contaminated food, water or drinks, clothes, utensils and bed sheets.
- Incubation period is variable.

Symptoms

- This is characterized by mild diarrhea. i.e loose stools if infected by E.Coli, frequent stool with blood and mucus and abdominal cramps if infected by shigella, dehydration, diminished appetite, fever, lower B.P., increase in pulse rate, etc

Treatment

- ORS is given repeatedly to check dehydration and loss of minerals.

Prophylaxis

- Proper sanitation and hygiene are needed for prevention

LEPROSY (HANSEN'S DISEASE)

- Mycobaterium leprac causes this dreaded disease.
- Presence of lepronain in skin test, can indicate the appearance of leprosy. It spreads through contact with infected person
- Its incubation period is up to five years
- It is of two types

(i) Tuberculoid leprosy involving tuberculoid granuloses formed by aggregation of macrophages

(ii) Lepromatous leprosy characterized by modular aggregates of lipis laden macrophages, lepra cells.

- Lepromatous leprosy gives positive test with lepromin while lepromatous leprosy is negative lepromin test.

Symptoms

- It is characterized by the chronic infection of skin and other tissues including nerves and wasting of body parts, formation of ulcers, nodules, scales, deformities of fingers, toes making the infected parts senseless or numb and hypopigmentation of skin

Treatment

- Surgery along with drugs diaminodiphenyl sulphone or dapsone, ofloxacin, chaulmoogra oil can cure the disease

TEATNUS (LOCK JAW)

- It is an incurable bacterial disease (Clostridium tetani) characterized by painful muscular contraction of jaw. The incidence its occurrence is quite common in India with high mortality in infants and mothers
- The bacterium occurs in intestine of horse and other animals from where they pass out as spores 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 caused the entry of spores into body
- The bacteria are released inside the body. They multiply and begins to secrete a toxin named tetanospasmin
- Incubation period is 3-28 days.

Symptoms

- Disease is caused by tetanospasmin reaching the CNS. It 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 heart failure suffocation and exhaustion

TYPHOID

- Salmonella typhi, a rod like bacterium causes this contagious disease of intestines.
- The organisms of the disease are present in stools and urine, therefore, carried by contaminated water and food
- Incubation period of the bacterium is 1-3 weeks

Symptoms

- This disease is characterized by the inflammation of ileum and colon, liver and spleen also becomes enlarged, abdominal pain, constant fever, extreme weakness, vomiting, rash of rose coloured spots called rose spot on the upper abdomen and sore throat.

Treatment

- Typhoid is diagnosed by Widal test.
- Typhoid vaccines (TAB vaccine) provide immunity for about three years
- Antibiotic like ampicillin and chlor amphenicol.
- Resistant cases are treated with quinoline derivative e.g. ofloxacin, cipro-flaxacin.
- Surgical removal of gall bladder (cholecystectomy) is carried out on the carriers in order to remove source of infection because the bacterium remain concentrated in gall bladder in carriers.

PNEUMONIA

- Pneumonia is a serious disease of lungs characterized by accumulation of mucus / fluid in alveoli and bronchioles to that extent the breathing becomes difficult
- It is caused by strepto coccus pneumonia or Diplococcus pneumoniae, have an incubation period of 1-3 days.
- It is spread through sputum of the patient.
- It is of two types
  i) Bronchopenumonia in young children and elderly persons
  ii) Lobarpneumonia in 10 -15 year old

Symptoms

- The onset of pneumonia is usually sudden with a single shaking chill, followed by fever pain with breathing on the side of lung involved, increased pulse and respiratory rates and cough. Sputum is bloody or rusty

Treatment

- Drugs against pneumonia are tetracycline, erythromycin and sulphonamide. If untreated pneumonia leads to death

PLAGUE (BLACK DEATH)

- Plague is caused by a rod shaped non-motile bacterium called Pasteurella / Yersinea pestis trismitted by the bite of infected rat flea Xenopsylla cheopis. This disease kills the rats. Rat flea leave the dead rats and attack humans. The death of rats is an indication of outbreak of plague
- It is of three types

i) Bubonic plague (black death) having an incubation period of 2-6 days. Pathogen multiplies in lymph nodes, especially armpit and groin which swell up into painful buboes. Other symptoms are high fever, chill, delirium, exhaustion and haemorrhages which turn black. The patient dies there after. Hence, plague is also called black death

ii) Septicemic plague – In this, buboes do not occur. It is characterised by sepsis, sever headache, rapid pulse, fever, chill, nausea, vomiting and rapid pulse, fever, chill, nausea, vomiting and delirium leading to death within two days

iii) Peneumatic or Pneumonic plague – It infects lungs causing pulmonary edema, fever, anoxia, delirium and death within twenty four hours.

Treatment and prevention

- Streptomycin or oral tetracycline is effective against plaque. Anti-plague vaccine, spray of insecticides, killing of rats, nose caps and high cots are some preventive measure

PROTOZOAN DISEASES

AMOEBIASIS OR AMOEBIC DYSENTERY

- Amoebiasis disease is protozoan infection of upper part of large intestine which is caused by monogenic protozoan known as Entamoeba histolytica
- The infection is by the cysts of Entamoeba present in the stool of infected person, cat, dog, monkey, rat, rabbit etc. through the agency of house flies, manure, air currents, number of other physical contacts and unsafe drinking water.
- Inside the intestine, the cyst germinates and releases 4-8 entamolbae. The parasites secrete an enzyme called cytolysin that partially dissolves the wall of large intestine
- The parasites reach blood capillaries and feed on red blood corpuscles.
- When the infection is sever, the parasites pass into blood stream and enter various body organs. The most commonly affected organs are liver, lungs, spleen and brain. These organs comes to have pus filled absecesses
- The feeding stage of a parasite is called trophozite or magna form (30μ). It stops feeding per-cystive stage is called minuta form (7-20μ).

Symptoms

- Amoebiasis disease is characterized by abdominal pain, mild diarrhea alternating with constipation, passing out of mucus, pieces of necrotic mucous membrane and blood in faeces, and faeces with cysts and charcot –Leydon white crystals.

Treatment

- This can be cured by administering drugs like, emetine, stremetine, carbosome, metronidazole and tinidazole.
  Prophylaxis
  - Disease can be prevented by proper sanitation with proper kitchen, protection of food from flies, proper washing of vegetables, heath education etc.

MALARIA

- Malaria is caused by a digenetic (have two hosts to complete its life cycle) and triphasic (having three phases of life cycle) protozoan parasites known as plasmodium
- There are four species of Plasmodium which causes four main types of malaria in human they are:
  i) Plasmodium vivax – Benign tertian malaria in which fever recurs after every 48 hours
  ii) P. malarie – Ouartan malaria in which fever appears after 72 hours and often produces persistent subclinical malaria
  iii) P. falciparum – Cerebral malaria or malignant tertian malaria where fever recurs in every 48 hours
- The parasite has two hosts:
  (i) Primary host or definitive host – female Anopheles mosquito
  (ii) Secondary or intermediate host – man
- The infective stage of parasite in human begins is sporozoite
- The incubation period of Plasmodium ovale and P.Vivaz is 10-15 days, 6-12 days for Plamodic falciparum and 28-30 days for P.malariae
- Sporozoites are introduced in human being by the bite of female anopheles mosquito and then the sporozoites undergo multiplication in different stages – pre-erythrocytic schizogony, exoerythrocytic schizogony, erythrocytic schizogony and post –erythrocytic schizogony. Only erythrocytic schizogony occurs in case of P.falciparum

- Erythrocytic schizogony occurs inside red blood corpuscles or erythrocytes, It occurs in repeated cycles. Infected red blood corpuscles are destroyed and melanin or haemozoin particles are released. They are toxic and cause rigor. The parasites present in red blood corpuscles ultimately form gametocytes. The ganetocytes are sucked by female Anopheles. Inside the mosquito the fertilization and development takes place to form sporozoites.

Symptoms

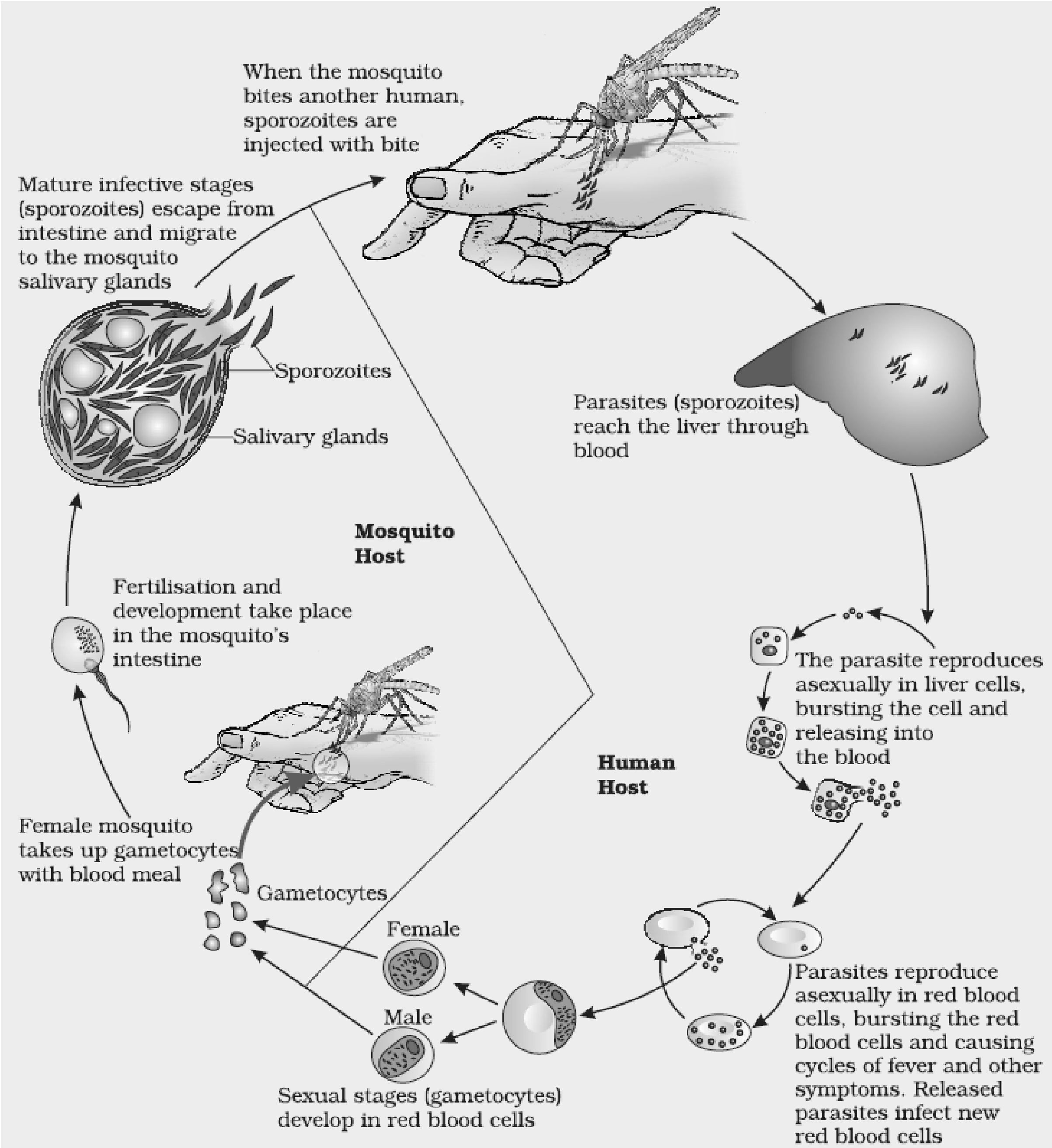
- Malaria is characterized by fever at intervals, sudden acute chillaess (cold or rigor state) accompanied by shivering followed by rise in temperature. Peak fever is $41.1^{O}C$ or $106^{o}F$ which persists for 3-6 hours. After 2-4 hours of fever there is profuse sweating which lowers the body temperature to near normal.
- Malaria is also accompanied by nausea headache, laziness and muscular pain. It also results in anemia and splenomegaly.
- Clinical fever in malaria is due to erythrocytic schizogony

Treatment

- Drugs like chloroquine and primaquine are administered to treat malaria. Other drugs like quinine obtained from the bark of cinchona plant, Camaquine, daraprix and artemesenin obtained from Artemesia annua.

Prophylaxis

- Fitting doors and windows with wire nets, using mosquito nets while sleeping, applying mosquito repellents and night, taking smaller prophylactic dose of ant malarial drugs at weekly intervals during malarial season can prevent effectively from infection of malaria
- Spreading areas with DDT, BHC and other insecticides. Introducing utricularia, ducks and larva eating fishes call Gambusia, stickle back and trout in larger water reservoirs for blocking the respiration of the larvae, covering all drains, introducing larvicidal Bacillus sphaericus, blue green algae like Aulosira and Anabaena in water bodies can help to protect against the breeding of mosquitoes
- National Malaria Eradication [Control] Programme was launched by the Ministry of Heath of the Government of India with the assistance of World Health Organization 9 WHO) in 1962 and almost controlled it by destroying the mosquitoes with DDT and other insecticide



AFRICAN SLEEPING SICKNESS OR TRYPANOSOMIASIS

- African sleeping sickness is of two types:

(i) Gambian (W. African) sleeping sickness caused by Trypanosoma gambiense by the bite of the blood sucking tse-tse fly. Glossina palpalis.

(ii) Rhodesian (E. African) sleeping sickness caused by Trypansoma rhodesiense by the bite of tse-tse fly.

- Trypansoma is a protozoan which is digenetic laving two hosts

(i) Primary host man

(ii) Antelope as reservoir host

(iii) Secondary host tse-tse fly Glossina palpalis

- The parasite lives in the blood stream and in the lymph, it invades the cerebrospinal fluid of the CNS causing fever, anemia, lethargy and death
- Chaga' disease (American sleeping Sickness) is caused by Trypanosoma cruzi spread by the bite of blood sucking bug Triatoma Sp.

Mode of infection

- The infection is initiated by the bite of tse-tse fly which harbours the infective metacyclic forms in the lumen of its salivary glands
- Then the parasite undergoes multiplication extracellular on sucked up to tse-tse fly along with the blood meal
- In human beings, the parasite live in the blood plasma
- Later the parasite enters cerebrospinal fluid and damages the brain

Symptoms

- This disease is characterized by swelling of lymphatic glands, irregular recurrent fever followed by weakness, loss of weight, anemia, increase in pulse rate and severe headache
- In due course the patient fall asleep, first at regular intervals and then lies prostate in coma. Ultimately lead to death

Treatment

- Trypanosomiasis can be treated in early stages by the drugs suramin sodium, atoxyl, tryparsamide, germanin etc. But it is very hard to control it once the parasites have entered the cerebrospinal fluid. Orsamine is fairly effective treatment when the CNS is involved

Prophylaxis

- Prevention depends on the eradication of tse-tse fly by insecticides like DDT

KALA – AZAR OR DUMDUM FEVER OR VISCERAL LEISHMANIASIS

- Kala – azar known as Black fever or Dumdum fever is a serious oriental disease of man. This disease is caused by the protozoan Leishmania donovani through the bite of the sand fly Phlebotomus.
- Primary host –man
  Secondary host –sand fly
  Reservoir host – dog

- In man , L. donovani lives as an intercellular parasite in leucocytes or cells of liver, spleen bone marrow, lymphatic glands etc.
- Incubation period is long from 3 to 4 months and symptoms may appear even after 2 years

Symptoms

- Early symptoms of kala-azar include swelling, high fever and enlargement of spleen and liver, followed by general weakness, emaciation, anemia due to reduction in number of blood cells and a peculiar darkening of skin
- In advanced stage hair becomes brittle and falls out. The body immune system becomes so weak that secondary infection by bacteria or viruses lead to death

Treatment

- Pentavalent antimony compound like sodium antimony tartrate and glyconate urea stibamine, aminostiburea, neostibosan etc. are used for treatment of kala-azar

Prophylaxis

- Eradication of the insect vector sandfly by insecticides, eliminating the reservoir host and avoiding the bite of sandfly ate prophylactic measures against kala-azar
- Other Leshmanial diseases of man
- oriental sores – Leishmania tropica
- Naso –pharyngeal leishmaniasis – Leishmania.
- South – America kala azar – Leishmania chagasi

CILIARY DYSENTERY (BALANTIDIASIS)

- Ciliary dysentery is caused by ciliated protozoan named Balantidium coli. The protozoan inhabits the human large intestine and reproduces there asexually by transverse binary fission and sexually by conjugation. This is followed by cyst formation and cysts pass out in the hosts faeces
- Infection occurs by ingesting cysts in food and drinks

Symptoms

- The protozoan causes ulcers in the colon and invades hyaluronidase. This generally results in vomiting abdominal pain, weight loss diarrhoea

Treatment

Tetracycline and iodoquinol are effective treatments against the disease

Prophylaxis

- Protection of food articles from dust and flies that may carry cysts in the best prevention from infection

GIARDIASIS

- Giardiasis, is a protozoan disease caused by Giardia intestinalis. It inhabits upper part of small intestine (duodenum and jejunum)
- It is the first human parasitic protozoan known
- It does not infect the intestinal wall but increases its number in the lumen and interferes with food absorption. A large number of cysts are formed which are released with faeces
- Infection is by contamination of food and drink with cyst

Symptoms

- Characterized by epigatric pain, abdominal discomfort, headache and mild diarrhea involving passage of pale, bulky, foul smelling and greasy stool

Prophylaxis

- Clean water supply, infection free food, proper washing hands, fruits and vegetables before eating etc.

FUNGAL DISEASES [DERMATOPHYTOUS]

- They are ringworm or round red or silvery type of superficial fungal infections of skin caused by species of Trichophyton, microsporeum and Epidermophyton. There are dry scaly lesions on skin, nails and scalp that causes intense itching. Heat and moisture promotes growth of these fungi especially in skin folds. Common source of infection are soil and towels, cloths, combs etc of infected persons

(i) Trichophyton rubrum : Dermatophytoses of foot (like foot ringworm, athlete’s foot, tinea pedis), onychomycosis (fungal infection of nails), ringworm of groin (tinea cruris, dhobi itch, jockey itch)

(ii) T. mentagrophytes: Oxeychomycosis, ringworm of body (tinea corporis, tinea circinata), ringworm of beard (tinea barbac or barber’s itch.

(iii) T. tonsurans, T. violaceum, Microsporum andoninii Ringworm of scalp (tinea capitis)

(iv) Microsporum canis : Cats and dogs and from there to children – tinea capitis, tinea corporis

(v) Epidermophyton floccosum, E. cruris, Tinea cruris, tinea pedis, tinea manum, tinea corporis, oxychomycosis

HELMINTHIC DISEASES

ASCARISIS

- Common ascariasis is caused by the common round worm Ascaris lumbricoides. It is a giant intestinal worm, white in colour and female longer than in male. Females lay about 200,000 eggs daily that pass out with human faeces and remain alive in soil for several days
- There is no intermediate host of the parasite so man acquired infection by directly ingesting Ascaris eggs, containing the infective stage rhabditoid larvae, with contaminated food or water

Symptoms

- Since a large number of adult Ascaris worm normally infect a single host, they obstruct the intestinal passage and thereby cause abdominal discomfort like colic pains. The patient may also suffer from impaired digestion, diarrhea and vomiting.
- They sometimes bore the intestinal epithelium and lead to some vital organs like kidneys spinal cord, brain or muscles causing injuries to the organs.
- They cause pneumonia with fatal consequences, with inflammation of alveolar tissue followed by oedema. The infection is followed by anaemia, leucocytosis and cosinophilia. Worms produces toxins which cause irritation of mucous membranes, nervous system like convulsions, nervousness, etc.

Treatment

- Infection of Ascaris can be treated with dose of hexylresorcinol crystals in a gelation capsule after about 12 hours of fasting. Some antihelminths drug like oil of chenopodium tetrachlorethylene, piperazine, hetrazan etc are also followed effecting against worms.

Prophylaxis

- Soil pollution with faecal matters should be prevented.

- Vegetable and fruit should be thoroughly washed.
- Finger nails should be cut regularly as eggs can accumulate below them.
- Children are more prone so abstaining children from sanitary habits.

FILARIASIS OR ELECPHANTIASIS

- The disease is due to nemantode Wuchereia bancrofti. Another species is Brugia malayi. This disease spread by then are respectively called bancroftian filariasis and brugian filariasis
- The pathogen is spread from one human being to another through mosquitoes like Culex and to a less extent by Amopheles and Aedes
- The parasite resides in lymph vessels, connective tissues and mesentery
- The parasite is viviparous. The young ones are called microfilariae . They are hardly 2.5 cm long
- Microfilariae enter the blood vessels and reach the skin area during night for being picked by female mosquito for completion of life history and change into infective stages
- The infective parasites are deposited near the site of mosquito bite. They pass through the punctured skin and reach the lymphatic system

Symptoms

i) In the first stage, the patient has increased cosinophils, enlarged lymph nodes and positive intradermal parasite test
ii) Second or carrier stage is symptomless but right blood examination can reveal the parasite
iii) Third stage is characterized by filarial fever, inflammation of lymph nodes and lymph vessel
iv) The final stage is manifested by thickening of subcutaneous tissues and skin so that there is permanent swelling mostly feet, legs, thighs, scrotal sac, breast etc. it is called elephantiasis

Treatment

- The disease can be cured by drugs like hetrazan, MSE and diethyl carbamazine (DEC)
- Reconstruction of affected body parts through surgery
- The disease can be prevented by prevented by taking precautions against mosquito bites

CANCER

- Cancer is a group of diseases characterized by uncontrolled proliferation of cells and ability of proliferated cells to invade other tissues / parts body. It is more common in old persons after 40 days and in tissues where cells undergo divisions regularly
- Neoplasm is a new abnormal tissue that is capable of continued growth, formation of tumour, crowding and disrupting of normal cells. Tumours grow or swelling are caused by abnormal proliferation of cells
- They are of two types, benign and malignant. Benign tumour is a large localized mass of abnormal tissue which pressures other tissues and cause pain but does not infiltrate adjacent tissue because it is encapsulated in connective tissue, malignant tumour 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 tumour
- Cancers are of three types

(i) Carcinoma : It is cancer of epithelial / epidermal tissue and their derivatives like skin, mucous membrane, glands, lungs, breast, pancreas, stomach etc

(ii) Sarcoma : It is the cancer of primitive mesodermal tissue like connective tissue, bones, muscles, lymph nodes, etc. Depending upon the tissue involved, sarcoma is of several types e.g. lymphoma (involving lymph vessels), lipoma (adipose tissue) osteoma (bone), malignant reticulosis etc

(iii) 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 myelcytic leukemia (9^{th} and 22^{nd} 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 man and uterine cervical cancer in women.

- Carcinogenic factors : Factors inducing cancer

(i) Carcinogens / chemical carcinogens

These are substances / environmental pollutants which causes cancer. Example soot, coal tar (skin an lungs), cigarette smoke (N-nitrosodimethylene – lungs), Cadmium oxide (Prostate gland), aflatoxin (liver) 2-naphthylamine and 4-aminobiphenyl (urinary bladder), mustard gas (lungs) nickel and chromium compounds (lungs), asbestos (lungs, pleural membrane), diethylstilbestrol (vagina), vinyl chloride (liver), artificial sweeteners, excessive coffins, diet rich in animal proteins (digestive tract), sex hormones (breast cancer).

(ii) Radiations

Both UV and ionizing radiations increase the incidence of cancer. Leukemia incidents are 10 time more in radiologists. Skin cancers are more common in areas with high UV radiations.

(iii) Heat

Reverse smoking causes mouth cancer. Kangri (heating devices) increases incidence of cancer in Kashmir.

(iv) Tobacco

Tobacco chewing produces mouth cancer. Smoking increases chances of throat and lung cancer.

(v) Mechanical agents

Friction, trauma or continuous irritation seems to produce cancer.

- Cocarcinogens

  They are chemicals or factors which function as cancer / tumour promoters. Cocarcinogens or epigenetic carcinogens promote neoplastic growth only after inhibition by carcinogen some cocarcinogens are Polonium, Nickel, Nicotine, Saccharine, Menobarbitol

- Mechanism / Carcinogenesis

  It occurs through following stages

(i) Initiation: Carcinogens produce DNA lesions Epidermiological studies indicate that initiation of cancer occurs in childhood and youth

(ii) Promotion : Proto –oncogenes are changed to oncogenes. A cell with oncogene is called latent tumour cell. Promotion is reversible common promoters are saccharine and phenobarbitol

(iii) Loss of adhesion or loss of contact inhibition : Normal cells do not divide because of contact inhibition. Latent tumour call losers contact with other cells. This changes it into active tumour cell

(iv) Progression : The active tumour cell begine to divide and forms neoplasm or cell aggregate which later turns into tumour. Progression is slow so that external symptoms do not appear till the tumour is formed. It presses adjacent organs and tissue.

(v) Metastasia : Tumour cells are also called cancer cells. They become less adhesive. The cancer cell do not undergo differentiation. They release angiogenic factors which stimulate growth of blood vessels. Soon the cancer cells begin to migrate with or without secondaries

- Cancer cells have irregular, hypertrophied nucleus, abundant nuclear granules, increased number of lysosomes, reduced cristal in mitochondria, more melanin mucus fat droplets and debris in cells. Further, genes llike ERCA1, BRCA2, CDH1, MLH1, PTEN mutate. This reduces the ability of DNA to repair itself. Same of the mutated genes were previously working as tumour suppressor genes

Symptoms

- A lump or hard area, swelling or sore that does not heal, unexpected loss of weight or hoarseness, change in colour of mole / wart, a change in digestive / bowel habits, loss of blood through a natural orifice or excessive loss of blood in women.

Diagnosis

- Biopsy of tissues endoscopy (gastroscope for stomach, laproscope for pelvic region), X-rays ultra –sound.

Anticarcinogens

- They are substances which prevent the action of carcinogens, Anticarcinogens occurs in green yellow vegetables, fruits and milk. They are riboflavin (milk), flavonoids (green yellow vegetables and fruits), vitamin C, indoles (cabbage, cauliflower), retinoids (milk, carrot, butter), some synthetic oxidants in preserved foods (butylated hydroxyl anisol and toluene) etc. β- carotene present in green – yellow vegetables is promoter – inhibitor which weakens the action of cancer promoters

Treatment

- Surgery, bone marrow grafting (Leukemia), radiotherapy (exposure to radioactive isotopes), hormonal therapy, chemotherapy. Two drugs (vincristin and vinblastin) from cantharantus roseus are effective in controlling leukemia. Taxol is anti –cancer drug obtained from Texus baccata.

- Prophylactic intake of taxomifen and raloxifene keeps breast cancer under check . Recently a drug tetrathiomolybdate has been tried with some cancer. It arrests tumour growth by starving cancer cells of copper PARP (Poly ADP ribose poly merase) inhibitors also kill tumour cells with no side effects. Extract from Fagonia cretica has been found to cure breast cancer.

- Immunity is the ability of an individual host to resists development of disease and allergy even after having received infective dose of pathogen with complete virulence and the various allergens.
- Immune system is the system of animal body which protects it from various pathogens / infectious agents / allergens and cancer
- Immunology is the science of development of immunity against particular pathogen or allergen
- The foundation of science of immunology were laid by three workers:

(i) Edward Jenner (1796)

A risky inoculation of small pox pustule through a scratch on vein was performed in Turkey and other eastern countries. Jenner noticed that milk – maids did not suffer from small pox though they did develop similar scabs of cowpox. He transferred the material from the scab of milkmaid sarah Nelmes to a young boy of eight years James Phipps. Later he inoculated the boy with live small pox material. The disease did not appear. The procedure was tried on other with equal success. Jenner also coined the term vaccine. He is regarded as father of immunology

(ii) Louis Pasteur (1879)

Developed the technique of weakening or attenuation of pathogen as heat, cold or starvation for preparation of vaccine

(iii) Von Behring (1891)

He discovered the technique of passive immunization by injecting of diphtheria pathogen into sheep and preparing serum from its blood after some time

- The agents which invite action of immune system are micro organism, their products certain food items, chemicals, drugs, pollen and pollutants. Body defense system or immunity is of two basic types, non-specific or innate and specific / acquired

NONSPECIFIC BODY DEFENSE

- It is natural defense system of the body with an individual is born and which is always available to protect the body against various types of discomfort causing environmental agents. This is done by having barriers to prevent entry of foreign agents and dispose of them as soon as they enter the body. Non specific body defense does not involve antigenic recognition. It is also called innate inborn, familial or natural immunity.
- There are number of components of innate immunity anatomic, physiological, phagocytic, inflammatory, natural killer cells and complement system. The

anatomic and physiological barriers constitute the first line of body defense. Phagocytic barriers, inflammatory barriers, natural killer cells and complement system constitute second line of body defense

- Innate immunity or non-specific body defense is only defense for most animals and plants.

(1) Anatomic / physical barrier : These don not allow foreign agents and pathogens to enter the body

(i) Skin : Keratinised dead outer cells of horny layer, do not allow entry of pathogen in body. Oil from sebaceous glands and sweat from sudoriferous glands make the skin acidic with pH 3-5, and possess bactericidal as well as fungicidal properties

(ii) Nostril hair: They filter out dust and micro –organism from inhaled air

(iii) External friendly microorganisms/ friendly bacteria : Many friendly bacteria live on skin, produce acids and secrete chemicals harmful to pathogens

(iv) Mucous membrane: They line digestive, respiratory and urinogenital tracts so as to prevent of entry of germs into body tissues.

(v) 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

(vi) Internal Friendly microorganism: They occur in intestine and vagina. Intestinal microorganisms secrete chemicals harmful to other microbes. Bacteria present in vagina secrete lactic acid for keeping it free from other microbes

(2) Physiological Barriers : They are barriers related to body temperature, pH and chemical of body secretions which inhibits growth of pathogens.

- (i) Fever : Thee is rising of body temperature due to toxins released by pathogens and pyrogens produced by leucocytes. Fever stimulates phagocytosis and inhibits growth of many pathogens
- (ii) External secretions: Sweat, oil and secretions of external friendly bacteria are acidic to prevent growth of many pathogens.
- (iii) Lysozyme: It is a bacteriolytic enzyme present in sweat, tears, saliva and mucus lysozymes bring about hydrolysis / break down of bacterial cell walls
- (iv) Activity of stomach : HCl of gastric juice kills most of microorganism ingested with food and drinks.
- (v) Bile : It does not allow growth of micro-organisms

(vi) Cerumen (ear wax) : It is secretion of ceruminous glands present in external auditory canal cerumen traps dust particles, kills bacteria and repels insects.

(vii) Interferons : They are glycoproteins which are produced in small amount of certain kinds of cells (wbc, NKC, fibroblasts, epithelial) when infected with virus. Interferons make the surrounding cells resistant to viral infection. Interferons were discovered by Isaac and Lindemann (1957). They are used in treatment of certain cancers, hepatitis, multiple sclerosis, oscteoporsis, influenza etc

(3) Phagocytic Barriers

Phagoctosis is carried out by leucocytes and macrophages. The act as soldiers of defense and scavengers of the body. Phagocytic leucocytes are neutropils and monocytes. They come out of blood capillaries through diapedesis, engulf and digest most of the microorganisms.

Macrophages are modified monocytes. They are large phagocytic cells of two types – fixed (inside lymph nodes, spleen, liver, bone marrow) and wandering (connective tissue). They constitute reticulo-endothelial system macrophages of liver are present along sinusoids and called Kupffer’s cells. Macrophages attack germ and inorganic substances that happen to enter tissues and engulf then. Pus may collect. Puss 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

(4) Inflammatory Barrier

Inflammation is reaction of living tissues to injury, irritation or infection which is characterized by pain, swelling, redness or heat. Inflammatory response can be localized (area of injury or infection) or systemic (whole body). The injured region attack mast cell (histamocytes) of connective tissue and basophils of blood. They release prostaglandins and histamine. Histamine dilates blood capillaries and other small blood vessels. Therefore, more blood flows into the area of injury making it red and warm. Histamine also makes fine blood vessel permeable, lowers blood pressure and allows greater leakage of phagocytes allows destruction of microorganism. Plasma contains serum proteins with antimicrobial activity. Accumulation of tissue fluid causes swelling and dilution of toxins produced by pathogens.

(5) Natural killer cells (NKC)

They are small lymphocytes / cells of immune system which are specialized to kill virus infected and tumor cells. Killer cells produce perforins. The latter produce pores in the plasma membrane of the target cells. Water enters the perforated cells. They swell up and burst. Cellular remains are then cleared by phagocytes.

(6) Complement system

It is a system of thirty proteins which participate in both innate and acquired immunities in cascade fission for protecting the individual from pathogens. Many of the proteins of complement system function as enzyme precursors. In acquired immunity the system becomes active in response to antigen – antibody complex. It is also called classical pathway. In innate immunity, the complement system is activated directly in response to bacterial endotoxins, microbial polysaccharides, cell wall and other components of invading the microorganisms. It is called alternate pathway as well as properdin system. The pathway helps in dealing with invading microorganisms even before a person becomes sensitized against them, certain proteins of this system cleave and form two components, membrane attack complex and biologically active fragments. Membrane attack complex functions as lytic complex which produces trans membrane pores in the microbes. The latter burst and die. Biologically active fragments produce opsonins, anaphylotoxins and chemotactic factors. They form a coat over the invading microbes and attract phagocytes (neutrophils and macrophages) for engulfing them. Complement system also causes agglutination of microbes, neutralization of viruses, activation of mast cells and basophils and has some direct inflammatory effect.

SPECIFIC BODY DEFENSE / ACQUIRED IMMUNITY

- It is immunity obtained during the life of an individual against a particular microorganisms due to previous infection vaccination or inoculation of antiserum. Specific body defense is also called acquired adaptive or specific immunity. This type of immunity occurs only in vertebrates. It supplements protection provided by innate or inborn immunity. However it takes a few to several days to become effective. Acquired immunity is also called third line of body defense.
- It has four unique characteristics:

(i) Specificity – It is a specific for each type of pathogen.

(ii) Diversity – Acquired or adaptive immunity can develop against all the diverse type of pathogens their toxins and other molecules

(iii) Discrimination between self and nonself – It can differentiate foreign (non self) and body (self) cells and molecules. Only the foreign or nonself materials are attacked

(iv) Memory – The first encounter between the specific foreign agent or microbe and the body's immune response but also memory of this encounter. Because of it a second encounter with the same microbe brings about quicker and heightened response.

- Acquired immunity or specific body defense is of two type

i) Active (acquired) immunity

This involves the active functioning of the person's own immune system leading to the synthesis of antibodies and / or production of immunologically active cells

Active immunity is produced by clonal selection and expansion. This occurs because interaction of an antigen with its receptors on the lymphocytes surface stimulates cell division, so that more lymphocytes are available to combat subsequent exposures to the same antigen

Clonal selection lead to the eventual production of :

(i) A pool of antibody – secreting plasma cells plasma cells are B-cells that have booled up (forming a large endoplasmic reticulum) for massive synthesis and secretion of an antibody. The antibody is the secreted version of the BCB (B-cell receptors for antigen)

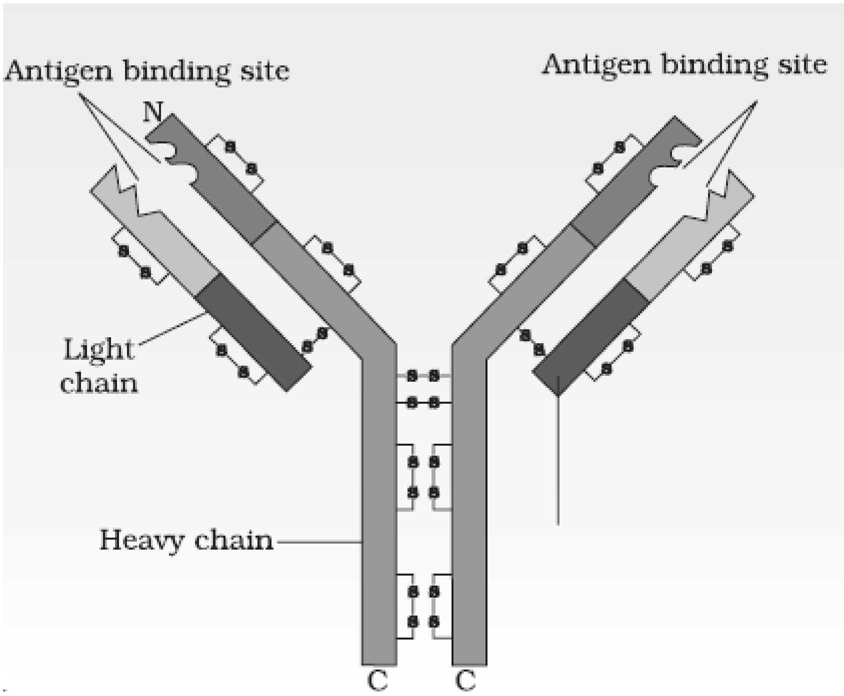
(ii) A pool of ' memory ' cell – These are B lymphocytes with receptors of the same specificity as those on the original activated B cell

ii) Passive (acquired) immunity

- Immunity is said to be passive when antibodies produced in other organisms are injected into a person who already has potential antigen in his body. Passive immunity is developed to counteract snake venom, rabies, tetanus toxin and salmonella infection

- An antigen or immunogen is any foreign substances like protein or polysaccharide present in the external coating of pathogen, toxin of pathogen, white egg, feathers, constituent of vegetable, fruit, meat, drug chemical, tissue or organ transplant which induces the immune system to produce antibodies. Sites over the antigens that are recognized by antibodies and receptors found on B and T cells are called antigen determinants (epitope). An antigen may have one to several types of antigen determinants

- Antibodies are glycoproteins which are of innumerable types, each specific to specific antigen. They occur in blood plasma as gamma-globulins or immunoglobulines (Ig). About 20% of plasma proteins are antibodies, each antibody consists of four polypeptides, two long heavy or H chains and two short, light or L-chains. They are held together in a Y-shaped configurations. Long H-chains are present throughout while short L-chains are restricted to the two arms. The tips of the two arms posses a specific architecture that fits over the antigen determinant in a lock and key fashion to form antigen-antibody complex. The antigen binding fragment (Fab) of arms is called variable or V-region while the stem and basal parts of arms of antibody form constant or crystalline fragment (Fc). The latter determines diffusivity and adherence of the antibody



IMMUNOGLOBULIN CLASSES AND THEIR FUNCTIONS

- IgA: Called secretory immunoglobulin because it is present in all body secretions including colostrum and mother's milk. Functions as first line of defense against inhaled and ingested pathogens by activating alternate pathway of complement system.
- IgD: Along with IgM occurs over B-lymphocytes as antigen receptors activation of B-cells, also present in serum tissue and effective against toxins and allergens.
- IgE : Present in mucous membranes, skin and lungs. Attaches to mast cells and basophils for releasing histamine and other substances that mediate hypersensitive response to allergens.
- IgG : Constitue 75% of total Ig, present in call body parts including milk and can pass through placenta providing passive immunity to neonates, stimulates complement system and phagocytes against toxins, fungi, viruses and bacteria

— IgM : Largest Ig with 10 binding sites, activates B-cells over which it is present along with IgD, also first to reach the site of infection and activate classical pathway of complement system.

COMPONENTS OF IMMUNITY SYSTEM

- Immunity system contains antibodies, specific cells, tissues and lymphoid organs. It takes part in recognition of foreign antigens, eliminates them and keeps a memory of the same. It has also a role in allergies, autoimmunity and organ transplantation.
- Immune system has two components humoral and cell mediated.

Humoral Immune System or antibody mediated immune response (AMIR)

- Antibody – mediated immunity is associated with the appearance of antibodies, secreted by cells of the B-lymphocyte series, in extra cellular fluids such as plasma, lymph and external secretions.
- The AMIR defends the body against
  a) Some viruses.
  b) Bacteria with polysaccharide capsule.
  c) Toxins that enter the body fluids (blood and lymph).
- When antibodies on a B cell's surface bind antigens, the B cell is activated and divides producing a clone of daughter B Cells. The daughter cell specialize into plasma B cells and memory B cells
- The plasma B cells are antibody factories. The antibodies pass into and circulate in three lymph to dispose of the antigens. For this, the antibodies selectively bind to the antigens forming antigen – antibody complexes to destroy the antigen. Each person can make 10^7 to 10^8 different kinds of antibody molecules so that there is an antibody molecules, so that there is an antibody on a B cells to fit any antigen
- The plasma cells do not migrate to the site of infection and act through a fluid (lymph). Hence they are said to form humoral immune system (L. humor = liquid). The B – lymphocytes are short lived and are replaced every few days from the bone marrow
- The memory B cells live for a long time and serve to quickly dispose off the antigens in case re-infection of the same virus or bacterium occurs.
- The antibiotics bind to their specific antigens an inactivate the invading microorganism or foreign molecules so that these are conveniently disposed of by the pathogen.
- The antibodies fight the antigene in five different ways

(i) Neutralization – some antibodies neutralize the antigens termed toxins and make them ineffective. They are called antitoxins. The phagocytes dispose off the neutralized antigen – antibody complexes

(ii) Agglutination – Certain antibodies causes the particulate antigen to stick together in clumps, thus immobilizing then for easy disposal by the phagocytes through ingestion. They are termed agglcutinins.

(iii) Opsonziation – Other antibodies coat the surface of the microbes and make them more susceptible to phagocytosis. Such antibodies are known as opsonin

(iv) Precipitation – other antibodies combine with the antigens to form precipitates that are easily ingested by phagocytes

(v) Complement activation – Antibody antigen complexes activate complement protein which may –

a) Lyse cell walls of bacteria, causing their disintegration.
b) Incite inflammatory response.
c) Opsonize antigen.
d) Attract phagocytes to area of infection.

Cell mediated immunity / Action of T cells

- T cells are long – lived cells which have upto 100,000 receptors sites on their surface for binding antigens. The cells develop antigen specificity through previous contact. They are often called competent lymphocytes. The latter respond to specific antigen by forming a clone of cells. The cells then differentiate into following types

1. Cytotoxic or killer T-cells : The cells reach the site of infection or agglutination and get attached to antigen containing microorganisms. They secrete perforins that produce holes in the attached cells. The killer T cells then pass toxic chemicals into attached cell for killing the same. Afterwards they move away for attacking new antigen containing cells. Killer T cells attack virus, invaded cells, cancer cells and cells of transplanted organs. They also destroy helper T cells when the latter are invaded by HIV. AIDS is due to deficiency of helper T cells. The killed cells are removed by phagocytes
2. Helper T cells : They constitute more than 75% of total T- cells. They regulate immune functions by secreting lymphokines. Interleukin-2 has positive feedback system for helper T cells, stimulates growth and proliferation of other T cells. Interleukin-4,5 and 6 stimulate B lymphocytes macrophages are attracted to the site of infection and stimulated to phagocytosis by lymphokines.

3. Suppressor T cells : The cells act as negative feedback and keep the activity of other T-cells under check. This protects the body tissues and chemicals from attack of phagocytes and their antibodies
4. Memory T cells : They are sensitized T Cells which retain memory of antigen specificity for future. Sometimes lifelong. Other T Cells are amplifier T cells, killer, helper and suppressive T-cells are also called effectors cells.

CELLS OF IMMUNE SYSTEM

- They are lymphocytes and antigen presenting cells like macrophages. A healthy human has about a trillion lymphocytes. Lymphocytes are of two types, T-layphocytes (T-cells) and B-lymphocytes (B-cells). Both of them develop in bone marrow from lymphatic system cells by the process called haematopoiesis, some of the young lymphocytes migrate into thymus for preprocessing. They are called T-lymphocytes. Afterwards they pass on to all the lumphoid tissues of the body and get lodged there. The other types of lymphocytes remain in the bone marrow and get preprocessed there. They are called B lymphocytes because in birds they are preprocessed in lymphoid diverticulum of cloaca called bursa of Fabricius. After being preprocessed B lymphocytes also migrate to all the lymphoid tissue of the body where they reside near but separate from T-lymphocytes
- MHC / HLA molecules (HLA antigen)
  Polymorphic molecules call MHC class I are present on most body cells, Another group of molecules, , MHC class II, occur over professional antigen presenting cells. They bind to peptide antigen producing MHC antigen complex. The same is present to CD4 and CD8 T-cells respectively
- Activation of adaptive / acquired immunity
  An antigen is processed by antigen presenting cells like macrophages and B-lymphocytes. A type of T-cells (T-helper cells) interacts with presented antigen and becomes activated. The activated T-cells not only form a clone of T-cells but also B-lymphocytes.

CLONAL SELECTION

- Formation of a clone of cells by each activated T-lymphocyte and antibody producing plasma cells by activated B-lymphocyte, each exhibiting the specificity for the same antigen is called clonal selection. The cells are of course of more than one type and perform different functions. One type of cloned lymphocyte do not function as effector cells but instead develop into long lived memory cells.

PRIMARY AND SECONDARY IMMUNE RESPONSES

- Primary immune response is the first immune response developed during the first encounter with the antigen. It is feeble but relatively longer
- Secondary immune response is quick heightened immune response against a subsequent encounter with some antigen. It is due to the presence of memory cells against that antigen. A person having caught chicken pox or measles only becomes immune to subsequent attack of the pathogen due to it.

LYMPHOID ORGANS

- They are those organs having lymphatic tissues where maturation and proliferation of lymphocytes occur. The sites where T-lymphocytes and B-lymphocytes mature and develop antigen specific receptors are called primary lymphoid organs viz. thymus for T-lymphocytes. And bone marrow for B-lymphocytes
- Secondary lymphoid organs are those organs having lymphatic tissues where B and T-cells are settled after maturation and where they undergo proliferation / differentiation on being activated by specific antigens e.g. lymph nodes, spleen and tonsils, MALT is mucosal lymphoid associated tissue. It constitutes more than 50% of the total lymphoid tissue.

VACCINATION AND IMMUNISATION

- Immunization is phenomenon of increasing specific antibody production and development of memory B and T cells against the potential attack of a pathogen. It is carried out through vaccination and injection of antiserum. When an immunized person is attacked by the pathogen, the existing antibodies immediately attack the antigen while the memory T and B cells give rise to a massive crop of lymphocytes and antibodies.
- Vaccination is a process of inoculation of harmless antigenic material into healthy person for providing active acquired immunity against the disease. A single vaccination against the disease. A single vaccination may not give adequate immunity. Therefore 2-3 booster doses of vaccine are administered later on at specific intervals. Vaccine is suspension / extract of weakened attenuated dead germs or antigen containing compound of pathogens which when injected into healthy person provides active acquired immunity to the disease
- Now vaccines are also available for diphtheria, cholera, typhoid, whooping cough, tetanus, tuberculosis, plague, measles, mumps and polio. The cells

infected with cancer causing viruses usually show on their surface to the virus. This has led to the first successful immunization against cancer in cats and chickens. Unfortunately, efforts to produce antibodies to cancers not caused by virus have had very little success

- Many serious infectious diseases also have no effective vaccines. These include malaria, trypanosomiasis and AIDS
- In India, vaccines are generally produced at Hoffkins Institute at Mumbai and Virus Institute at Pune
- National Institute of Immunology (NII), New Delhi is involved in the production of antifertility vaccine kits to detect pregnancy and infectious disease etc.

DISORDERS OF IMMUNE SYSTEM

AUTOIMMUNITY (Auto immune diseases)

- Auto immunity is an abnormal immune response against self antigens. When the cell acts as antigens in the same body then they are called autoantigens
- The nature of auto immune diseases depends on the autoantigens involved. For example, if the autoantigens are RBC then the body destroys its own RBCs, resulting in chromic anemic, if the autoantigens are muscle cells then it results in the destruction of its own muscles resulting in severe weakness (myasthenia gravis); if the autoantigens are liver cells, then it results in chronic hepatitis, etc. Other autoimmune diseases are insulin dependent diabetes, Addison's disease, ulcerative colitis and rheumatoid arthritis

ALLERGY (Hypersensitivity)

- Allergy is the inappropriate immune response of person to harmless substances coming in contact with the body or entering the body from the environment or in food or in medicine
- The substances which causes allergic reaction are called allergens. They are generally weak antigens. The common allergens are dust, dust mites, cat, pollen, feathers, fur, venom etc.
- Allergic reaction depends on the nature of the allergen. The common allergic reactions are inflammation of mucous membrane, sneezing, gasping, running of eyes, irritation of upper respiratory tract, itching, skin rash
- Allergy involves mainly IgE antibodies and histamine. It causes marked dilation of all the peripheral blood vessels and the capillaries becomes highly

permeable so that large amounts of fluid leak out from the blood into tissues. The blood pressure decreases drastically often resulting in the death of the individual within a short time

- Hay fever : In this allergic form, there is swollen, reddened, running eyes and nose. The drugs called antihistamines are of major importance in treatment.
- Asthma: The tissue surrounding the respiratory tubes in the lungs swell up and compress the tubes. Hence there is difficulty in breathing. Antihistamine drugs are also given in this disease

IMMUNODEFICIENCY

Severe combined immune deficiency (SCID)

- Severe combined immunodeficiency (SCID) represents a group of rare, sometimes fatal congential disorders characterized by little or no immune response
- It is a defect in the specialized white blood cells (B and T-lymphocytes)
- Without a functional immune system, SCID patients are susceptible to recurrent infections such as pneumonia, meningitis and chicken pox. Though invasive, new treatment such as bone marrow and stem cells transplantation save as many as 80% of SCID patients.
- Sometimes new born children are without T-cells and B-cells. These children are susceptible to various infections
- SCID is caused by a defect in the gene that codes for the enzyme adenosine deaminase on chromosome number 20. Lack of the enzyme adenosine deaminase (ADA). Means that the substrate for this enzyme accumulate in the cells. Immature lymphoid cells of the immune system are particularly sensitive to the toxic effects of these unused substrates, so fail to reach maturity.
- As a result, the immune system of the afflicted individual is severely compromised or completely lacking. Lack of this enzyme makes the body defenseless against infections.
- SCID is the first genetic disorder to be combated with gene therapy.

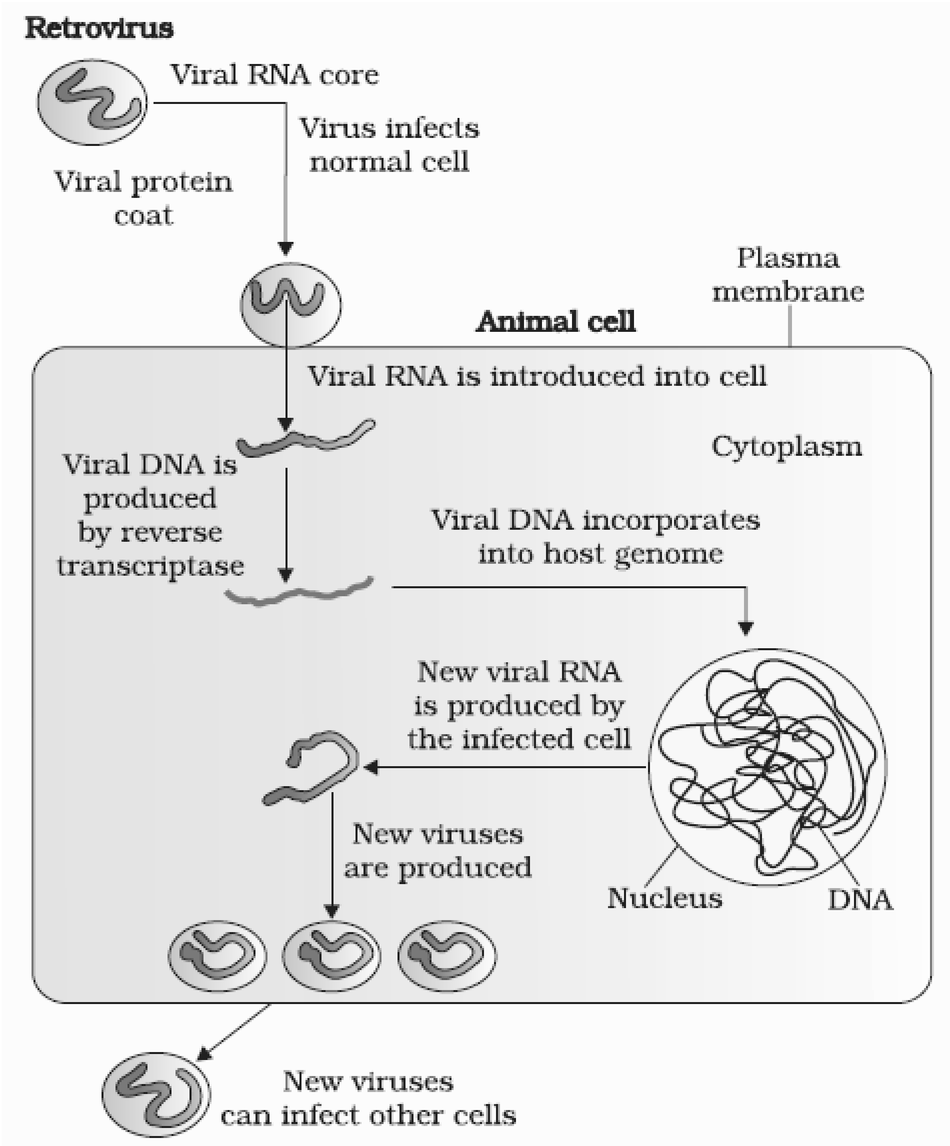
Acquired immune deficiency syndrome (AIDS)

- AIDS is a disorder of cell mediated immune system of the body. There is a reduction in the number of helper T-cells which stimulate antibody production of B-cells. This results in loss of natural defense against viral infection
- AIDS infection were detected in India for the first time in prostitutes of Chennai in 1986.

- Virus responsible for AIDS was identified and named HIV

AIDS virus – HIV

- HIV virus belong to the retrovirus family, a family of single stand RNA viruses distinguished by possession of viral reverse transcriptase that transcribes viral RNA into provirus DNA which is integrated into the host cell genome.
- HIV is 100 to 140 nm in diameter, has a cylindrical core, single-stranded linear RNA and reverse transcriptase enzyme surrounded by glycoprotein coat, double lipid membrane and two protein coats
- Virus of AIDS was isolated and identified in green monkey by Prof. Luc Montagnier in France in 1983 and almost the same time by Prof Robert Gallo in USA (1984)
- HIV is subdivided into two distantly related types, HIV-1 and HIV-2. HIV-1 is the predominant world wide isolated from individuals with AIDS or at high risks for the development of AIDS. HIV-2 is endemic among people in west Africa.



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- HIV -1 and HIV-2 differ in their ability to cause disease and their geographical distribution
- Both, HIV-1 and HIV-2, cause the body to produce antibodies with three to six months, although the period between initial infection and illness may be longer in case of HIV-2
- The incubation period of HIV is 15 -57 months. Average incubation period is 28 months

Transmission

- AIDS is transmitted only by a constant of infected cells containing blood of a patient with the blood of a healthy person as in:

(i) Unprotected sexual intercourse with an infected person

(ii) Use of contaminated needles and syringes to inject drugs or vaccines.

(iii) Use of contaminated razors for shaving

(iv) Use of infected blood or blood product for transfusion
(v) Organ transplant
(vi) Parturition from mother to baby due to rupturing of blood vessels

- The sexual rout of transmission accounts for over 75% of infections
- AIDS can not be acquired by

i) Insect bites
ii) Crowded transport
iii) Shaking hands
iv) Sharing towels
v) Coughing and sneezing
vi) Kissing and embracing
vii) Sharing utilities

Signs and symptoms of AIDS

- People infected with AIDS virus remain apparently well even after infection. They may not show any physical symptoms of illness for a long time
- When the AIDS virus enters the blood stream it begins to attack certain white blood vessels and antibodies. These antibodies can be detected by a specific blood test usually two weeks to three months after infection.
- In some people, the protective immune system may be destroyed by the virus and then other germs that ordinarily do not attack cause opportunistic disease to infect and destroy the body.
- Opportunistic infections occur during the last phase of HIV, which can occur up to 10 to 11 years after the infection. These infections are described as AIDS related complex (ARC)
- AIDS virus may attack nervous system causing damage to the brain resulting in memory loss and other neurological disorders.
- Some early signs may be persistent cough and fever associated with difficulty in breathing.
- Certain cancers
- Tuberculosis
- A typical pneumonia by fungus pneumocystis carinii
- Brain damage
- Night sweats and tiredness
- Swollen lymph nodes and fever
- Weight loss, chronic diarrhea that last for more than one week, loss of appetite and lack of resistance to infection.

Diagnostic test

- HIV is diagnosed by testing the blood for the presence of antibodies to the virus.
- ELISA (Enzyme -linked immunosorbent assay) screening test is the initial one. The test works by detecting antibodies, substances, proteins which are produced in the blood, when the virus is present.
- Western blot test will confirm the result of repeated test through detection of HIV proteins.
- Viral load test measures the amount of virus in the blood which will help in determining the probable progression of the disease

Treatment

- However, no specific treatment has been found so far, and the mortality from AIDS is virtually 100%
- A combination of three and more antiretroviral agents, called triple therapy or highly active anti-retroviral theory (HAART), has been highly effective in reducing the number of HIV particles in blood stream though HAART is not cure for HIV.

Prevention

- The following steps may help in controlling this dreaded disease:
  - i) People should be educated about AIDS transmission, advantage of condoms.
  - ii) Disposable needles and syringes should be used
  - iii) High risk group should be refrain from donating blood
  - iv) Sexual habits should be changed
  - v) Before receiving blood, ensure that it has been screened for HIV
  - vi) While getting dental treatment, insist on the use of thoroughly sterilized equipment.
- December 1 is celebrated every year as the world AIDS Day.

(SECTION III : MENTAL HEALTH AND ADDICTION)

- Mental health is a state of balanced development of individual's personality and emotional attitude towards family members, society, social institutions, leisure and balanced satisfaction of potentially conflicting instinctive drives.
- In 1950, a WHO experts committee on mental health reviewed the various definitions of metal health and observed that mental health is influenced by biological and social factors and is not static condition but subject to variation and fluctuation
- A mentally healthy person has:
  - Self respect.
  - Knowledge of one's possibilities and limits.
  - Independent personality but comfortably placed in hierarchy in work, family and society.
  - Feeling for friendship and trust for other
  - A purposeful life with reasonable goals to achieve
  - Potential to perform all the daily chores not dependent on any other person.
  - Ability to meet all the demands of live solving problems as they arise.
- A mentally sick person has:
  - Inability to concentrate.
  - Absence of sound sleep.
  - Worrisome behavior.
  - Short temper.
  - Unhappiness.
  - Mood fluctuations from depression to elation.
  - Tendency to get upset by a change in routine.
  - Apprehensive nature.
  - Bitterness.
  - Dislike of others.
  - Considering others to be wrong.
  - Feeling of pains/aches in different body parts without any actual ones
- 10^{th} of October is observed as the "world mental Health Day".

TYPES OF MENTAL ILLNESS / MENTAL DISORDERS

- It is of three types:

(SECTION III : MENTAL HEALTH AND ADDICTION)

- Psychosis / Insanity / Madness
- Mental disability
- Neurosis / psychoneurosis

PSYCHOSIS / INSANITY / MADNESS

- It is a severe type of mental illness or disorientation in which the patient no longer remains in touch with realities of life.
- These patients are usually associated with other defects such as diabetes, high blood pressure, tuberculosis and other diseases of central nervous system.
- The patient is not aware of illness and refuses to take the treatment.

MENTAL DISABILITY

- Mental disability are caused by physical, physiological and psychological defects like

a) Injury
b) Nutritional deficiency during development of infant.
c) Radiation damage during neutral development.
d) Toxicity of lead and mercury.
e) Degeneration due to ageing.
f) Tumors.
g) Poor availability of oxygen , blood supply.
h) Excessive intake of alcohol.
i) Excessive use of psychotropic drugs.

- Epilepsy is a mental illness characterized by abnormal electrical discharge in a part 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 characterized by stooped posture, stiffness and slowness of movements, fixity of facial expression and rhythmic tremor of limbs which subsides on relaxation or activity willed movement
- Alzheimer’s disease is a progressive degenerative disease of brain which is caused by senile plaques and neuro –fibrillary tangles resulting in loss of choline acetyetransferase activity.

(SECTION III : MENTAL HEALTH AND ADDICTION)

- First signs are subtle changes in personality, memory disturbance and trembling of hands. It is followed by progressive increase in dementia over 5-10 years. This disease commonly appears after the age of 40, though it can occur in any age group.

NEUROSIS / PSYCHONEUROSIS

i) Anxiety disorder : It is a group of mental disorder in which the patient shows anxiety to stressful event, panic disorder, associate with a range of unpleasant symptoms like palpitation, sweating, nausea, trembling, diarrhea, muscular tension etc.
School phobia, social phobia, agoraphobia and separation anxiety disorder are some common anxiety disorders found in children and adolescents.
ii) Obsessive – compulsive disorder : That are psychological disorders characterized by recurrent obsessions or compulsions, severe enough to interfere with person's working house, personal or social functioning. Performing the compulsive ritual releases tension temporarily but resisting the same increases tension. The common obsessions are constant doubts, violence, contamination of dirt and germs.
iii) Attention deficient disorder : The disorder is more common in young boys and is characterized by restlessness, nervousness, difficulty in remaining seated, easy distractibility, inability to follow instructions, under achievement, behavioral problems and tendency to be disliked by other children.
iv) Mood disorder: They are mental disorders characterized by disturbance of mood (depression disorders), bipolar disorder with alternate bouts of low (depression) and high (elation, manic) moods.
Depression is a mood disorder characterized by feeling of sadness, despair / hopelessness, low self esteem, uncontrolled weeping, decline in interest, energy, concentration, changes in sleep pattern and appetite
In bipolar mood disorders, depression alternates with manic mood or mood of exaggerated arousal over – activity and taking of several task simultaneously
v) Schizophrenia – It is a mental illness or disorder which is characterized by
   a) Distorted thoughts, auditory hallucinations, delusion, sense of being influenced by other, feeling of being controlled by outside forces
   b) Shallowness of emotional life, often shifting from one response to another
   c) Progressive deterioration of personality.

(SECTION III : MENTAL HEALTH AND ADDICTION)

d) Laughing and crying at inappropriate occasion.
e) Incoherent / bizarre behavior lasting for few days.

- As the schizophrenias suffer from hallucination and delusions, they are unable to perform even simple jobs.
- Schizophrenia can be due to excessive dopamine production, alterations in neuropeptides, increased ventricular brain ratio and decrease in frontal lobe activity. Recovery is possible with regular use of chloropromazine along with psychosocial therapy.

iv) Borderline personality disorder (BPD) : It is an emotionally unstable personality disorder where the patient suffers from impulsively unpredictable moods, outburst of emotions, uncontrolled anger, impulsive and self damaging acts and repeated conflicts with other. BPD is characterized by a specific patterns. BPD is characterized by a specific pattern of behavioral, emotional, cognitive instability and dysregulation.

- The individual over-react with problem of anger and anger expression. There are episodes of depression, anxiety and irritability. The patients have fear of abandonment. Therefore, besides having chaotic relationship with others, they are always tense and hard to give up. Patient feels boredom or emptiness. They have a recurrent tendency of self mutilation, injury and suicidal tendency.

ADOLESCENE

- It is a period of extreme turbulence (9 -18 yrs in girls and 10-19 years in boys.) which begins with the appearance of first signs of puberty and terminates with cessation of some somatic growth.
- A healthy adolescence is essential for healthy adulthood because adolescence is a preparatory phase for adult life when physiological and physical developments occur in the body. It is accompanied by mental development and behavioral adjustments. The adolescence comes out of the familial environment and begins to find out self identity and position in the outer world.

(SECTION III : MENTAL HEALTH AND ADDICTION)

COMMON PROBLEMS OF ADOLSCENCE

1. Acne
   It is a skin disorder of adolescents of both sexes where eruptions / pustules develop over face, chest and back caused by over activity of sebaceous glands and clogging of skin pores in response to influx androgen. Acne appearing on face makes oneself conscious because of their unsightliness. A proper understanding of their being natural and requiring proper medical treatment helps the aldoscent to come out of the stress.
2. Hypochondria
   It is a mental disorder in which the patient is preoccupied with body functions and normal sensations finding faults and seeking medical attention. Negative diagnostic evaluations and guarantee of good health by physicians increase the patient's concern. Hypochondria usually occur in late developer adolescents due to anxiety syndrome.
3. Moods
   Socially and emotionally, adolescents feel alternate moods for loneliness and gregariousness. Most of it depends upon their friends and social circle. There are periods of social awkwardness, exhibitionism and aggressive self assertion
4. Craze
   There is a tendency to attract attention and appear different from others. Some adolescence become conscious of their weight and tend to eat little resulting in development of various type of deficiencies. Some adolescents develop excessive craving for food, resulting in overeating and obesity
5. Physiological Aberrations
   Some adolescents may suffer from perceptual disturbances or physiological aberrations like irregular/ absence of monthly periods in females. They must be got attended to by experts.
6. Neurasthenia
   It is a chronic mental and physical weakness and fatigue which results inability to concentrate and enjoy. There is development of insomnia, headache, depression and irritability.
7. Phobias
   They are persistent, irrational, intense fears of specific objects, activity or situation. Phobias are of various types like acrophobia (fear of heights),

agoraphobia (fear of open space), arachnophobia (fear of spiders) claustrophobia (fear of confined space, cynophobia (fear of dogs), scotophobia (fear of darkness), social phobia (fear of embarrassment in social situations)

8. Post – traumatic stress disorder
   It is a mental disorder in which is a result of traumatic event like rape, assault, natural disaster, torture, etc in which the patient re-experiences the traumatic event in recurrent intrusive recollection, nightmares or flash – back. A treatment by psychiatrist is required.

9. Addiction
   Addiction is a state of being up to some habit forming articles like drug, alcohol, tobacco smoking or chewing. It begins in adolescents due to curiosity, advertisement, peer pressure, elders, frustrations, or depression, feeling of independence, false belief in enhanced performance etc.

ADDICTION

- Addiction is the state of being given up to an habit , drug, alcohol, tobacco etc. due to becoming physically, psychologically and physiologically dependent upon the same is called addict.
- Medically, addiction is of three types
  (i) Drug addiction / drug abuse
  (ii) Tobacco addiction
  (iii) Alcohol addiction

DRUG ADDICTION OR DRUG ABUSE

- Drug abuse is taking drugs for purpose other than clinical use, in amount, concentration or frequency that impair physical, physiological and psychological functions of the body
- It is intake of drug:
  (i) Without valid medical prescription
  (ii) For non medical purposes
  (iii) In amount, strength, manner or frequency that damages the physical and mental functioning of an individual

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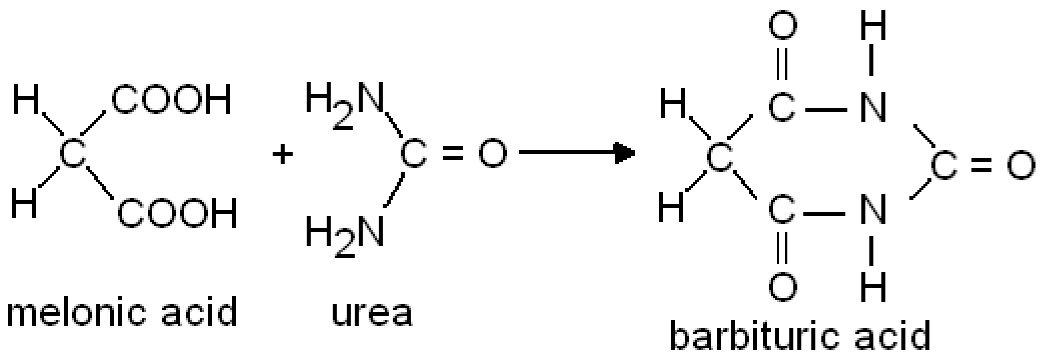
Psychotropic drugs

I) Sedatives and hypnotics

- These are antidepressant drugs or formulation which overcome mental irritability and excitement, assuage pain and lower activity causing drowsiness or sleep. The sleep inducing drugs are also called hypnotic.
  Examples Barbiturates, benzodiazepines, furazepam, echinamate etc.
  - Barbiturates are derivatives of barbituric acid that bind GABA receptors or nervous system and keep the chloride channels open for longer period
  - This depresses activity of excitable cells and induces sleep, hence used as sleeping pills
  - Repeated use leads to skin allergy and coma, while withdrawal may lead to epilepsy.
  - Benzodiazepines are antianxiety as well as sedative drugs.



II) Tranquilizers

- They are antidepressant drugs with calming and soothing effect
- Major tranquilizers are the one which is used to treat psychotic state, minor or common tranquilizers are employed to treat anxiety
- Common tranquilizers are antianxiety drugs that reduce mental tension and fatigue without inducing sleep. Most of them are bezodiazepins like diazepam (valium, calmose), chlordiazepoxide (Librium), lorazepan (larpose), nitrazepam (hypnotex) alprazolam (alprax)
- Reserpine (alkaloid from Rauwolfia serpentina) is used as tranquilizer as well as antihypertension drug. It is however known to be precipitate suicidal tendency, mental depression and epileptic convulsions.
- Tranquilizers bring about relaxation of muscles, block reflexes, increase frequency of chloride opening channels and reduce excitability of cells. Drug

abuse leads to behavioral changes, non-coordination of body movement, headache impairment of memory and sexual functions

- Some drugs have both sedative and tranquilizer properties. They are called tranquilo-sedatives
  Example : Diazepan (valium)

III) Opiate / opioid narcotics

- The opiate narcotics are drugs that suppresses brain activity and relieve pain. They are popularly called pain killers. They also have a sedative and astringent effect. The opiate narcotics are also used for cough relief and for the treatment of vomiting and diarrhoea
- The bad effects of casual opiate users:
  - Drowsiness
  - Reduction in visual activity
  - Constriction of pupil
  - Impaired attentivity
  - Apathy or loss of interest at work
  - Nausea and vomiting
  - Slow breathing
  - Slow pulse
  - Slurred speech
- Its continued use brings about:
  - Impaired digestion and absorption.
  - Loss of weight
  - Sterility
  - Chances of respiratory and cardiovascular arrest.
  - Poor immunity with repeated infection
  - Opiates taken intravenously may cause blocked veins, hepatitis and HIV infection.

(i) Opium

- Opium is the air-dried, milky latex obtained by incising the unripe (fruits) of white poppy plant, papaver somniferum or its varity P.album
- It is the most effective pain killer and also induces a state of euphoria, an exaggerated feeling of well being, also called “high” opium is eaten or smoked. Opium contains some twenty alkaloids. Its main derivatives are morphine and codeine

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(ii) Morphine
- It is the active principle of opium morphine is the most valuable analgesic. It is also used as sedative and an antianxiety agent.
- It is widely used in small doses to relieve pain and induce sleep in case of serious injury, burns, fractures and surgeries.
- Morphine reduces heart beat, blood pressure and urine output, increases blood sugar and causes constipation.

(iii) Codeine
- It may be obtained from opium or morphine. It is in fact, methylmorphine
- It has mild analgesic properties. It does not cause addiction. It is an ingredient of many medicines and cough syrups. A notable side effect of codeine is constipation

(iv) Heroin
- Heroin is a white or brown crystalline semi-synthetic compound prepared from morphine by acetylation. It is the most dangerous apiate. It is thrice as potent as morphine and about 200 times stronger than opium.
- It is highly addictive. It is banned even for medical use except for research.
- Heroin may be orally taken, inhaled or injected. It induces drowsiness and lethargy. It's after effect includes impaired digestion, decreased weight, reduced vision, sterility and total loss of interest in work
- Withdrawal symptoms of heroin include vomiting, diarrhea, shivering, running nose, muscular cramps and epilepsy

(v) Smack
- It is a crude by-product of heroin synthesis and is commonly called 'brown sugar'. The addicts heat the smack powder and inhale its vapour. Smack is diacetylmorphine hydrochloride. It is a stronger analgesic than morphine

(vi) Pethidine
- Pethidine is a widely used narcotic analgesic. It has sedative and euphoric effect also. It has a local anesthetic action.

(vii) Methadone
- Methadone is an orally effective analgesic. Its action is slightly stronger and longer than that of morphine. It causes psychic and physical dependence, but withdrawal symptoms are mild.

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IV) Stimulants

- The stimulants temporarily stimulate the nervous system, make a person more wakeful, alert and active and cause excitement.

(i) Caffeine

- Caffeine is a mild stimulant. It is 1,3,7 trimethylxanthine. It is white, crystalline slightly bitter alkaloid and is commonly taken as beverages – tea, coffee, cocoa and cola drinks. It is also taken in chocolate bar and chocolate confectionary
- Caffeine increases the metabolic rate of neurons, thereby increasing alertness and thought. It improves performance and removes freedom. Higher dose cause nervousness, restlessness and insomnia. Excessive intake of caffeine causes addiction
- A cup of tea contains 30-75 mg of caffeine and 200 ml cola drinks has 25-60mg
- Excessive use causes anxiety, irritability diarrhea, irregular heart beat and decreases concentration. It also causes indigestion and disturbs pancreatic and renal functions
- Withdrawal from caffeine leads to headaches, disturbed sleep, lethargy etc.

(ii) Cocaine (coca alkaloid)

- It is an alkaloid and is extracted from dried leaves and young twigs of the south American shrub called erythroxylon coca. It is also synthesized from ecgonine or its derivatives.
- Cocaine is vaso-constrictor and is, therefore, used as local anesthetic
- Cocaine is CNS stimulant. It increases mental alertness and physical strength. It gives a feeling of well being and delays fatigue. It causes lack of sleep and loss of appetite. It is taken for excitement by addicts. Its use may ultimately lead to mental disorder and insanity. Its overdose may cause severe headache, convulsions and death due to respiratory or cardio-vascular failure

(iii) Carck

- Crack is highly potent smokable derivative of cocaine. When smoked, it results in a brief intense ‘high’ and intense craving for the drug arises in the user
- Crack may cause complication such as heart and nasopharynix damage, seizures and mental problem

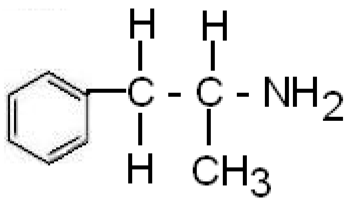
(SECTION III : MENTAL HEALTH AND ADDICTION)

(iv) Betel nut

- Kernel of the betel nut palm. Areca catechu enclosed in betel leaves and mixed with an aromatic paste is chewed extensively in India and Africa. It contains an alkaloid arecoline and red tannin. It is mild CNS stimulant. It stains teeth and gum red.

(v) Amphtamines

- These are synthetic drugs, commonly called antisleep drugs. The amphetamines are strong CNS stimulants and produce increases self-confidence and flow of ideas besides causing excitement and alertness. They are thought to increase physical and mental performances. They are taken by truck driver, students and night workers to keep awake. They impair judgment and vision. This may result in road accidents. They do not remove fatigue. They causes addiction.
- Amphetamine is used as spray or inhalant for relief of cold, asthma etc and are used among the 'dope test' drugs for athletes who use them to stimulate physical and psychological strength. They suppress hunger and are used to reduce weight.
- High does causes sleeplessness which may lead to mental confusion. Their use may produce after effect like nausea and vomiting.



Amphetamines

PSYCHEDELIC DRUGS (Psychotogenic drugs or hallucinogens)

- These are the drugs which induce behavioural abnormalities resembling psychosis by changing thoughts, feelings and perceptions without any actual sensory stimulus e.g. mescaline, psilocybine, LSD, phencyclidine, cannabis compounds.
- They causes optical or auditory hallucinations i.e. illusions, apparent perception of external objects or sounds not actually present.

(SECTION III : MENTAL HEALTH AND ADDICTION)

(i) Mescaline

- It is a water soluble white powder alkaloid which is obtained from the crowns of cactus Lophophora williamsii
- Mescaline cause alteration in mood changes in perception, reveries, visual hallucinations, delusions (false belief), depersonalization (to lose the feeling of one's own reality) etc mescaline also increases temperature and blood pressure

(ii) Psilocybine / Psilocybin

- It is also called indocybin and is obtained from the fruiting bodies of the Mexican mushroom (fungus) Psilocybe Mexicana
- Psilocybin is used as a hallucinogenic agent. Mexican aborigines use psilocybin to induce trances

(iii) LSD

- LSD or D-Lysergic acid diethyamide-15 is crystalline amidated alkaloid derived from ergot, an extract of fruiting body of fungus Claviceps purpurea
- LSD is smoked by the addicts and causes nightmares, hallucination, floating sensation, chronic psychosis and severe damage to the central nervous system. It may cause unconsciousness and even death. LSD also brings about chromosomal and foetal abnormalities. Pathological condition caused by LSD abuse or by eating graxin affected by ergot is called ergotism. An LSD dependent person can be readily identified by incoherence in writing.
- LSD is used to induce contraction of involuntary uterine muscle, for checking haemorrhage and to alleviate migraine.

(iv) Hemp or cannabis compound or cannabinoid

- Four drugs, namely bhang, ganja, charas and marijuana, also called marihuana, are obtained from the dried leaves and flower of the hemp plants, cannabis sativa, commonly called bhang.
- The most active principle of hemp plant is tetrahydrocannabinol (THC). Hemp products may lead to heroin addiction
- The receptors for cannabinoids are mainly present in brain
- There are four types of hallucinogenic products.
    - Bhang: It is fresh / dried leaves and flowering shoots of both male and female plant. Cannabis indica used as ingredient of a drink or other food article.

(SECTION III : MENTAL HEALTH AND ADDICTION)

- Ganja / marijuana: It is dried unfertilized female inflorescence with stem of hemp plant cannabis sativa. Usually smoked in cigarettes and pipe.
- Charas / Hashish : It is resin collected from flowering tops of generally female plant cannabis sativa which is usually smoked with tobacco.
- Hash oil : It is a lipid soluble plant extract and highly concentrated. The active psychoactive substance is Δ9-tetrahydrocannabinoid or THC. Its concentration is 5mg/cigarette in case of marijuana, 0.5-6 in bhang, 8-12% by weight of hashish and 25-60% in hash oil. It is quickly absorbed in lungs and converted to psychedelic chemical, 11-hydrotetrahydro cannabinol in liver. Excretion occurs through faeces.

- Use of bhang, ganja or charas leads to light headiness, pleasure, anxiety, fearfulness, suspiciousness, dry mouth, dilation of pupils, redness of eyes, increased appetite, impaired depth perception, impaired driving ability, chest pain, slowing of time sense, delayed response, increased urination and hallucination.
- Regular use causes addiction. It results in behavior changes, reduced secretion of testosterone, loss of fertility, tachycardia, chronic cough and bronchitis.

(v) Datura and Belladona

- Seeds of Datura stramonium and aerial parts of Atropa belladona are misused for their hallucinogenic properties because of the presence of anticholinergic alkaloids atropine, hysocyamine and scopolamine. However, even in slight excess, they can cause death.

(vi) PCP / Phencylidine

- It is a veterinary medicine used in immobilizing large animal. PCP is available to addict as angle dust or white granular powder. A dose of 5mg causes excitement, analgesia, dysarthria (disorder of impaired motor coordination, flushing distortion of body image, feeing of estrangement, horizontal or vertical oscillation of eye ball, vasospasm of cerebral arteries, insomnia and chronic scizoprenia

(vii) Methylenedioxy methamphetamine (MDMA)

- MDMA has recently becomes popular with students under the name ‘ecstasy’ drug. MDMA has CNS-excitant and hallucinogenic properties. It seems to relax inhibitions and enhance communication.

(SECTION III : MENTAL HEALTH AND ADDICTION)

REASONS FOR DRUG ABUSE

- Curiosity : Reference to drugs, smoking and alcohol in print media, electronic media, movies, internet and by addicts creates curiosity for having a personal experiences.
- Experimentation. There is natural tendency of every child to experiment
- Adventure and excitement : A child may go in for use of drug, smoking and alcoholic drink for the sake of adventure and excitement.
- Family set up: In certain families, use of alcohol, tobacco, sleeping pills and pain killers are common. It induces the youngsters to taste the same
- Group or peer pressure: Friends and peer groups often initiate some adolescents to drugs, alcohol and smoking as a defiance of authority and feeing of independence.
- Feeling of independence: Non –adjustment to social hierarchy may initiate some adolescents to drug, alcohol and smoking as defiance of authority and feeling of independence.
- Progressiveness: There is a false perception that taking of drugs, alcohol or smoking is assign of progressiveness in society.
- Stress: Adolescents are often under stress due to pressure from excelling in academic, sports hobbies and other activities. They fall in for addictive substances in order to overcome stress.
- Overcoming frustration and depression: Set back in academic, professional or family life may lead some person to use alcohol drugs or tobacco for overcoming frustration and depression.
- Unsupportive family structure : An unstable or unsupportive family structure often leads youngsters to drug, tobacco or alcohol addiction.

EARLY WARNING SIGNS OF ADDICTION

- Adolescents, hostelers, unemployed, failed and freshly employed persons are likely to start drug abuse. Family members, parents and teachers must keep an eye over their wards for
  - Change in friend circle.
  - Irregular completion of class-work.
  - Poor performance in examination.
  - Avoiding extracurricular activities.

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- Avoiding families duties and responsibilities.
- Physical changes like poor appetite, frequent sore throat, redness in eyes, weight loss, reduced physical activity.
- Behavioural changes like withdrawn nature mood alterations, unexpected anger and violence, telling lies, etc.
- Arrest by police or other legal problem.

EFFECTS/SYMPTOMS OF DRUG ABUSE

- Behavior : Addicts show reckless behavior. Vandalism and violence. Interest in work, commitment to duty and self confidence is lost.
- Body coordination : Neural and neuromuscular junctions are affected. As a result, coordination of body parts, working of nervous and muscular systems are influenced. Tremors become common.
- Impaired digestion: Addicts have not much interest in eating proper food. Addiction disturbed peristalsis and secretion of digestive enzymes. Therefore digestion is impaired.
- Nausea and vomiting : Disturbed digestive and nervous system leads to frequent nausea and vomiting.
- Damage to liver and kidney : Drugs, alcohol and tobacco affect liver and kidneys as they become involved in metabolism and elimination of their products. This is not their normal function. They, therefore, becomes damaged. The damaged liver undergoes cirrhosis.
- Disturbed respiratory system: There is irregularity in breathing due to effect of addictive substances on the respiratory centre of brain. The disturbance may lead to respiratory arrest.
- Sexual dysfunctions: Insufficiencies develop in reproductive system leading to impotency.
- Abnormal babies: Drug alcohol and tobacco addict mothers are liable to give birth to abnormal babies
- Infections: Taking of drugs intravenously may spread the serious infections like AIDS and hepatitis B due to sharing of infected needles and syringes. They also spread the infections to life partners since the infections may be sexually transmitted.

(SECTION III : MENTAL HEALTH AND ADDICTION)

WITHDRAWAL SYMPTOMS

- Depressed mood : Cheer disappears. There is little interest in happening in the family or work place.
- Anxiety : An internal feeling of nervousness, fear, agitation and uncertainty occurs.
- Nervousness: There is feeling of nervousness courage and comfort are lacking.
- Restlessness: Inability to settle down due to feeling of uneasiness.
- Irritability : The person becomes angry over the slightest pretext.
- Insomnia : Sleeplessness or insomnia occurs.
- Increased appetite: Many persons develop a tendency to eat more.
- Dryness of throat : A feeling of dryness of thought occurs.
- Craving : There is a persistent internal urge to start taking addictive substances.

The withdrawal symptoms are at their peak after 1-2 days of stoppage. They slowly begin to fade and most of them disappear 3-4 weeks after abstinence.

DEADDICTION

- It is treatment of drug habituation and carving for the abused drug. The various steps in the treatment of drug addiction are
  - Pharmacotherapy
  - Psychosocial therapy
  - Health restoration.
  - Psychological treatment.
  - Prevention of relapse or re-addiction
- Pharmacotherapy: It comprises replacement of abusive drugs with less reinforcing and legally available ones.
- Psychosocial therapy : This includes rehabilitation of drug dependent in the form of counseling by relatives, friends and physicians
- Health restoration: Vitamin administration, proper nutrition, restoration of electrolyte balance, proper hydration are the measures aimed at restoring the health damaged by drugs.

(SECTION III : MENTAL HEALTH AND ADDICTION)

- Psychological treatment : Reasons of taking drugs should be explored and sincere efforts should be made to eliminate them.

PREVENTATION AND CONTROL

- Discipline : Good nurturance with consistent discipline but without suffocating strictness reduces the risk of addictions
- Communication: The child must be able to communicate with the parents seeking clarification of all doubts and discussing problems that arise in studies or develop the class, with friends, siblings and others.
- Independent working : Give responsibility to the child for small task and allow him / her to perform independently
- Avoid undue pressure : No child should be asked to perform beyond threshold limits whether in studies, sports or extracurricular activities
- Education and counseling: Stresses, failures, disappointments and problems are part of life. A child has to be trained, educated and counseled to face them as and when they come.
- June 26 is observed as International Day Against Drug abuse and Illicit Trafficking

ALCOHOL ADDICTION

- Regular consumption of alcohol either in low concentration or in high concentration causes dependency on alcohol which is called alcoholism.
- Alcoholism is addiction, chronic overindulgence and dependence on alcoholic drinks which is often associated with defiant behavior.
- A person addicted to alcoholic drink is called alcoholic. Alcohol is chemically ethyl alcohol or ethanol (C_2H_5OH).

DEVELOPMENT OF DRINKING HABIT

- Gesture of defiance to elders, friends and life partners
- Feeling of independence
- Overcoming of frustration of failure
- Unhappy family life
- Curiosity
- Group pressure

(SECTION III : MENTAL HEALTH AND ADDICTION)

- Pleasure or excitement
- Relief from pain
- Desire to do more work

METABOLISM OF ALCOHOL

- Alcohol is absorbed mainly in stomach and proximal part of intestine. Major metabolism occurs in liver
- 2-10 % is excreted through lungs, urine and sweat, 10% is metabolized over smooth endoplasmic reticulum. Rest is converted into acetaldehyde with the help of alcohol dehdrogenase.
- Acetaldehyde is oxidized in cytosol by acetyaldehyde dehydrogenase : It liberates heat. Hence alcohol drinks give them a feeling of flushing.

BLOOD ALCOHOL CONCENTRATION (BAC)

LOW BAC	Flushed face, feeling relaxed and high talkative, drunken behavior
RISING BAC	Effect on cerebellum resulting in clumsy gait, boisterous, loss of motor coordination so that driving ability is impaired
HIGH BAC	Blurred tunnel vision, slurred speech, aggressive behavior. Severe intoxication may result in unconsciousness or even coma

EFFECTS OF ALCOHOLISM

1. Gastric disorder : Alcoholism causes gastric ulcers and inflammations of gastric mucosa.
2. Depressant : Alcohol is generally depressant and reduces efficiency of all organs
3. Arterial dilation : The arteries undergoes dilation, becomes rigid and brittle.
4. Energy : Alcohol is oxidized to release energy which is dissipated from skin making face flushy.

(SECTION III : MENTAL HEALTH AND ADDICTION)

5. Blood sugar : Alcohol addiction reduces level of blood sugar so that nutrient supply to different tissue become deficient.
6. Neuritis : There is inflammation of nerve axon.
7. Babies : Alcoholic mothers give birth to unhealthy, under weight and abnormal babies.
8. Kidneys : Urine is hyper osmotic. This disturbs kidney functions.
9. Breathing : Excess intake of alcohol slows down breathing.
10. Blood: RBC size increases but there is reduced number of erythrocytes, leucocytes and blood platelets.

PSYCHOLOGICAL EFFECTS

1. Amnesia: continuous use of alcohol leads to decreased mental functions. Forgetfulness increases.
2. Suspiciousness: Due to decreased vigour and increased forgetfulness, an alcoholic develops suspiciousness.
3. Accidents: Alcoholics often cause industrial and traffic accidents.

SOCIAL EFFECTS

1. Antisocial behavior: under the influence of alcohol, inhibitions, conscience and morals are often shed leading to all type of antisocial behavior.
2. Absenteeism: Addiction of alcohol leads to loss of interest in work.
3. Neglect of family : An alcoholic is self centered and stops bothering about other members of the family.

DEADDICTION

Alcohol dependence becomes both psychological and physiological. Therefore, withdrawal symptoms are quit apparent -insomnia, anxiety, tremor, irritability, gastric problems. In some cases the symptoms are more sever-hallucinations, confusion and seizures.

1. For deaddiction, psychotherapy or counseling is very important.
2. Patient is provided with thiamine rich diet and brain depressants like benzodiazepines.
3. Patients are also given disulfiram or carbimide. It causes violent reaction if alcohol is taken. The phenomenon is called aversion treatment.

- Mineral nutrition is the absorption, distribution and metabolism of various inorganic substances or minerals by plants for their growth, development, structure, physiology and reproduction. The first study in inorganic or mineral nutrition was carried out by Van Helmont in 1648.

HYDROPONICS

- The soilless production of plants is called hydroponics. Plants are raised in small tanks of concrete and metal. The tanks are covered over a wire netting or gauze. They are filled up with a water solution containing appropriate quantities of all mineral elements. The solution is changed from time to time. It has a mechanism for aeration and circulation. Iron is added as Fe-EDTA otherwise it gets precipitated, especially in alkaline pH. The agent which keeps metals in a soluble state is called chelating agent or ligand. EDTA (Ethylene diamine tetracetic acid) is one such agent. Fe-EDTA complex is called chelate. As soon as the plants enlarge they are tied to the roof of the chambers by means of string. Hydroponics is useful in area having thin, infertile and dry soils. They conserve water. Hydroponics can regulate pH optimum for a particular crop, control soil borne pathogens, avoid problems of weeding and obtain consistently better yield. Out of season, vegetables and fruits can be obtained. However the cost of setting up of a hydroponic system is very high.
- In tank system hydroponics, the roots are immersed in nutrient solution and air is bubbled through the solution. In film technique of hydroponics, plants are grown in a trough or tube having a thin film of recirculated nutrient solution. In aeroponics, roots are suspended in air over the nutrient solution which is whipped into nutrient mist (cloud of moisture in air) by a motor driven motor.
- Hydroponics or soilless culture helps to know:
  - The essentiality of mineral elements
  - The deficiency symptoms developed due to non-availability of particular nutrients.
  - Toxicity of plat when nutrient is in excess
  - Possible interaction between different elements present in plants
  - The role of essential elements in metabolism of plant.

SAND CULTURE

- In this method, sand is used as rooting medium and nutrient solution is added to it.
- This method has following weakness:
  - The sand being highly alkaline in nature, has to be treated with acid before use.
  - The sand gets very warm during summer and very cool in winter, hence may cause injury to the root system
  - The water holding capacity of sand is low hence it requires frequent watering.

ESSENTIAL ELEMENTS

- An essential element is the one which has a specific structural or physiological role and without which plants cannot complete their life cycle.
- 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) Element cannot be replaced by another element.
- Minerals salts dissolved in soil solution are constantly passing downwards along with percolating (gravitational) water. The phenomenon is called leaching.
- Functions of essential minerals are :
  (i) Constitute of organic molecules example C,H,O,N,P,S,Fe,Mg, Ca
  (ii) Oxidation – Reduction reaction. example Fe and Cu, with variable valency
  (iii) Catalytic effect: Component or cofactors of enzyme example Zn, Cu, K, S etc.
  (iv) Osmotic pressure: Minerals slats and their ions present in cell sap exert an osmotic pressure for maintaining turgidity of plants and absorption of water
  (v) Turgor movements: They are mainly controlled by influx and efflux of K^+ ions
  (vi) Membrane permeability: Na^+, K^+ ions are known to increase membrane permeability while Ca^{2+} and other divalent decreases the same

- Essential elements are differentiated into

1. Macro-element (macro nutrients)
   They are those essential elements which are required by plants in quantity of more than 1 milligram/ gram or 10 mmol/kg of dry matter. Essential macronutrients area nine in number – C, H, O, N, P, K, S, Mg and Ca. Silicon and sodium occur in some plants in the range of macronutrients
2. Micro-element (micronutrient)
   They are those essential elements which are required by plants in quantity of less than 1 milligram or 10m mol/kg of dry matter. Micronutrients are eight in number Fe, Mn, Zn, Cu, Mo, B, Cl and Ni. Functional elements which occur in the range of micronutrients are Cobalt, Vanadium and Aluminium.

MAJOR ELEMENTS

CARBON, HYDROGEN AND OXYGEN

- The three elements are taken up by the plant in the form of CO_2 and water.
- All the components of living organism contains C, H, O particularly carbohydrates, lipids and nucleic acid.
- Oxygen is terminal electron acceptor in respiration. Full respiratory activities can continue even when the concentration of oxygen is just 1%. The pH is finally governed by hydrogen.

NITROGEN

- Nitrogen is generally taken up by the plant in the form of nitrates (NO_3^-), nitrite (NO_2^-) and ammonium salts and rarely in molecular form.
- It is present in amino acids, which constituent for proteins, in purines and pyrimidines that form nucleic acids, coenzyme A, Cytochromes, alkaloids and vitamins (B_1, B_2 , B_6)

Deficiency symptoms

- Chlorosis (yellowing) first appearing in older leaves then in younger leaves.
- Decrease in protein synthesis.
- Decrease in cell size and cell division.
- Plants remains stunded.
- Delay or complete suppression of flowering.

PHOSPHORUS

- The plant absorbs it in the form of phosphate ion.
- The acidic soil has monovalent form ($H_2PO_4^-$) the intermediate pH soil has divalent ion (HPO_4^{-2}) and alkaline has trivalent form (PO_4^{3-}).
- At pH 6, both monovalent and divalent phosphate ion are present.
- IT is a constituent of nucleic acids, phospholipids, coenzymes I and II (NAD, NADP), coenzyme A, found in phosphoproteins.
- The main function of phosphorus is energy transfer.
- The carbohydrates becomes more reactive due to the presence of phosphorus.
- Heavy concentration of phosphorus is found in the meristems.

Deficiency symptoms

- Accumulation of anthocyanin.
- Older leaves becomes chlorotic while younger leaves remain green.
- Formation of necrotic (dead) spots on the lamina of leaves, petioles and fruits
- Decrease in protein synthesis.
- Plants becomes stunted i.e. decrease in shoot growth.
- Root growth also restricted.
- Distortion in leaf shape.
- Slow maturation of fruits.
- Premature leaf fall.

SULPHUR

- The soil has sulphur in both organic and inorganic forms.
- It is taken up by the plant as SO_4^-.
- The sulphate ions are weakly absorbed.
- With the increase of soil pH, the adsorption decrease.
- The organic sulphur becomes available to plants through biological oxidation as the microorganisms change it to sulphuric acid.
- The sulphur is present in amino acids
- It is important in FeS proteins in photosynthesis and ferrodoxin synthesis.

Deficiency symptoms

- Chlorosis (yellowing due to degradation of chlorophyll) followed by anthocyanin development; the younger leaves show chlorosis before older ones.
- Reduced growth with hard woody stem.
- Extensive growth of root system.
- Decrease in stroma lamellae and increase in grana stacking.
- Increase in starch and sucrose accumulation and decrease in reducing sugars.

POTASSIUM

- Potassium is present in the soil in fixed, exchangeable and soluble forms.
- It is absorbed by the plant in ionic form (K^-).
- It is the commonest free ion in the cell which is found in abundance in the meristems.
- It plays a significant role in closing and opening of stomata.
- It also maintains differential permeability of cytomembranes and apical dominance.
- It is needed by enzymes DNA polymerase.
- It acts as enzyme activator in peptide bond synthesis.
- It is important in the enzymatic reactions of respiration, photosynthesis, chlorophyll synthesis, etc.
- It is important in the enzymatic reactions of respiration, photosynthesis, chlorophyll synthesis etc.

Deficiency Symptoms

- Plant growth becomes stunted due to shortening of internodes
- Mottling and chlorosis first appears in older leaves
- Necrosis at the tip and margin of leaves, leaf tip curves down.
- Destruction of pith cells of tomato and increased differentiation of phloem elements.
- Decrease in carbohydrate metabolism and increase in respiration.

CALCIUM

- Calcium is the cation available in fertile soil in plenty.
- The middle lamella is composed of calcium and magnesium pectate.
- It also influences permeability character of cell membrane.

- The calcium salt of lecithin is perhaps involved in the formation of cell membranes.
- Calcium is involved in organization of mitotic spindle.
- It acts as enzyme activators.

Deficiency symptoms

- Ultimate death of meristems as found in shoot, leaf and root tips.
- Chlorosis along the margins of younger leaves.
- Distortion of leaf shape.
- Roots poorly developed.

IRON

- It’s availability depends upon the pH of the soil.
- Due to increased soil pH, the plants begins to show iron deficiency symptoms.
- It is present in cytochromes and freedoxin.
- It is also component in various peroxidases and flavoprotein.
- It is also needed in chlorophyll synthesis.

Deficiency symptoms

- Extensive interveinal chlorosis in leaves; only the young leaves.
- Inhibition of chloroplast formation.
- Aerobic respiration severely affected.

MAGNESIUM

- It is present in soil in water soluble form as silicates.
- It is component of chlorophyll and an important building substances for ribosomal subunits.
- It acts as an activator for several enzymes and also needed by CO_2 fixing enzymes.

Deficiency symptoms

- Interveinnal chlorosis is older leaves.
- Development of anthocyanin and necrotic.
- Development of collenchymas and depression of internal phloem.

MINOR ELEMENTS

MANGANESE

- It exists in soil in bivalent and tetravalent forms.
- In alkaline soil, due to oxidation, this element becomes unavailable to plants
- It acts as an enzyme activator in respiration and nitrogen metabolism.

Deficiency symptoms

- Chloroplast loses chlorophyll.
- Starch grains become yellow-green, vacuolated and finally degenerate.

BORON

- It is absorbed by plants as borate.
- It is involved in the transport of carbohydrates.
- It is required in pollen germination, cell differentiation etc.

Deficiency symptoms

- Death of shoot tips because boron is needed for DNA synthesis.
- Leaves develops a thick coppery texture, they curve and become brittle.
- Root growth is arrested and flowers not formed.

ZINC

- It is absorbed in ionic form.
- It availability decrease with the rise of soil pH.
- It plays a significant role in protein synthesis and also acts as enzyme activators.

Deficiency symptoms

- Interveinal chlorosis in mature leaves.
- Rosette due to shortening of internodes.
- White bud of maize.
- Mottled leaf in apple and walnut.

COPPER

- The amount of copper found in the soil solution is very low.
- It is taken in ionic form.

- It is component in phenolases, lactases and ascorbic oxidases.
- It participates in the electron transport chain in photosynthesis.

Deficiency symptoms

- Necrosis at tip of young leaves.
- Exanthemma in fruit trees.
- Wilting of entire plant occurs under acute shortage.

MOLYBDENUM

- It is present in the soil as molybdate ion.
- It is a component of nitrogenase and thus brings about fixation of gaseous nitrogen.
- It also participates in phosphorus metabolism.

Deficiency symptoms.

- Fall in the ascorbic acid content of the plant.
- Mottling and nerosis first in older leaves and then younger leaves.
- May lead to abscission of flowers.
- Whip tail of cauliflower.

CHLORINE

- Like manganese, it also needed in photolysis of water.

Deficiency symptoms

- Chlorosis of leaves followed by necrosis and bronzing of leaves.
- Stunting of root tips flower abscission, reducing fruiting.

FUNCTIONAL ELEMENTS

SODIUM

- It is also needed by blue –green algae for growth.
- In higher plants, it maintains differential permeability of cytomembranes. It also participates in nitrogen metabolism.
- C_4 plants also require sodium.

SILICON

- It is present in grass, equisetum.
- It is necessary for growth of sunflower and barley.

ALUMINIUM

- It is found to improve growth.
- Many plants are known to possess sensitivity to aluminium toxicity.

COBALT

- It is a component of vitamin B_{12}.
- A few blue-green algal and bacterium Rhizobium, a symbiotic nitrogen fixing bacteria of leguminous nodules also requires cobalt.

GALLIUM

- Fungus Aspergillus niger requires gallium for their growth.

SELENIUM

- Astragalus acts as selenium indicators.

IODINE

- Some marine algal like Laminaria accumulate iodine in huge amounts.

VANADIUM

- It is also necessary for growth of certain plants.

TOXICITY OF MICRONUTRIENTS

- Toxic concentration which retards the dry weight of tissue by about 10% is called toxic. This toxicity level differs from plant to plant.
  Example : In soybeans, manganese is toxic at concentration beyond 600 μg/g but sunflower plants shows toxicity symptoms only beyond 5300 μg/g.
- Some time due to excess of an element, uptake of another element may be reduced.
- Manganese competes with iron and magnesium for nutrient uptake. It also competes magnesium for binding with enzymes. So manganese in toxic concentration leads to deficiency of iron and magnesium.

ABSORPTION OF MINERALS

- Mineral absorption can be passive or active. Minerals usually occurs into two forms, cation and anion.
- There are two phases of mineral absorption, initial and metabolic. In the initial phase, there is rapid uptake of ions into the outer or free space of cells comprising cell walls. Ions absorbed in free space are fully exchangeable. In the metabolic phase, the ions pass into inner space comprising cytoplasm and vacuoles of cells. After entering inner space, the ions do not remain freely exchangeable with those of external medium.
- Entry of ions into outer space is passive absorption as no entry is required for it. Passage of ions into inner space requires metabolic energy. It is therefore an active absorption. Movement of ions into cells is called influx while movement of ions out of the cells is called efflux.

PASSIVE MINERAL ABSORPTION

- Passive mineral absorption is absorption of minerals by physical process which do not involve any direct expenditure of metabolic energy. It can occur through
  (a) Diffusion: It is passive movement of minerals along the gradient of their chemical potential across the cell membranes. Diffusion is of two types.
    (i) Passive diffusion – Membrane have pores and channel for diffusion. No energy is required for opening of channels.
    (ii) Facilitated diffusion – Cell membranes possess permeases or special protein particles that facilitate the passage of mineral ions over them without involving expenditure of energy.
  (b) Mass flow: Minerals are swept into root and passed into plant parts along the current of water caused by transpiration pull.
  (c) Donnan equilibrium: Occurrence of a non-diffusible ion in the cell interior will cause the similarly charged external ion to diffuse inwardly. The other ion will also diffuse inwardly till the multiple of free cations and inions in the interior becomes equal the multiple of free cations and anions in the external medium.
  (d) Ionic exchange: The root passes out ions in order to absorb similarly charged cations and anions.

ACTIVE MINERAL ABSORPTION

- It occurs against concentration, chemical potential gradient. Metabolic energy is utilized for this. Tare of respiration increases to meet the requirement of energy. The excess of respiration is called slat respiration. It provides extra ATP for active absorption.
- Active mineral absorption can cause accumulation of minerals. The process involves specific carriers and vesicles. A carrier is activated by energy from ATP, picks up ions from surface of membrane, froms ion-carrier complex, moves across the membrane and reach the other surface. Here, the complex breaks and ions are released. Active transport can be uniport (single ion), symport (two in the same direction) and antiport (two in opposite direction).

ION TRAFFIC INTO ROOT

- Typically, inorganic ions are taken up from the soil water via the roots to the xylem. This takes place by two pathways- apoplast and symplast.
- The apoplastic pathway, basically involves diffusion and bulk flow of water from cell to cell through spaces between cell wall polysaccharides. The ion entering the cell wall of epidermis, cell wall of pericycle and finally accumulate in xylem vessels.
- In symplastic pathway, ions entering the cytoplasm, cortex, endodermis of pericycle, through plasmodesmata and lastly to xylem vessels.

FACTORS AFFECTING SALT ABSORPTION

- Temperature – The rate of salt absorption is directly proportional to temperature within cardinal limits
- Light – The effect of light is indirect. When there is sufficient light, more photosynthesis occurs. As a result more food energy becomes available and uptake increases.
- Oxygen – The increased oxygen tension helps in increased uptake of salts. No active salt uptake is possible in absence of oxygen.
- Growth – The growth of a plant or tissue provides more surface area and binding sites for mineral ions. As a result, salt absorption is enhanced.
- pH – A plant readily taken up monovalent ions. If pH becomes alkaline, the absorption of bivalent and trivalent ion is favoured.
- Mineral interaction – The absorprtion of one type of ion is affected by other types. The absorption of K^+ is affected by Ca^{2+}, Mg^{2+} and other polyvalent ions.

However, the uptake of K^+ and Br^- becomes possible in presence of Ca^{2+} ions. There is mutual completion in the absorption of K, Rb and Cs ions

NITROGEN METABOLISM

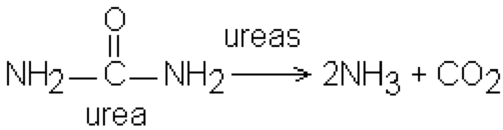
- A regular supply of nitrogen to the plants maintained through nitrogen cycle.

ABIOLOGICAL NITROGEN FIXATION

- Abiological nitrogen fixation is of two types:

Industrial nitrogen fixation

- Nitrogen and hydrogen combine to form ammonia industrially, under pressure and temperature.



Natural abiological nitrogen fixation

- Due to lightening and thundering of clouds, N_2 and O_2 of the air react to from nitric oxide (NO)
- The nitric oxide is further oxidized with the help of O_2 to form nitrogen peroxide (NO_2)
- NO_2 combines with H_2O to form nitrous acid (HNO_2) and nitric acid (NHO_3)
- The acid falls along with rain water.
- Now it acts with alkaline radicals to form water soluble NO_3^- (nitrates) and NO_2^- (nitrides)

  $N_2 + O_2 \rightarrow 2NO$ (in presence of lightening)

  $2NO + O_2 \rightarrow 2NO_2$

  $2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$

BIOLOGICAL NITROGEN FIXATION

- Some blue green algal (Anabaena, Nostoc) symbiotic bacteria (Rhizobium) and free living bacteria (Azotobacter) pick up atmospheric nitrogen, reduce it to ammonia, combines with organic acids to form amino acids

Free living nitrogen fixing bacteria

- Azotobacter, Beijerinckai (both acrobic) and Bacillus, Clostridium (anacrobic) are saprotropjic bacteria that perform nitrogen fixation.

- Desulphovibrio is chemotrophic nitrogen fixing bacterium.
- Rhodopsludomonas, Rhodospirillum and Chromatium are nitrogen fixing anaerobic photoautrophic bacteria.

Free living nitrogen fixing cyanobacteria

- Many free living blue-green algae perform nitrogen fixation. Example, Anabaena, Nostoc, Calothirs, Aulosira, trichodesmium.
- Aulosira ferilissima is the most active nitrogen fixing rice field while cylinderospermum is active in sugarcane and maize fields.

Symbiotic nitrogen fixing cyanobacteria

- Anabaena and Nostoc species are common symbionts in lichens, Anthoceros, Azolla and cycad roots.
- Azolla pinnata (a water fern) has anabaena, azolla in its fronds. It is often inoculated in rice field for nitrogen fixation.

Symbiotic nitrogen fixing bacteria

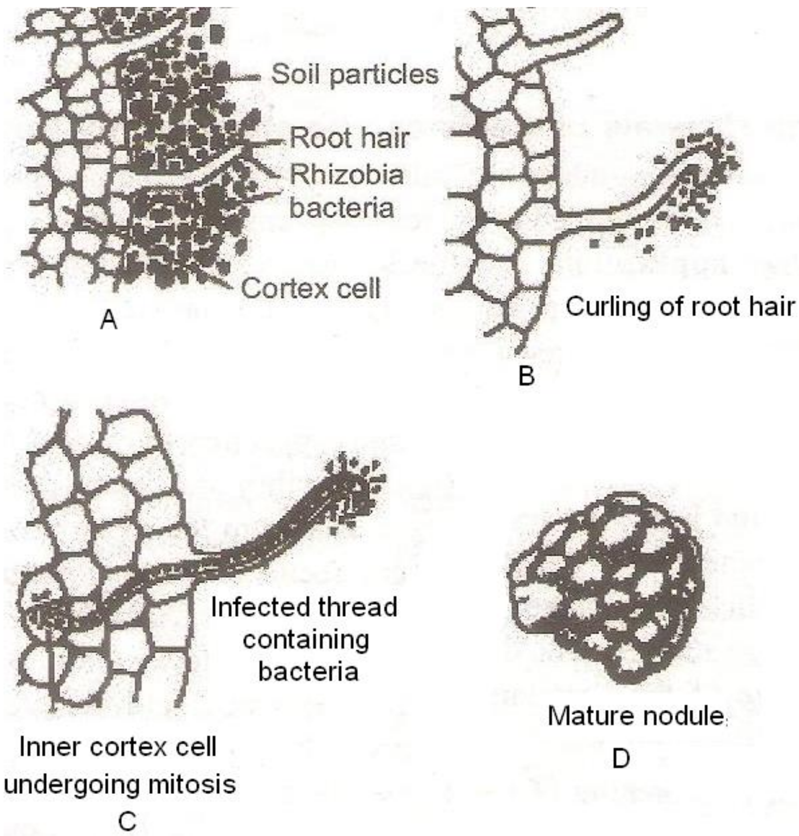
- Sesbania rostrata has Rhizobium in root nodules and Aerorhizobium in stem nodules.
- Frankia is symbiont in root nodulues of several non-legume plants like casuarinas (Australian pine), Myrica and Alnus (Alder)
- Xanthomonas and Mycobacterium form symbiotic association with the leaves of several members of rubiaceae and myrsinaceae.
- Rhizobium is the most important for crop lands because it is associated with pulses and other legumes of family fabaceae.

SYMBIOTIC NITROGEN FIXATION

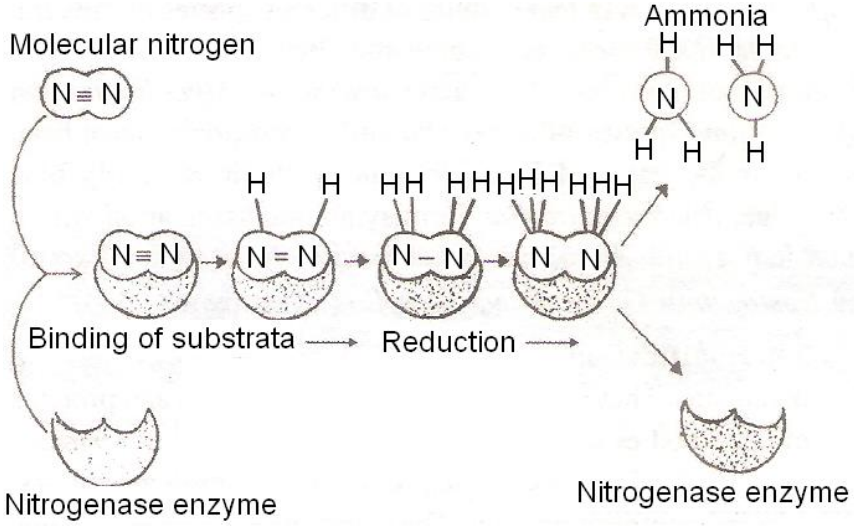
- Symbiotically bacteria are found in the root nodules of the members of family leguminosae. The best known nitrogen fixing symbiotic bacterium is Rhizobium leguminosaeum.
- Members of the family leguminosae such as beans, peas , grarams, soyabeans, etc on primary roots bears small nodules like swelling. Rhizobium penetrates to the cortex of root through infection thread. Simulated to divide more vigourously to form nodules on the root.
- Roots of the legume secrete chemical attractants. Bacteria collect over the root hairs, release nod factor that cause curling of root hairs around the bacteria. Infection thread grows alongwith multiplication of bacteria. It

branches and its end comes to lie opposite protoxylem points of vascular strand. The infected produces swellings or nodules. Nodule formation is stimulated by auxin produced by cortical cells and cytokinin liberated by invading bacteria. The infected cells and cytokinin liberated by invading bacteria. The infected cells enlarge. Bacteria stop dividing and form irregular polyhedral structures called bacteroids. However, some bacteria retain normal structures, divide and invade new areas.

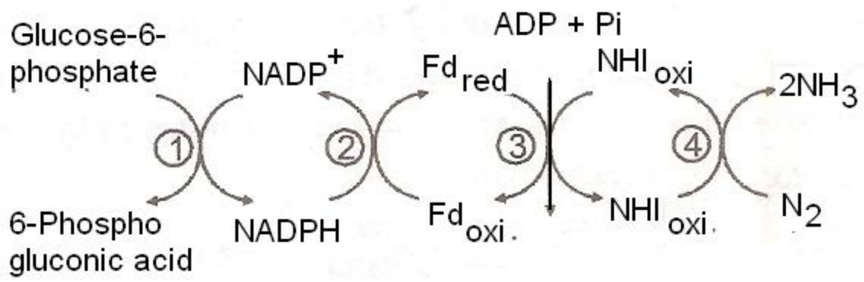
- If an infected cell bacteruiods occur in groups surrounded by host membrane. When a section a root nodules is observed, the presence of a pigment, leghaemoglobin is seen to impart pinkish colour to it. This pigment is closely realted to hemoglobin and helpful in creating optimal condition for nitrogen fixation. Like haemoglobin, leghaemoglobin is an oxygen scavenger. Fixation of nitrogen is done with the help of enzyme nitrogenase, which functions under anaerobic conditions. Leghaemoglobin combines with oxygen and protects nitrogenase.



- It is believed that during the process of nitrogen fixation, the free, atmospheric nitrogen is first bound to the enzyme surface and is not released until it is completed reduced to ammonia. Nitrogen fixation requires reducing power like NADPH, source of energy like ATP, enzyme nitrogenase and compounds for trapping ammonia formed by reduction of dinitrogen enzyme nitrogenase has iron and molybdenum. Both of them take part in attachment of a molecule of nitrogen. Bonds between the two atoms of nitrogen become weakened by their attachment to the metallic components. The weakened molecule of nitrogen is acted upon by hydrogen from a reduced coenzyme. It produces diamide (N_2H_2), hydrazine (N_2H_4) and then ammonia ($2NH_3$) Ammonia is not liberated. It is toxic in even small quantities. The nitrogen fixers protect themselves from it by providing organic acids

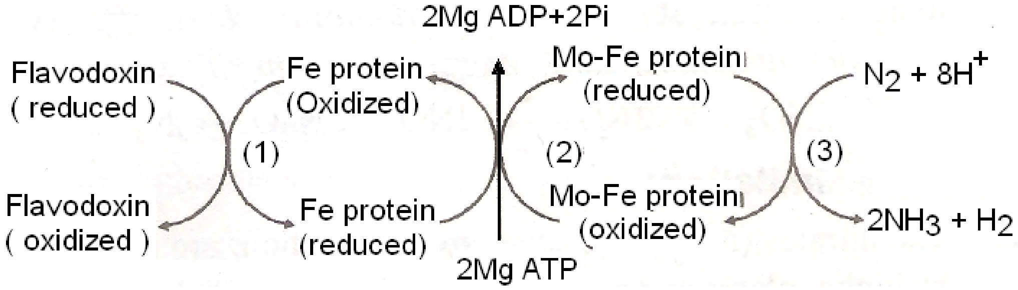


- The reduction of nitrogen into ammonia by nitrogenase in bacteroids depend upon availability of ATP and reduced substrate capable of donating hydrogen atoms to nitrogen. ATP is generated in bacteroid respiratory chain system and reduced substratory chain system and reduced substrate is obtained from host cells. Glucose-6-phosphate is considered to be reduced substrate for the process and reduced NADP together with ferredoxin function as electron carriers. The ATP interacts with non-heme iron (NH1) protein component of nitrogenase and bring about conformation change to convert it to a powerful reluctant. This powerful reductant becomes capable of transferring electrons to reduce N_2 into NH_3.



- The in vitro studies on the process reveled that at least four molecules of ATP are hydrolysed for each pair of electrons transferred to nitrogen. Thus, the reduction of one molecule of nitrogen into molecules of ammonia requires twelve molecules of ATP because six electrons are required per molecule of nitrogen reduced.

$N_2 + 6H^+ + 6e^- + 12ATP \rightarrow 2NH_3 + 12ADP + 12\ Pi$



- Ammonification – It is carried out by decay causing organisms. They act upon nitrogenous excretions and proteins of dead bodies of living organisms. Example, Bacillus ramosus, B. Vulgaris, B. mesentericus, Actinomyces. Proteins are first broken up into amino acids organic acids released in the process are used by micro-organisms from their own metabolism.

$$\text{Proteins} \xrightarrow{+H_2O} \text{R- NH2} \xrightarrow{+H_2O} \underset{\text{organic acid}}{\text{ROH}} + \underset{\text{ammonia}}{\text{NH3}}$$

- Nitrification – it is a phenomenon of conversion of ammonium nitrogen to nitrate oxygen. It is performed in two steps – nitrite formation and nitrate formation. Both the steps can be carried out by Aspergillus flavus. In the first step, ammonium ions are oxidized to nitrites by Nitrosococcus, Nitrosomonas. Nitrites are changed to nitrates in the second step by nitrocystis, Nitrobacter.

$$2NH_3 + 3O_2 \xrightarrow[\text{Aspergillus flavus}]{\text{nitroscoccus , nitrosomonas}} 2NO_2^- + 2H^+ + H_2O + \text{energy}$$

$$2NO_2^- + O_2 \xrightarrow[\text{Aspergillus flavus}]{\text{Nitrobacter Nitrocystis}} 2NO_3^- + \text{energy}$$

- Denitrification – under anaerobic conditions, some microorganism use nitrate and other oxidized ions as source of oxygen. In the process, nitrates are reduced to gaseous compounds of nitrogen. The latter escape from the soil. Common bacteria causing denitrification of soil are Pseudomonas denitrificans, Thiobacillus denitrificans, micrococcus denitrificans.
$2NO_3^- \rightarrow 2NO_2^- \rightarrow 2NO \rightarrow N_2O \rightarrow N_2$

NITRATE ASSIMILATION

- The nitrates (NO_3^-), produced by nitrification, are absorbed by higher plants and assimilated by the process called nitrate assimilation.
- The nitrates absorbed by plant roots get converted into amino acids and amides before incorporating acids proteins and other macromolecules.
- Reduction of nitrate into ammonia is called nitrogen assimilation.
- The overall summary equation of reduction of nitrate to ammonia is as follows
  NO_3^- + 8 electrons + $10H^+ \rightarrow NH_4^- + 3H_2O$

This process consists of the following two distinct enzymatic steps:

Reduction of nitrate to nitrite

- The reaction is catalyzed by enzyme nitrate reductase and occurs in the cytosol outside any organelle and require NADH as an electron donor, FAD as a prosthetic group, cytochrome b_{557} as an electron carrier and molybdenum (Mo) as an activator of enzyme

$$NO_3 NAD(P)H + H^+ \xrightarrow[\text{FADIFMN}]{\text{Nitrate reductase}} NO_2^- + H_2O + NADP^+$$

Reduction of nitrite

- The reaction is catalysed by enzyme nitrite reductase and the most probable electron donor in the reaction appears to be reduced ferredoxin
- Nitrite reductase requires power and the product of nitrite reduction is ammonia

$$2NO_2^- + 7NAD(P)H + 7H^+ \xrightarrow[\text{ferredoxin}]{\text{nitrite reductase}} 2NH_3 + 4H_2O + 7NAD(P)^+$$

SYNTHESIS OF AMINO ACIDS

- Reductive ammination – In this process, ammonia reacts with α-ketoglutaric acid and forms glutamic acid

$$\alpha\text{-ketoglutaric acid} + NH_4^+ + NAD(P)H \longrightarrow \text{Glutamate} + H_2O + NAD(P)$$

- Catalytic amidation – In the presence of enzyme synthestase and ATP, ammonia combines with amino acid glutamate to form amide glutamine. Glutamine reacts with α-ketoglutarate in the presence of reduced coenzyme to form two molecules of glutamate.

$$\text{Glutamate} + NH_4^+ + \text{ATP} \xrightarrow[\text{synthetase}]{\text{Glutamine}} \text{Glutamine} + \text{ADP} + \text{Pi}$$

$$\text{Glutamine} + \alpha\text{-ketogluarate} + \text{NAD(P) H} \xrightarrow[\text{synthetase}]{\text{glutamine}} 2\ \text{Glutamine} + \text{NAD(P)}$$

- Transamination – It involves the transfer of amino group from one amino acid to the keto group of organic acid. Glutamic acid is the main amino acid from which other 17 amino acids are formed through transamination. The enzyme responsible for such reaction is known as transaminase.

1.0 Microbes

- Microbes are the micro-organism which have a size of less than 0.1mm. These micro-organisms are omnipresent, they even exist on sites where no other life forms could possibly exist like high salinity (halophytes) deep inside the earth crust where temperature may be as high as 100^{O}C , highly acidic atmosphere and even under layers of snow.
- The term 'microbes' include bacteria fungi, viruses, mycoplasma, blue-green algae, nematodes and even protozoans.
- Microbes can be grown on artificial culture media where they form colonies. During their metabolisms, microbes has been in use by human beings, microbes can also be modified genetically to produce any type of chemicals. Therefore microbes are ideal for biotechnology.

2.0 Microbes in food processing and household products

1) Microorganism like Lactobacillus commonly called as Lactic Acid Bacteria (LAB) is used in preparation of curd from milk. Milk is boiled and cooled to temperature slightly less than 40^{O}C and small quantity of inoculum or curd is mixed. Inoculum or curd contain LAB like *Lactobacillus acidophilus*. These bacterium produce lactase which converts milk sugar lactose into lactic acid. It also partially digest milk protein casein. Lactic acid causes coagulation of protein to form curd. LAB improves nutritional quality of curd by increasing vitamin B_{12}. In our stomach, the LAB play very beneficial role in checking disease causing bacteria
2) Mixture of dosa and idli is allowed to undergo fermentation with the help of *Leuconostoc mesenteroides* and *Streptococcus faecalis* Coconut water is fermented to produce a refreshing drink called

toddy. It is a traditional drink in some part of southern India and is also made by fermenting sap from palms

3) Soybean preparations: (i) Tempeh is Indonesian food formed by fermenting, drying, salting and frying of soybean.
(ii)Tofu are cheese-like products of soybean obtained after fermentation with mucor species
(iii) Soy sauce is flavored salted brown sauce that is obtained from a mash of soybean, wheat and wheat bran fermented with the help of *Aspergillus oryzae*, *Lactobacillus. Saccharomyces rouxii* and *Torulopsis* species.
4) Cheese: Cheese is one of the oldest food items in which microbes are used. The large holes in "Swiss cheese" are due to production of a large amount of CO_2 by a bacterium named Propionibacterium Shermanii. The 'Roquefort cheese' is ripened by growing a specific fungus on them, which gives them a particular flavor. In order to prepare special cheese, such as blue Roquefort and soft camembert, the blue mold, Penicillium is commonly used.
5) Bread: Wheat flower is kneaded. A small quantity of Baker's yeast i.e. *Saccharomyces cerevisiae* is added to it. Yeast can be replaced by *Clostridium* species. The dough is allowed to ferment for a few hours. It leaves or rises. The puffed up appearance is due to production of CO_2 gas. Actually yeast produces three types enzyme – amylase, maltase and zymase complex. Amylase changes a small amount of starch into maltose, maltase changes maltose to glucose. Zymase complex acts on glucose. Zymase complex acts on glucose to form complex to form bubbles of ethyl alcohol and carbon dioxide.
6) Bacteria are used in the separation of fibres of flax, hemp and jute. For this purpose, the stems of plants are submerged in water, where the bacterial activity results in the rotting of softer parts. The tough bast fibres become loosened and easily separated from each other.

7) Sausages : They are fermented meats which possess particular taste due to microbes lactic acid bacterium *Pediococcus cerevisiae*. Lactic acid produced by the bacterium also preserves the sausage

8) Single cell protein (SCP) or probiotics: It is protein rich microbial biomass which can be used as food and feed e.g. *Methylophilus methylotrophus*, SCP has all the essential amino acids. Fat contents is low. Both autotrophs and heterotrophs are used as SCP. Amongst autotrophs, *Spirulina* has become an important food supplement which is used in various forms including tablets. It has 60% proteins, all minerals, vitamins and unsaturated fats. Amongst heterotrophs, yeast and mushrooms are being raised as SCP. There is an increasing use of low cost organic matter for raising SCP like Filamentous fungus *Fusarium graminearum* and common mushrooms. Live microbial food is called probiotic

3.0 Microbes in sewage treatment

- Large quantity of waste water is generated every day in cities and towns. This waste water is also called sewage. In sewage, most of the microorganisms are pathogenic. This huge quantity of sewage or urban waste water is discharged into natural water bodies like rivers and streams after treating in sewage treatment plant (STPs) so as to make it less polluting.
- The treatment of sewage is carried out in following two stages
  (i) Primary treatment: It is a physical process of removal of large and small particles from sewage through sequential filtration and sedimentation. The sewage is first shredded and churned. It is then passed through many screens or skimmers to remove large pieces of organic matter. The sewage is now passed into a large primary settling tank having a gentle slope. Grit, sand and other heavy particles settle down. All solids that undergo sedimentation and screened organic matter constitution and screened organic

matter constitutes primary sludge. Primary sludge can be used for preparing compost or manure directly, or used in generation of biogas. It can also be burnt. The waste water after removing the primary sludge contain fine organic matter. It is passed for secondary treatment.

(ii) Secondary treatment: It involves biological process of microbial degradation of organic matter. There are three main methods –oxidation tanks trickling filter method and activated sludge method. In activated sludge method the effluent from primary settling tank is passed into an aeration tank. It is agitated mechanically. Air is pumped into the effluent. Part of the previous activated sludge is inoculated into it. It contains a large population of aerobic heterotrophic microbes including bacteria, fungi and protozoans. The microbes form flocs and floccules with help of slime. The BOD of the effluent falls to 10-15% of the raw sewage. Biochemical oxygen demand (BOD) refers to the amount of oxygen that would be consumed, if all the organic matter in one liter of water is oxidized by bacteria. Thus, indirectly BOD is a measure of the organic matter present in the water. The greater the BOD of waste water more is its polluting potential. After decrease in BOD, it is taken to secondary settling tank where the flocs undergo sedimentation. The sediment is called activated sludge. The supernatant is allowed to pass into rivers and streams. Activated sludge is taken to anaerobic sludge digesters along with the primary sludge. Here, anaerobic microbes act upon organic matter to first produce monomer and then organic acids. Methanogens then convert the latter into a mixture of gases like methane, hydrogen sulphide and carbon dioxide. The gaseous mixture is called biogas. It is inflammable and is used as source of energy. The spent sludge is used as a manure, land fill or can be burnt. Pathogens present in the original sewage, get killed during anaerobic digestion.

4.0 Microbes in biofuels

- Biofuels are fuels of biological origin, which are used for the production of heat and other forms of energy. The energy derived from the biofuels is called bioenergy. Fuel wood and biogas are the sources of bioenergy. Biologically generated hydrogen, methane, ethanol, butanol and diesel are referred as bio-hydrogen, bio-methane, bioethanol and biodiesel respectively
- The advantages of biofuels are
  1. These are renewable energy resources
  2. They release relatively low greenhouse gases including carbon dioxide emission than fossil fuels
  3. The raw materials used in biofuel production are often wastes, including municipal waste. Therefore, it helps in pollution control

4.1 Biogas or Gobar gas

- Biogas is a methane rich fuel gas produced by the anaerobic breakdown or digestion of biomass with the help of methanogenic bacteria. It is mainly produced from the animal waste. The main ingredient of biogas is methane (CH_4, 50-70%). Other components are carbon dioxide (CO_2, 25-35%), hydrogen (H_2 1-5%), nitrogen (N_2, 2-7%) and hydrogen sulphide traces. Besides generation of biogas, biogas plants also produce manure which is equivalent to manure produced by conventional method of dumping biomass in open.
- The technology for biogas plants was developed in India by IART (Indian Agriculture Research Institute) and KVIC (Khadi and village industries commission)
- A family sized biogas plants has a large (10-15 feet deep) concrete or brick lined air tight cylindrical tank called digester. It has a

charge pit for passage of slurry into digester, a floating gas holder of metal with an outlet for gas and a pit for removal of sludge or manure

- Various microorganisms are involved in production of biogas are as follows

1. Hydrolytic and fermentative bacteria

   These include both obligate and facultative anaerobes, which can hydrolyse and ferment the organic materials and produce organic acid, carbon dioxide and hydrogen

$$\boxed{\begin{array}{l}\text{Cellulose, starch, proteins}\\ \text{acids+hydrogen}\\ \text{lipids, nucleic acids}\end{array}} \xrightarrow[\text{Hydrolytic fermentative bacteria}]{\text{Group I}} \boxed{\begin{array}{l}\text{Organic acids +}\\ \text{Carbonic}\end{array}}$$

2. Syntrophic hydrogen producing bacteria:

   This group includes obligate hydrogen producing or obligate proton producing bacteria, which breakdown, organic acids having more than two carbon atoms in their chain to produce acetate, carbon dioxide and hydrogen

$$\text{Organic acids} \xrightarrow[\text{Group II}]{\text{Low } H_2\text{, partial pressure essential}} \text{Acetate} + H_2 + CO_2$$

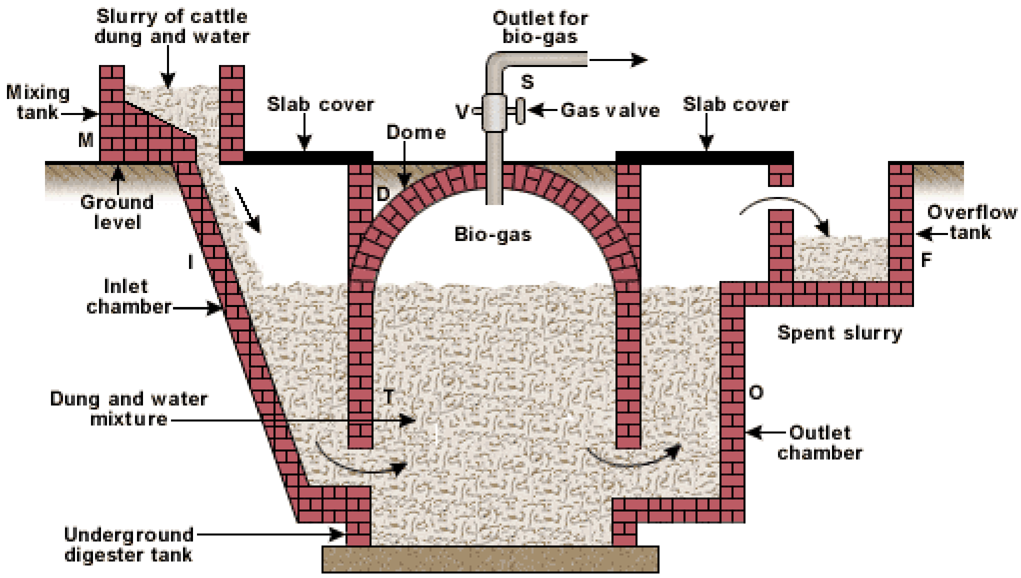
   e.g. *Syntrophomonas wolfei* and *S.wolinii*

3. Methanogenic bacteria: This group converts acetate, carbon dioxide and hydrogen into CH_4. E.g. *Methanosarcina barkeri* and *Methanobacterium omelianski*

$$\boxed{\begin{array}{l}\text{Formate actate} + H_2\\ CO_2\end{array}} \xrightarrow[\text{Group - III}]{\text{methanogens}} \boxed{CH_4 + CO_2}$$

4. Acetogenic bacteria: This group of bacteria oxidize H_2 by reducing CO_2 to acetic acid. Which is then used up by the methanogens to generate methane.

$$CO_2 + H_2 \xrightarrow[\text{Group IV}]{\substack{\text{Acetogenic bacteria}\\ \text{(these reduce partial } H_2 \text{ pressure)}}} \text{Acetic acid}$$



Fixed-dome type bio-gas plant.

4.2 Advantages of biogas

a) It is cheaper than other fuels
b) It is ideal for small scale production
c) It helps to clean environment because waste materials can be used as substrate
d) Aseptic condition are not required
e) Recovery of methane is spontaneous
f) Renewable source of energy

4.3 Disadvantage of biogas

a) It has low heat value
b) It has low yield of biogas
c) Large scale production is not economical
d) It contains some gases as impurities

5.0 Microbes as bio-fertilizers and bio control agents

- India is the 3rd largest producer and consumer of chemical fertilizers and pesticides. Chemical fertilizers are mostly synthesised from fossil fuels. They increase salt loading of ground water and causes pollution of surface bodies, pepticides are often persistent, induce resistance and ecological imbalance. Therefore, there is stress on fertilizers and pesticides of biological origin. Fertilizers of biological origin are of two types, manure and bio fertilizers, Pesticides of biological origin includes bio herbicides and bio insecticides

5.1 Manures

Manures are semi-decayed organic substance which are added to the soil in order to maintain soil's fertility.

Manures improves the following properties of soil

i) Fertility

ii) Aeration

iii) Water holding capacity

iv) Crumb structure

5.1.1 Types of manure

a) Farm yard manure (FYM): It consists of a mixture of cattle dung, farm refuse, fallen leaves, and twigs etc. which are dumped in heaps to undergo decomposition by which dark amorphous manure is obtained.

b) Composite manure/compost: It consists of rotten vegetable matter, garbage, sewage sludge and animal refuse which is often enriched with small amount of chemical fertilizers like ammonium sulphates, super sulphates, lime etc. during decomposition.

c) Vermicomposting: It is composting of organic matter with the help of earthworms. Worm castings are rich in phosphorus, nitrogen calcium and other minerals

d) Green manure: It is ploughed back young leguminous crop like *Sesbania aculeate* (= s. *cannabina, Daincha*), *Sesbania rostrata* (both root and stem nodules), *Crotalaria juncea* (Sunn Hemp), *Cyamopsis tetragonoloba* (Cluster bean/Guar), *Melilotus parviflora* (M. *indica*, sweet clover/Senji), Trifolium alexandrinum (Egyptian clover/Berseem) etc. Green manure not only maintains soil form but also increases its nitrogen content, increasing yield by 30-50%, Green manure also helps in checking weed growth and reclaimation of saline and alkaline soils.

6.0 Bio fertilizers

Bio fertilizers are of three types- nitrogen fixing bacteria, nitrogen fixing cyanobacteria and mycorrhiza

1. Free living Nitrogen Fixing Bacteria
   They are bacteria of diverse nutritional status which are able to absorb molecular nitrogen (N_2) from soil air and convert the same into nitrogen salts (amino acids) Soil is enriched through exudation and formation of nitrates after their death and decay. Nitrogen added to soil is 10-25 kg/ha/annum. Bacterium like Azotobacter (aerobic) *closteridium* (anaerobic), *Beijerinckia* (aerobic), *Rhodopseudomonas, Rhodospirillum, Chromatium*, etc. comes in this group.
2. Phyllosphere and Rhizosphere nitrogen fixing bacteria:
   They are free living nitrogen fixing bacteria which form associative mutualism on the surface of leaves and roots of plants providing nitrogen to plants and getting nutrition through exudations. Example *Azospirillum lipoferum*, *Beijerinckia*
3. Symbiotic Nitrogen fixing bacteria
   Rhizobium leguminosarum and other species forms mutually beneficial association with root nodules of legumes. A root nodule has a growing point, vascular strand and reddish pigment leghaemoglobin but lacks root cap and root hair. Its central infection zone has large cells with group of bacterioids covered by membrane lined by leghaemoglobin. In sesbania, the stem nodules contain another bacterium called *Aerorhizobium caulinodans*. Root nodules of non-legume plants (e.g. casuarina, alnus = Alder) possess Frankia while leaf nodules of Ardisia have Xanthomanas. Frankia can fix nitrogen in the soil as well. Nodules produced by it do not have leghaemoglobin. Instead, they have hopanoids for O_2 scavenging. Plants having symbiotic bacteria have higher protection content. No external nitrogen fertilizers is required. Presence of phosphorus is essential for nitrogen fixation
4. Free living nitrogen fixing cyanobacteria
   They increase nitrogen content of moist soil and water bodies e.g. Anabaena, Nostoc, Tolypothrix, Aulosira fertilissima is most active nitrogen fixer of rice fields.
5. Symbiotic nitrogen fixing Cyanobacteria

Azolla pinnata is a small aquatic fern incoculated to rice fields of south-east Asian countries. It contains symbiont Anabaena in its leaf cavities. Increase in yield is more than 50%

6. Mycorrhiza

   Mycorrhiza is a mutually beneficial relationship between fungus and roots of higher plant. The shape is irregular or coralloid with wooly covering but no root hairs or root cap. Mycorrhiza helps in absorption of water, minerals from organic matter and protection from soil borne pathogenic fungi

   (i) Ectomycorrhiza: the fungus forms a mantle on outside and intercellular hyphae in cortex. Host secretes nutrients in intercellular spaces. E.g. eucalyptus, oak, pine

   (ii) Endomycorrhiza : Fungus sends hyphal tips into cells as vesicles and arbuscules (branched masses). Hence VAM or vesicular-arbuscular mycorrhiza. Intercellular hyphae and external hyphal present but fewer e.g. grasses, orchids

7.0 Bioherbicides

- Bioherbicides are organism which destroy weeds without harming the useful plants. The first bio herbicide was a mycoherbicide, which was based on a fungus *Phytophthora palmivora*. First herbicide, developed in 1981, is used to control the growth of milk weed in citrus orchards. Biological control of weed may involve either utilization of insects, which would feed selectively on a weed or use of certain microorganisms, which produce diseases in weeds and eliminate them
- Bio herbicides be categorized as

(i) Predators herbivores: In India and Australia, cochineal insect (*Cactoblastis cactorum*) was used for the control of cacti (Opuntia) Similarly in USA, chrysolina beetles were used to control *Hypericum perforatum* (Klamath weed) and beetle *Zygogramma bicolorate* is used for controlling *Parthenium hysterophorus* (the congress grass)

(ii) Smoother crops: The crops, which do not allow the weeds to grow nearby, are called smoother crops. Examples are sweet clover, soya beans alfa-alfa, sunflower, rye, sorghum. These crops eliminate weeds through the chemicals. Therefore, crop rotation with these smoother crops will reduce the incidence of weeds

(iii) Mycoherbicides: Devine and Collego are fungal spores, which are sprayed over weeds for their elimination. These spores are identical for marketing, because they can tolerate adverse conditions and can remain viable for long periods

(iv) Transgenic plants: Transgenic plants are genetically engineered plants, which develop resistance against pests. They contain genes of smoothers crops. Pest and herbicide resistance e.g. transgenic tomato resistant against horn worm larva

(v) Vegetables: Certain weeds such as Amaranthus, chenopodium etc can be eliminated or made useful by using them as vegetable or fodder

8.0 Bio-insecticides

Living organisms or their products used for insect control are called bio-insecticides

(1) Sporeine was first commercial bio-insecticide . It was developed in France in 1940s from the soil bacterium *Bacillus thuringineis* (Bt). This bacterium carries a gene coding for Bt-toxin proteins. One of these, thurioside is active against several insects through the damage of intestinal tract by inhibiting ion transport in the midgut e.g. heavy destruction of coffee plantation by insects. *Prophantis smaragdina* is controlled by thurioside.

(2) 'DOOM' is a mixture of *Bacillus papillae* and *Bacillus lentimorbus*, which has been commercially used for controlling Japanese beetles Popilliae.

(3) Ladybug (lady bird beetle) and praying mantis can control scale insect or aphid pests of vegetables, cotton and apple

(4) Vedalian beetle (*Radiola cardinalis*) has been found effective against cottony cushion scale (*Icerya purchasi*)

(5) Mycar is a product obtained from the fungus *Hirrutella thompsoni* and used to control citrus rust mite

(6) Predator bug (*Cystorhinus mundulus*) has been successfully used to control sugarcane leaf hopper in Hawaii.

(7) Bacillus sphaericus is toxic to larva of Anopheles mosquito

(8) Boverin is obtained from a fungus *Beauveria bassiana* and is used for controlling Colorado potato beetle (*Leptinotarsa decemlineata*) and coding moth

(9) The fungus *Entomophthora ignobilis* may be used for controlling green peach aphid

(10) The fungus coelomomyces is useful to control mosquito larvae

9.0 Sustainable agriculture and organic farming

Sustainable agriculture is an agriculture practice which uses renewable practice which uses renewable resources, causes minimum pollution and maintain optimum yield level. Sustainability of agriculture will be enhanced if there is reduction in use of nonrenewable resources and decrease in level of pollution. The various component of sustainable agriculture are bio fertilizers, bio pesticides, developing resistant varieties and single cell protein. The nonuse of artificial fertilizers and chemical pesticides and use of bio pesticides as well as bio fertilizers in agriculture is called organic farming

10.0 Integrated pest management (IPM)

IPM or integrated pest management is the practice of pest control through biological or natural methods and using the chemical pesticides to the minimum when it is essential. It consists of

(i) Sanitation: removal of crop residue and using it for maturing at a distance
(ii) Culture practices: Use of pest resistance varieties, crop rotation, mixed cropping and intercropping
(iii) Biological control: Allowing the natural predators, parasites and parasitoids of the pests to keep the population of the latter under check e.g. bugs and beetles
(iv) Natural pesticides: They are nonpollutant pesticides e.g. thurioside, azadirachtin, cinerin, pyrethrin

11.0 Microbes in industrial process alcoholic fermentation

- Louis Pasteur found for the first that beer and butter milk are produced due to activity of yeast and yeast like organism
- The nutrient medium is barley matt for beer, fermented rye malt for gin, fermented rice for sake, cashew apple for fenny, potato for vodka, 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 complex carbohydrates as present in cereals and potato. Hydrolysis of starch is carried out in separate tank at high temperature ($55^{O}C$) for 30 minutes. The crushed food mixed with hot water for obtaining malt is called mash. The sweetened nutrient medium prior to alcoholic fermentation is called wort

1. Bioreacter/fermentation tank is sterilized with the help of steam under pressure. The liquid nutrient medium or wort is added into the tank and sterilized similarly. It is then allowed to cool
2. When the liquid 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 up to 2,25,000 litre of medium. Yeast and nutrient are allowed to remain there till maximum alcohol content is achieved (6-12%). It is called wash. The same is removed and the tank sterilized for the next batch
   (ii) Continuous process
   There is regular removal of a portion of fermented liquor/wash addition of more nutrient
   (iii) Feed batch process
   It is intermediate between batch and continuous process. Here, the culture is continuously fed with fresh medium Immobilized yeast. Lately yeast is being used in immobilized

state in calcium alginate beads. The technique is 20 times more efficient

3. In case of beer, the fermented liquor having alcohol content of 3-6% is filtered, lightly hopped and pasteurized. In case of wines, 10-27% alcohol content is achieved through refinement and concentration. Fortification by direct addition of alcohol may also be carried. Distillation is done in other cases. E.g. gin(41%), rum (40%), brandy (60-70%). Rectified spirit is 95% alcohol. Absolute alcohol is 100% alcohol
4. By 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, pyruvic acid, succinic acid, lactic acid, caproic acid, caprylic acid, ethyl acetate, acetaldehyde, diacetyl, hydrogen sulphide etc
5. Beer: It contain 3-6% alcohol. Nutrient medium is barley grain which have been semi germinated and crushed to form malt. Before inoculation with yeast, the infusion of malt or wort is treated with hops (dried petals of vine *Humulus lupulus*) to provide flavor, colour and stability. Beer is allowed to age before pasteurization. Lager beer is prepared by carrying out ageing in the cold.
6. Wine: It is alcoholic beverage prepared from ripe fruits and fruit juices. Red wine is red due to colour from grape skin, Cider is apple wine. Alcohol content ranges from 10-20%. Sparkling wines are naturally carbonated due to continuation of fermentation after bottling. Champagne is the most popular sparkling wine other famous wines are port wines and sherry wines
7. Brandy : It has an alcoholic content of 60-70%. Brandy is prepared from distillation of generally grape wine but can also be mixture of distillates various fermented juices and wine
8. Whisky and other alcoholic drinks are prepared through distillation as the maximum content of alcohol in fermentation is 6-12%. Vodka has an alcoholic content 60-80%. Gin (40% alcohol) is flavored with juniper berries. Rum has 40% alcohol. The alcohol content of whisky varies with brand

12.0 Antibiotic synthesis by microorganisms

- Antibiotics are chemical substance produced by microorganism which can kill or inhibit the growth of disease causing microorganism. These also inhibit the metabolic activities of other microorganisms. The term 'antibiotic was defined by Waksman in 1942. A microorganism which produces an antimicrobial substance is called an antibiont. At present more than 7000 antibiotic sunstances are known and approximately 100 are available for medical use

- The first antibiotic was penicillin, a product of the moulds *Penicillium notatum* and *P.chrysogenum* discovered by Fleming in 1928.
- Sir Alexander Fleming noticed a halo (technically known as plaque or zone of inhibition) of bacterial growth around a contaminate blue-green mould on a staphylococcus plate culture. He concluded that the mould was releasing a substance that was inhibiting bacterial growth. He grew a pure culture of the mould and discovered that it was Penicillium notatum in 1928. *P.chrysogenum* is a strain was previously known as *Penicillium notatum*. *P.chrysogenum* has been used industrially to produce penicillin and nanthocillin X, to treat pulp mill waste and to produce the enzyme polyamine oxidase, phosphor gluconate dehydrogenase and glucose oxidase.
- Antibiotics are used (i) as medicine for treatment (ii) as preservatives in perishable fresh food articles (iii) As feed supplement especially poultry because they enhance growth

12.1 Microbes as nutritional supplements

- Yeast e.g. *Saccharomyces cerevisiae*, which is a deactivated test is known as nutritional supplement organisms. It is an excellent source of protein and vitamins, especially the B-complex. Vitamins required in metabolism. It is also required for minerals and cofactors essential for growth. Nutritional yeast is low in fat and sodium and fortified with vitamin B_{12}
- It has a nutty cheesy flavor that makes it popular as an ingredient in cheese substitutes. It is also used as topping for popcorn and in mashed and fried potatoes, as well as in scrambled eggs. It is available in the form of flakes, as a yellow powder and is similar in texture to cornmeal. Chlorella (green algae) and Spirulina (simple, one called organism) are also referred as source of protein
- Microbes are commercially used in various industries for the large scale production of various chemical substances such as organic acids, alcohol and enzyme. In the production of chemical substances, microbes are used for fermentation and oxidation reactions.

12.2 Solvents, acids, enzymes and Other bioactive chemicals

1. Solvents
   Acetone, methyl alcohol and butanol are important industrial solvents. Which have been produced through fermentation of sugar and starch by *Clostridium acetobutylicum* and *C.saccharoacetobutylcium*. Glycerol is formed by adding sodium sulphite to alcoholic fermenter. It prevents ethanol formation. Instead glycerol is formed
2. Organic acids
   (i) Acetic acid: it is both microbial and synthetic in origin, Vinegar is 10-13% ripened acetic acid. Initially molasses or

other sugar solution is allowed to undergo alcoholic fermentation by yeast. It is an anaerobic process. As soon as 10-20% alcohol is formed, the liquid is filtered to remove yeast. It is aerated and inoculated with *Acetobacter acetic*. The latter produces acid.

$$C_6H_{12}O_6 \xrightarrow{\text{Yeast}} C_2H_5OH + 2CO_2$$

$$C_2H_5OH + O_2 \xrightarrow{\text{acetobacter acetic}} CH_3COOH + H_2O$$

When 10-30% acetic acid content is achieved, the liquid is filtered. The filtrate is allowed to ripen till the disagreeable smell disappears. It is pastured and called vinegar. The acid is concentrated and vinegar is used as souring agent, preservative and condiment. Acetic acid is used in plastics, pharmaceuticals, colouring agents, insecticides, production of solvents and flavoring agent.

(ii) Citric acid: *Aspergillus niger*, *Mucor* species can ferment sugar to produce citric acid. Citric acid is preservative and flavoring agent. It is also used in medicines, engraving, dyeing and inks

(iii) Lactic acid: First organic acid is to be fermented, lactic acid is obtained by activity of bacteria like *streptococcus lacti*, fungus Rhizopus etc. Over a variety of nutrient media like hydrolysed corn or potato starch, molassess, sulphates liquor etc. Lactic acid is used in cleansing, flavoring, preserving pickles, curing of meat. It is used as mordant in tanning, dyeing, printing of wool and preparation of plastics

(iv) Other organic preparations:

(a) Gallic acid is obtained with the help of Aspergillus niger. It is employed in ink making.

(b) Gluconic acid is manufactured through the agency of Penicillium purpurogenum, for use as calcium gluconate (providing calcium to infants, lactating mother and treating milk fever in high milk yield cows and in preparation of pharmaceuticals

(c) Butyric acid is formed by activity of *Clostridium butyricum*. It is the acid that occurs in rancid butter

3. Enzymes

(i) Pectinase: They are obtained from fungi grown on pectin containing media. Eg. Aspergillus niger, Pectinases are used in enhancing juice extraction from fruits, cleansing of fruit juice, removing bitterness retting of fibres and fermentation of green coffee

(ii) Proteases: They are obtained from both bacteria (e.g. *Bacillus subtilis, B. lichenformis*) and fungi (e.g. *Aspergillus oryzae*). Proteases are used in enhancing tenderness of meat, extraction of fish liver oil, clarification and chill proofing of alcoholic drinks, synthesis of glue, cleaning of hides and in detergents for removing protein based strains

(iii) Lipase they are lipid digestive enzymes that are obtained by growing *Candida lipolytica, Aspergillus niger* etc lipases are used in flavouring cheese, hydrolyzing oils for soap manufacture and in detergent formulations for removing fat based stains

(iv) Amylases they are starch digesting enzymes which are obtained from *Aspergillus oryzae, B. diastaticus* etc. The enzymes are used in softening and sweetening of bread, desizing fibres, cleansing starch related stains, clearing starch related stains in utensils and clothes

(v) Streptokinase: It is also called tissue plasminogen activator or TPA which is obtained from haemolytic streptococcus species and modified genetically to be useful in human beings. It is used as clot buster or dissolving blood clots in vessels of patients having undergo mycocardinal infaction or heart attack

4. Cyclosporin A
   It is an 11=membered cyclic oligo-peptide. It is obtained from fungus *Trichoderma polysporum* or *Tolypocladium inflatum* cyclosporin A has immunosuppressive property as it inhibits activation of T-cell response to transplanted organ
5. Statins
   They are inhibitor of enzyme HmG can reductase of liver which forms mevalonate required for cholesterol synthesis. Statin are synthesised by activity of yeast Monascus purpureus
6. Vitamins
   (i) Vitamin C: Acetobacter is helpful in dehydrogenation of D-sorbital and its conversion to L-sorbose. Which is precursor of vitamin –C or L-ascorbic acid
   (ii) Vitmin B_{12} : Organism like *Propionibacterium frendeureichii*, *Streptomyces oliaceus* are used on nutrient medium made of starch, corn syrup or molasses. The cells are harvested and autolysed to separate the vitamin.

- Reproduction is a biological process in which an organism gives birth to offspring similar to itself.
- Reproduction enables the retention continuity of the species, from generation to generation. The genetic variation is created and inherited during reproduction.
- When offspring is produced by a single parent without the involvement of gamete formation, the reproduction is called asexual.
- When two parents (opposite sex) participate in the reproduction process and also involve fusion of male and female gametes, it is called sexual reproduction.

ASEXUAL REPRODUCTION

- In asexual reproduction, a single parent is involved and is capable of producing offspring. As a result, the offsprings that are produced are not only identical to one another but are also exact copies of their parent. Asexual reproduction is common among single celled organisms, and in plants and animals with relatively simple organizations. It is also seen in multicellular organisms.

ASEXUAL REPRODUCTION IN ANIMALS

In animals the common mode of asexual reproduction are as follows

(1) Fission
   - This method is observed in protists and monerans. In fission, the nucleus divides first and the cytoplasm next. Subsequently, the mother cell splits into two equal sized daughter cells. This division is of cell division type.
   - When the cytoplasmic division passes through any direction (e.g. amoeba) the fission is called simple binary fission.
   - If the plane of cytoplasmic division coincides with the transverse axis of the individual the fission is termed transverse binary fission. E.g. paramecium and planaria.
   - In Euglena and vorticells, the plane of cytoplasmic division coincides with the longitudinal axis of the individual. This kind of fission is designated as longitudinal binary fission.
   - Binary fission involves mitosis only and consequently the resultant offsprings are genetically identical to the parent and to each other. It may be mentioned here that genetically identical offsprings resulting from a single parent are considered as clones.
   - Sometimes, the nucleus divides several times by amitotic divisions (nuclear). Thus large number of nuclei are formed. Cytoplasm does not divide during this period. Then cytoplasm collects around each nucleus. Thus, with one material cells, innumerable unicellular and uninucleate

offspring are formed. In course of time, they live as independent, unicellular organisms. This method of reproduction is called multiple fission. Multiple fission is observed in Amoeba and Paramoecium.

(2) Sporulation

- Sporulation occurs during unfavourable conditions. Organisms like Amoeba withdraw their pseudopodia and become round in shape. They create a hard protective three layered cyst around themselves, this process is called encystations.
- When conditions becomes favourable, the nucleus of encystated Amoeba undergoes multiple divisions and large number of Amoeba are formed. These are called pseudo-podiospores. This process is called sporulation. When the cyst raptures all new Amoebae are released. In plasmodium this process occurs at a specific stages in its life cycle.

(3) Budding

- In this method, first of all, cells of some parts of the body of the animal repeatedly undergo mitotic cell divisions and the raised regions of cell masses, called bud, are formed. From such a bud a young animal develops. It separates from the parent body and lives as independent animal.
- If such a bud us produced on the outside of the body it is called exogenous budding. In Hydra, exogenous budding is observed.
- In fresh waaer sponge (e.g. spongilla) and marine sponge (e.g. sycon) specialized cell masses are produced towards the inside of the body. An envelopes surrounds this cell mass. Such structures are called internal buds or gemmules. Each gemmules give rise to a new animal. This is called endogenous budding.

(4) Fragmentation

- In this method of reproduction, the body becomes fragmented into several distinct parts. Each part develops the remaining body parts and becomes a complete animal. This capacity is known as regeneration. Fragmentation is observed in planaria, Hydra, Starfish, etc.

ASEXUAL REPRODUCTION IN PLANTS

- The common modes of asexual reproduction in plants is as following:

  (1) Fission

  - It is the simplest method, commonly found in algal, fungi and monerans (bacteria). In this process, the unicellular mother cells divides mitotically to form two daughter cells; each eventually grows into an independent organism.

(2) Buds

- Some algal produces adventitious branches (e.g. dictyota, focus) or buds (e.g. protosiphon). Where as fungus like yeast produces buds. These structures are formed due to unequal division and are attached to the parental cell which eventually gets separated and matured into a new organism.

(3) Fragmentation

- In some algal (e.g. Ulothrium, Dedogonium, spirogyra and zygnema) and fungi (e.g. mucor, Rhizophus, saprolegnia), the vegetative thallus or hyphae break up into small segments due to mechanical pressure and each segments is capable of growing into a new mycelium.

(4) Spore formation

- Asexual reproduction takes place by a variety of motile and non-motile spores / conidia.
- Ciliate motile spore, called zoospores are produced by algal and fungi, which swim in water for some time with the help of their flagella and then directly develops into new independent individuals e.g. ulothrix, chlamydomonas, oedogonium.
- Non-flagellate and non-motile spores/ conidia of various common among terrestrial fungi. Such spores are light, dry and provided with a tough coat and are well adapted for dispersal by wind. E.g. penicillium, Aspergillus.
- True spores are always born by a sporophyte. Thus, the sporophyte of mass produces asexually by spores. Similarly ferns (Nephrolepis) bear spores and reproduce asexually by them. These plants are homosporous (bear only one kind of spores).
- While in selaginella (a pteridophyte) and gymnosperms are hetrosporous (bear two types of spores)

- In flowering plants the method of vegetative propagation or reproduction are grouped into natural and artificial.

(i) NATURAL METHODS

- In natural methods of propagation, the development of a new plants from some organ of the mother plant under suitable environmental conditions is very common. Such special reproductive organs develop from stem, leaf, root or even flower.
- Vegetative reproduction occurs through roots in sweet potato, Asparagus and Dahlia.
- In plants like Bryophyllum, buds develop in the margins of leaves. These buds produce new plants.

- In plants like Agave and Oxalis, floral buds produce new plants and in Dioscorea, axillary buds do so.
- Among the other natural methods of vegetative propagation, runners observed in lawn grass, offsets found in Pistia, Stolons in Nephrolepis and Suckers in mint plants.

(ii) ARTIFICAL METHODS

- Methods are developed for artificial vegetative propagation in which some part of the plant organ is utilized for obtaining a new complete plant. Amongst them the most common methods are – cutting. Layering and grafting.

a) Cutting

- Cut pieces of root are planted in moist soil and development of adventitious roots is artificially induced. New plants are developed in this way in lemon and tamarind.
- In Rose, sugarcane, croton, china-rose and chrysanthemum plants, proper size of stem pieces are obtained and are planted in moist soil to develop new plants. From the underground parts of stem, adventitious roots develop and buds on the aerial parts of stems develop and buds on the aerial parts of stems sprout. The plants, so developed is called a ‘cutting’. Later, these cutting are transplanted in proper places.

b) Layering

- This method is employed in the cultivation of Rose, Lemon, Grape, Hibiscus and jasmine. The lower branches of the plant are bent and pressed under the soil in such a way that the tip of the branch remains outside the soil and the middle portion is buried inside the soil. When adventitious roots develop from this buried region of plant stem, this branch is cut and separated from the parent plant. Thus, a new plant is obtained.

c) Grafting

- Grafting is practiced in plants which do not root easily, or have a weak root system. In this method a union is established between two plants of the same or different kinds. Such a union is established between tissues of the two plants. This process can be induced more meristematic tissue.
- The main supporting plant is called stock plant. The plant which is being grafted on it is called scion. A plant possessing higher and desirable characters is selected as ‘scion’ various methods of grafting scion are practiced. Mango, Apple, Pear, Citrus, Guava, Litchi and many other fruit – yielding plants are thus obtained and maintained.

- Grafting may be of different types, namely bud grafting, side grafting, tongue grafting. Wedge grafting and crown grafting depending on the methods of uniting the two parts.

SIGNIFICANCE OF VEGETATIVE REPRODUCTION

1. Vegetative reproduction is an ideal method of reproduction in plants in which it is desirable to maintain the same characteristic in the offspring which are present in the parents.
2. Plants showing reduced power of sexual reproduction, long dormant period of seed or poor viability can also be multiplied easily through this method.
3. Vegetative reproduction also helps in removing common infections from the parent plant.
4. In the plants raised through grafting, it is even possible to bring together the desired characters from two plants.

SEXUAL REPRODUCTION

- Sexual reproduction involves formation of the male and female gametes, either by the same individual or by different individuals of the opposite sex. Thus gametes fuse to form the zygote which develops to form the new organism. It is a complex and slow process as compared to asexual reproduction. Because of the fusion of male and female gametes, sexual reproduction results in offspring that are not identical to the parents or amongst themselves.
- Though the plants, animal or fungi differ in external morphology, anatomy and physiology, yet their sexual mode of reproduction is similar in pattern. All organisms reach a certain stage of growth and maturity in their life before they can reproduce sexually. This period is called the juvenile phase and in plants it is known as vegetative phase.
- After attaining maturity, all sexually reproducing organisms show events and processes which have fundamental similarity, but the structures associated with sexual reproduction are quite different. In all cases, the sexual reproduction is characterized by the fusion of the male and female gametes of the species. For convenience these sequential events may be grouped into three distinct stages namely, the pre fertilization, fertilization and the post fertilization.

PRE-FERTILIZATION EVENTS

1. Gametogenesis
   - Gametogenesis is the process of formation of gametes. Generally gametes are of two types; male and female gametes. Gametes are haploid (n) cells. In some algal where two gametes are similar in appearance they are called isogametes or homogametes. It is morphologically and physiologically similar and usually notice and has flagellates (e.g. Cladophora, Ulothrix). However in a majority of sexually reproducing organisms the gametes produced are of two morphologically and physiologically distinct types which are known as heterogametes or anisogametes. The male gametes are smaller and more active where as the female gametes are larger and sluggish. In such cases the male gametes is called anthrozoid or sperm and the female gamete is called egg or ovum.
   - Gametes are always haploids, but the parent plant body from which they arise many be either haploid or diploid. A haploid parent produces gametes by mitotic division. Several organism belonging to Monera, Fungi, Algae and Bryophyta, Gymnosperms, Angiosperms and most of the animals, the parental body is diploid. Here meiosis takes place to produce haploid gametes.
   - In diploid organisms the meiocytes undergo meiosis, only one set of chromosomes (n) gets incorporated in each gamete.

(2) Gamete transfer

After formation, the male and female gametes are brought together to facilitate fertilization. In a majority of organisms, male gamete is motile and the female gamete is stationary. There is need for a medium though which the male gametes move. In Algae, Bryophytes and Pteridophytes, water is the medium through which this gamete transfer takes place.

- A large number of the male gametes, however, fail to reach the female gametes. To compensate this loss of male gametes during transport, the number of male gametes produced is several thousand times the number of female gametes produced.
- In angiosperms pollen grains are the carriers of male gametes and ovule has the egg cells. Pollen grains are produced in anthers and are transferred to stigma, a phenomenon, which is known as pollination. This phenomenon requires the involvement of external agents such as insects, animals, wind and water pollen grains germinate on the stigma and the

pollen tubes carrying the male gametes reach the ovule and discharge two gametes near the egg cell.

- In bisexual animals, since male and female gametes are formed in different individuals, the organism must evolve a special mechanism for gamete transfer. It is essential for fertilization.

FERTILIZATION

- The fusion of two similar or dissimilar gametes is called syngamy and in its result diploid zygote is formed. This process is known as fertilization.
- In majority of algae, fishes and amphibians syngamy occurs in the external medium i.e. water (Outside the body of organisms). This type of gametic fusion is called external fertilization. This happens in the bony fishes and frogs where a large number of offspring are produced. A major disadvantage is that the offspring are extremely vulnerable to predators threatening their survivals up to adulthood.
- In plants group (i.e. fungi, bryophytes and pteridophytes) as well as reptiles, birds and mammals, syngamy occurs inside the body of the organism, hence the process is called internal fertilization. In this process, male gametes are motile and have to reach and fuse with egg. This takes place inside the female body.
- In seed plants, the non-motile male gametes are carried to female gamete by pollen tubes.

POST-FERILIZATION EVENTS

1. Zygote
   - Formation of zygote (2n) is common in all sexually reproducing organism. In organism with external fertilization, the zygote is formed in the external medium (water), whereas in those exhibiting internal fertilization, zygote is formed inside the body of organism. Further development of zygote depends on the type of life cycle the organism possesses and the environment to which it is exposed. In organism, such as algae and fungi, zygote develops a thick wall that is resistant to dessication and damage commonly it undergoes a period of rest prior to germination.
   - Some unicellular protest animals (e.g. Paramoecium) exhibit sexual reproduction by forming male and female gamete nuclei, which they exchange through temporary cytoplasmic bridge, later the cytoplasmic bridge appears and the gamete nucleus of one individual fuses with that of

the other to form zygote nucleus. This mode of sexual reproduction is known as conjugation.
- Zygote is the vital link that ensures continuity of species between organism of one generation and the next.

2. Embryogenesis
   - Embryogenesis is the process of development of embryo from the zygote. During embryogenesis zygote undergoes cell division (mitosis) and cell differentiation.
   - Cell divisions increase the number of cells in the developing embryo while cell differentiation help group of cells to undergo certain modifications to form specialized tissues and organs to form organism.
   - In animals, when the development of zygote takes place outside the body of the female parent, it is called viviparous.
   - In oviparous animals like Reptile and Birds the fertilized eggs covered by hard calcerous shell are laid in a safe place in the environment after a period of incubation, young ones hatch out. On the other hand, in viviparous animals like mammals including human beings, the zygote develops into a young ones are delivered out of the body of the female parent. Because of proper embryonic car and protection, the chances of survival of young ones is greater in viviparous organisms.
   - In Angiosperms, the zygote is formed, inside the ovule. After fertilization, the sepals, petals and stamens of the flower fall off. The pistil, however, remains attached to the plant. The zygote develops into the embryo and the ovules develop into the seed. The ovary develops into the fruit. Which develops a thick wall called pericarp that is protective in function. After dispersal seeds germinates under favourable condition to produce new plants.

- Respiration is a biochemical process by which organic compounds are oxidized to liberate chemical energy from food in step-wise process. The organic compounds are carbohydrates, fats and proteins and the energy released is stored as the ATP molecules.
- Cellular respiration is the use of oxygen and production of carbon dioxide at cellular level.

TYPES OF RESPIRATION

1. Anaerobic respiration
   When food is oxidized without the use of molecular oxygen, it is called anaerobic respiration. The organism undergoing this type of respiration are termed as anaerobes. Examples are anaerobic bacteria, yeasts, many parasitic animals such as Taenia, Fasciola and Ascaris. In microorganisms, this respiration is termed as fermentation and this is termed after the name of the product they form, such as alcoholic fermentation and lactic acid fermentation.

- Alcoholic fermentation occurs in yeasts, where they oxidize glucose to ethyl alcohol and carbon dioxide
  $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ + energy
- Lactic acid fermentation occurs in some bacteria where glucose is metabolized to lactic acid
- Anaerobic respiration occurs in cytoplasm and provides less energy (2ATP molecules)
- In muscles and erythrocytes, glucose is metabolized to form lactic acid which enters the blood and reaches the liver, where it is converted to glycogen aerobically for further reuse. Accumulation of lactic acid in muscles causes fatigue.

2. Aerobic respiration
   When oxygen is used for the oxidation of food it is termed as aerobic respiration and the organisms undergoing this process are termed as aerobes. It is a high energy yielding process. It is of two types:
   a) Direct respiration: It is the exchange of environmental molecular oxygen with the carbon dioxide of the body cells without any special respiratory organ and blood. It is found in aerobic bacteria, protists, plants, sponges, coelenterates, flatworms, roundworms and most arthropods.
   b) Indirect respiration: In this, exchange of gases takes place through special respiratory organs such as skin, gills, bucco-pharyngeal cavity and lungs. It needs blood for transporting oxygen and carbon dioxide after the exchange.
      - The respiration through organs are termed according to their names. Examples skin – cutaneous gills- brachial, buccopharyngeal cavity – buccopharyngeal and lung-pulmonary respiration.

- The indirect respiration occur in two phases external respiration and internal respiration. These are preceded by a preliminary phase called breathing (ventilation)
- Aerobic respiration occurs both in cytoplasm (glycolysis) and in mitochondria (krebs cycle and electron transport chain) and provides much more energy (38 ATP molecules)
- Breathing refers to the movement that sends fresh air to the respiratory organs and remove foul air from them.
- External respiration : It is intake of oxygen by the blood from air or water in the respiratory organs and elimination of carbon dioxide.
- Internal respiration – It involves 4 process.
  Uptake of oxygen by tissue cells from blood via blood tissue.
  Oxidation of food in the tissue cells by the action of oxidizing enzymes producing carbon dioxide, water and energy. This is also termed as cell respiration.
- Storage of energy from oxidation in the phosphate bonds of ATP.
- Release of carbon dioxide by tissue cells into the blood via tissue fluid.

RESPIRATORY SURFACE

- The surface at which exchange of gases (CO_2 and O_2) occurs is termed respiratory surface. This surface must have enough area of gas exchange to meet the metabolic needs of the organism.
- For the exchange to be efficient, respiratory surface should have the following features.
  i) It should be thin, large and moist.
  ii) It should be permeable to respiratory gases.
  iii) It should be highly vascular.
  iv) It must be directly or indirectly in contact with the source of oxygen.

RESPIRATORY STRUCTURE FOR THE EXCHANGE OF GASES IN DUFFERENT GROUPS OF ANIMALS

1. Protozoans (e.g amoeba, paramecium) : Plasma membrane
2. Sponges (e.g. Sycon) : Cell's plasma membrane
3. Cnidarians (e.g. Hydra): Body surface
4. Platyhelminthes
   i) Free living (planaria): Body surface
   ii) Parasites (e.g. Tapeworm); No exchange of gases
5. Nemathelminthes
   i) Free living (e.g. Rhabditis): Body surface
   ii) Parasites (e.g. Ascaris) : No exchange of gases
6. Annelids (e.g. Earthworm) : Skin (cutaneous respiration)

7. Arthropods
   i) Prawn, crayfish : Gills (Branchial respiration)
   ii) Insects, centipedes, millipedes, ticks: Tracheae (Tracheal respiration)
   iii) Scorpions, Spiders : Book lungs
   iv) King crab (Limulus) Book gills
8. Molluscs
   i) Unio : Two ctenidia (gills)
   ii) Pila : One ctenidium (gill) and one pulmonary sac (lung)
9. Echinoderms (e.g. starfish) : Dermal branchae, tube feet.
10. Hemichordata (e.g. Balanoglossuse); Pharyngeal wall.
11. Chordata
   i) Urochordata (e.g. Herdmania): Pharyngeal wall
   ii) Cephalochordata (e.g. Branchiostoma) : Pharyngeal wall
   iii) Vertebrata
      a) Cyclostomes, fish : gills
      b) Amphibians : Skin, lungs, buccopharyngeal lining.
      c) Reptiles, birds mammals : Lungs.

PROBLEMS OF WATER – BREATHING

- Water-breathing animals face the following problems in ventilating their respiratory surfaces (gills
  - Water contains much less oxygen than air.
  - Oxygen diffuses through water far more slowly than through air. Therefore, a large quantity of water is required to be passes over the gills to fulfill the oxygen need
  - Water is absorb 800 times denser than air so that the fish has make a great muscular effort to maintain water flow.
  - At a higher temperature an animal needs more supply of oxygen because rise in temperature increases their metabolic rate, but less oxygen is available to them in warmer water holds less oxygen.

PROBLEMS OF AIR BREATHING.

- Land animals for breathing air face following difficulties:
  - They have to protect their respiratory surface from drying out.
  - Respiratory surface must be kept moist as gases pass through liquid medium.
  - They lose their precious water through evaporation from their respiratory surface.

HUMAN RESPIRATORY SYSTEM.

- The human respiratory system is divided into upper respiratory tract and lower respiratory tract. The upper respiratory tract includes external nostrils, nasal passage, internal nostril and pharynx. The lower respiratory system includes larynx, trachea, bronchi and bronchioles.
- The special mammalian features of respiratory system are:
  1. Presence of nose
  2. Elongation of nasal passage and its complete separation from buccal passage through palate. So, that internal nostrils open deep into nasopharyngeal part of pharynx.
  3. Long wind pipe due to presence of well defined neck
  4. Spongy, solid lungs

EXTERNAL NARES (NOSTRILS)

They are a pair of slit-like opening present on the lower end of nose.

NASAL CAVITY

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

a) Vestibule
   It is a lower smaller part just above external naris which is lined by skin and bears hair as well as oil glands. Hair help in filtering out dust particles from incoming air.
b) Conditioner (Respiratory region)
   It is middle part of nasal chamber. There are three bony projections called nasal conchae or turbinates (superior, middle, inferior) and some sinuses (maxillary, frontal, sphenoid and ethmoid)
   - The conditioner part is reddish pinkish in coloured by ciliated pseudostratified columnar epithelium with mucous and serous glands. The inhaled air is moistened warned and cleaned.
c) 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 choanac.

PHARYNX

- Nasopharynx occurs at the base of skill and has lining of ciliated stratified squamous epithelium.
- Nasopharynx leads to oropharynx or common pathway of respiratory and digestive system.
- Oropharynx passes into laryngopharynx which contains epiglottis and passes into larynx.

LARYNX

- Larynx or voice box opens into laryngo-pharynx through a slit-like glottis which can be widened by intrinsic muscles. Glottis can be closed by a large leaf-like cartilaginous flap called epiglottis.
- Larynx has C-shaped thyroid cartilage (on sides and in front where it can be felt as Adam's apple), a pair of triangular arytenoids (arytaenoid) cartilages (on back), a ring like cricoids cartilages and a pair of nodule like cartilages of santorini (upper end of arytenoids cartilages). Internally larynx has ciliated columnar mucous epithelium and a pair of vocal cord (attached to thyroid and arytenoids cartilages).
- Vocal cords become thickened in adult males. Vocal cord are shorter and thinner in women produced by passage of air between vocal cords and modulations created by tongue, teeth, tips and nasal cavity.

TRACHEA (WIND PIPE)

- It is 10-12 cm long tube with 2-3 cm diameter which arises from larynx and passes upto middle of thorax. Trachea is supported by 16-20 C-shaped incompleted cartilaginous rings and lined by ciliated pseudostratified mucous epithelium.

BRONCHI

- Trachea divides into right and left primary bronchi. Left bronchus is about 5 cm long while right bronchus is only 2.5 cm long. Right bronchus almost directly enters the right lung. Infection 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 latter into bronchioles. All bronchi are lined by ciliated and mucus secreting pseudostratified epithelium and supported by incomplete cartilaginous rings.
- Bronchioles divides into terminal bronchioles, respiratory bronchioles, alveolar ducts, air sacs and alveoli. Mucus secreting cells are absent from terminal bronchioles and their branches. Epithelium is ciliated in bronchioles and terminal bronchioles. It is non-ciliated in respiratory bronchioles and their branches.

LUNGS

- A pair of conical spongy elastic lunges of pinkish to slate grey colour occur inside air tight thoracic cavity. A small space called mediastinum lies in between the two lungs (especially due to concavity called cardiac notch of left lump). It encloses heart. Each lung is covered by a pleural sac made of an outer parietal pleuron in contact with wall of thoracic cavity and inner visceral pleuran in contact with the surface of lung. A narrow pleural cavity (0.02 mm) occurs between them. It contains pleural fluid. It allows frictionless sliding of pleura during inspiration and expiration. Protection and moistening of lungs are also provided. Pleurisy is painful infection involving inflammation of pleura and over-production of pleural fluid. Normally pleural fluid is under negative pressure due to its formation from the membranous covering.
- Left lung is slightly narrower and longer than the right one. Right lung has three lobes – right superior, right middle and right inferior. Left lung has two lobes – left superior and left inferior. It contains a cardiac notch in antero-median region for accommodating heart. Each lobe is divided internally into segments and segments into lobules. A lobule receives a terminal bronchiole.
- Terminal bronchiole produces a few respiratory bronchiole produces a few respiratory bronchioles. A respiratory bronchiole give rise to 2 – 11 alveolar sac or infundibulum. The latter has a number of small pouches named alveoli or air sacs. Number of alveoli in human pulmonary system is 300 – 400 million with a surface area 100 m^2. Each alveolus is polyhedral in outline with a thin wall made of non-ciliated squamous epithelium with a few cubical cells that secrete a lipoprotein surfactant to present collapse and sticking of alveolar walls during expiration. Life span of epithelial cells is about 3 weeks so that alveolar wall is being continuously replace. Blood capillaries occur on the surface of alveoli for gaseous exchange.

DIAPHRAGM

- It is a membranous musculo – tendinous partition between thorax and abdomen. Normally it is convex with convexity towards thorax.

MUSCLES

- Phrenic muscles attach diaphragm to ribs and vertebral column. Contraction of muscles straighten the diaphragm to increase thoracic cavity
- Intercoastal muscles: There are
  i) External intercoastal
  ii) Internal intercoastal
  iii) External oblique

iv) Internal oblique muscles

- Abdominal muscles: Relaxation allows compression of abdominal organs when diaphragm straightens. Contraction presses the abdominal viscera against diaphragm to bulge it more upwardly (for expiration).

MECHANISM OF BREATHING

INSPIRATION

- It is the process by which the fresh atmospheric air enters into the alveoli of the lungs. It is an active process and is brought about by activity of inspiratory muscles. The main muscles of inspiration in normal quiet breathing are the external intercoastal muscles and phrenic or radial muscles of diaphragm. During difficult or deep breathing (forced inhalation) they are assisted by the muscles of abdomen.
  i) Diaphragm: When relaxed the diaphragm is dome-shaped structure which separates the thoracic cavity from the abdominal cavity. Phrenic or radial muscles extened from diaphragm to ribs and vertebral column. When these muscles contract diaphragm becomes flat, thus increases the thoracic cavity antero posteriorly. These are the principle inspiratory muscles and play about 75% role in inspiration, other muscles play 25% role in inspiration.
  ii) External intercoastal muscles: They occur between the ribs. These are 11 pairs of muscles extending between 12 pairs of ribs. Their contraction pulls the ribs and sternum upward and outward there by increasing the thoracic cavity dorso-ventrally and laterally.
  iii) Abdominal muscles: These muscles relax and allow compression of abdominal organs by diaphragm.
- Due to simultaneous contraction of inspiratory muscles, volume of thoracic cavity increases in all directions.
- As the lungs are held tightly against thoracic wall, enlargement of thoracic cavity results in expansion of lungs
- This decreases the intrapulmonary pressure than atmospheric pressure by -2 to -6 mmHg.
- As it is property of gases, that they move from the place from higher pressure to place of lower pressure, fresh air rushes through respiratory passage into the lungs to equalize the pressure.
- The movement of fresh air into lungs is called inspiration

EXPIRATION

- It is the process by which foul air is expelled out of the lungs. Expiration is normally a passive process and involves the relaxation of inspiration, expiratory muscles becomes active, making expiration an active energy consumed process

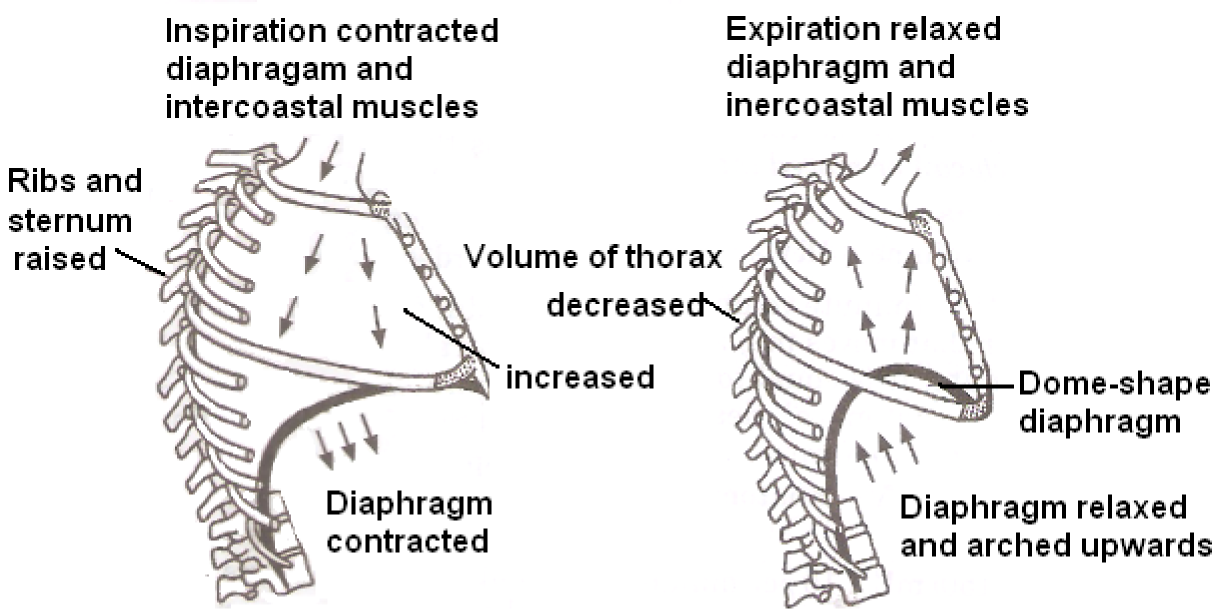
i) Diaphragm: When muscles of diaphragm relax it again becomes dome-shaped, decreasing the thoracic cavity.

ii) External intercoastal muscles: When these muscles relax, sternum and ribs come to their original position. This also decreases thoracic cavity.

iii) Abdominal muscles: Contraction of abdominal muscles presses the abdominal viscera against the diaphragm, bulging it further upward and thus decreasing the thoracic cavity more vertically.

iv) Internal intercoastal muscles: Contraction of these muscles moves the ribs downward and inward and reduces the thoracic cavity laterally and dorsoventrally. The abdominal and external intercoastal muscles are called expiratory muscles.

- Due to the action of above muscles, the overall volume of thoracic cavity decreases and the intra pleural pressure increase by +3 to +4 mmHg. Due to this increased pressure in lungs, foul air is given out of them.
- One breath includes one inspiration and one expiration.
- The respiratory rate is the number of breaths taken per minute. For a person breathing normally at rest, it is equal to 12-14 breath per minute.
- Breathing through nose is healthier as it get filtered and conchal of nose warm up the air.
- Mammals have a negative pressure breathing as it allows them to eat and breath at the same time and in human female thoracic breathing is more predominant.



[FIG showing the changes in capacity of the thoracic cavity during breathing]

PULMONARY AIR VOLUMES AND CAPACITIES

- Spirometry is the process of recording the changes in the volume movement of air into and out of lungs and the instrument used for this purpose is called sphirometer or respirometer. The graph showing the changes in the pulmonary volumes and capacities under different conditions of birthing is called spirogram.
- The quantity of air the lungs can receive, hold or expel under different conditions are called pulmonary volumes.
- Combinations of two or more pulmonary volumes are called pulmonary capacities.
- Tidal volume (T.V.): Volume of air inspired or expired in relaxed or resting position -500ml. It consists of 150 ml of dead space volume and 350 ml of alveolar volume.
- Dead space: Part of inspiratory tract not involved in gaseous exchange. (Nose to terminal bronchi, volume 150 ml)
- Residual volume (R.V): Air left in lungs and dead space after forceful expiration. 1.1-1.2 litres. The air left in lungs is useful in uninterrupted gaseous exchange.
- Inspiratory reserve volume (I.R.V = complemental air) : Volume of air in excess of tidal volume which can be inhaled due to forceful inspiration.
- Expiratory reserve volume (E.R.V = Supplemental air): Volume of air in excess of tidal volume which can be exhaled due to forceful expiration 1 – 1.1 litres.
- Vital capacity (v.C): It is the total volume of air inspired and expired to a maximum level. It is the sum total of tidal volume, inspiratory reserve volume and expiratory reserve volume

  VC = T.V. + I.R.V. + E.R.V.

  It is 3.5 to 4.5 litres

  i) The vital capacity is higher in athletes mountaineers or mountain – dwellers and lower in non-athletes, people living in plains, women, old individuals, cigarette smoker.

  ii) Higher the vital capacity, higher is the amount of air exchanged in each breath.
- Inspiratory capacity (IC): It is the total volume of air that can be inhaled after normal expiration. It includes tidal volume and inspiratory reserve volume.

  IC = T.V. + I.R.V

  It is 2.5 to 3.0 litres
- Expiratory capacity (E.C.): It is the total volume of air that can be exhaled after normal inspiration. It includes tidal volume and expiratory reserve volume.

  EC = T.V. + E.R.V

  Its value is 1.5 to 1.6 litres
- Functional residual capacity (FRC); It is the sum total o residual volume and the expiratory reserve volume.

  F.R.C. = R.V. + E.R.V.

Its value is 2.3 to 2.7 litre

- Total lung capacity (TLC): It is the total amount of air present in the lungs and the respiratory passage after maximum inspiration. It is the sum total of vital capacity and residual volume

TLC = VC + RV or TLC = TV +IRY + ERV + RV

Its value is 5 to 6 litre

- Alveolar ventilation: It is the rate at which the fresh air reaches the alveoli and adjoining areas like alveolar ducts, alveolar sacs and respiratory bronchioles. It is calculated as.
- Alveolar ventilation per minute

  = Rate of respiration × (TV – dead space volume)

  = 12 × (500 -150)

  = 12 × 350

  = 4.2 litres / minute

EXCHANGE OF GASES

- Alveolar air is separated from blood present in surrounding blood capillaries by very thin partition of 0.2 μm thickness. It is called respiratory membrane. The membrane consists of alveolar surfactant, alveolar epithelium, epithelial basement membrane, a thin interstitial space, capillary basement membrane and capillary endothelial membrane.
- Diffusing capacity of a gas across a membrane is the volume of gas that diffuses per minute for a pressure difference of 1mmHg. The rate of diffusion of CO_2 is 20 times faster than that of oxygen while oxygen diffuses faster (twice) than nitrogen. Partial pressure of O_2 in alveolar air (PO_2) is about 100-104 mmHg while that of deoxygenated blood in alveolar capillary is 40mmHg. Therefore, oxygen diffuses into blood and combines with haemoglobin to form oxyhaemoglobin. Pressure of (PO_2) oxygenated blood is 95 mmHg. PCO_2 (pressure of carbon dioxide) of alveolar capillary blood is 46 mmHg, while in fresh alveolar air it is 40mmHg. As the diffusing capacity of CO_2 is 20 times higher than that of O_2, CO_2 of blood rapidly passes out into alveolar air. Its partial pressure in oxygenated blood is 40 mmHg.
- Gaseous exchange occurs again in the tissues cells and capillary blood through the interstitial fluid. Partial pressure of oxygen, PO_2 in respiring cells is 20mmHg, tissue fluid is 40mmHg, while it is 95mmHg in capillary blood. Therefore, O_2 diffuses from blood into tissue fluid and from there into cells. Blood leaving the tissue capillaries has PO_2 of about 40mmHg. PCO_2 of blood capillaries is 40mmHg, tissue fluid 45mmHg and that of cells 52mmHG. Therefore, carbon dioxide diffuses out of cells into tissue fluid and form tissue fluid into blood. Blood leaving the tissue capillaries has a PCO_2 of 46mmHg.

TRANSPORT OF OXYGEN

- Oxygen is carried by blood in two forms in solution and as oxyhaemoglobin as RBCs

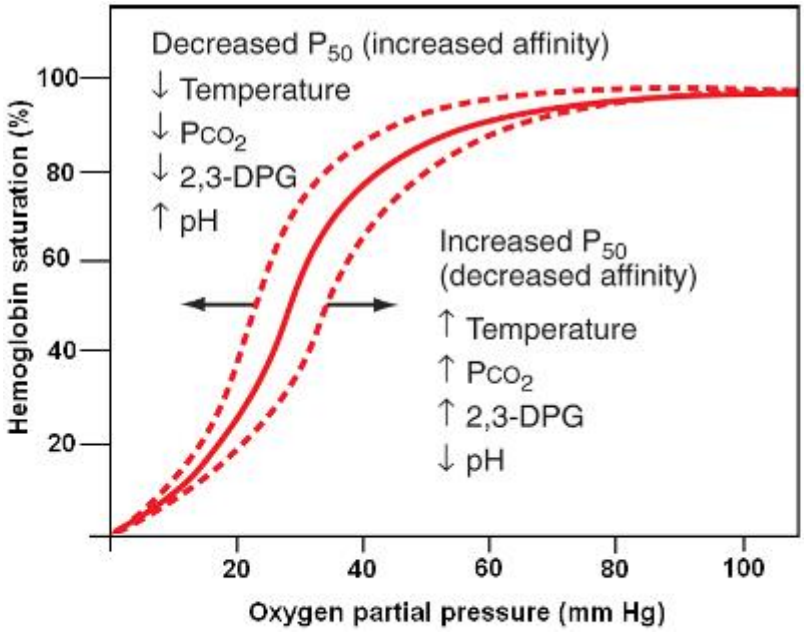
1. IN SOLUTION
   - Oxygen is soluble in plasma to a small extents under normal conditions of temperature and pressure. Hence most of it is carried by red blood cells. About 3% of oxygen is transported by blood in dissolved form in plasma of blood. Example, out of about 4.6ml of oxygen entering each 100ml of blood in lungs only 0.17 ml travels in solution form in the plasma.
2. AS OXYHAEMOGLOBIN
   - RBC contain a protein called haemoglobin. It has four polypeptide chains and four haem groups attached to it or 4 atom of iron in ferrous form (Fe^{2+}), thus it can react with 4 molecules of oxygen to form Hb_4O_8. This is called oxyhaemoglobin. This combination process is called oxygenation.
   - On an average 15gm of haemoglobin (Hb) is present in 100ml of blood. 1gm of Hb combines with 1.34ml of O_2. Thus 100ml of blood carries approximately 20ml of O_2 (19.4 ml to be exact)
   - But when blood reaches the tissues, its O_2 concentration reduces gradually to 14.4 ml which is collected by veinules and vein. Thus 5ml of O_2 is transported by 100ml of blood under normal condition.
   - Haemoglobin has higher affinity for oxygen and this affinity is increased by fall in PCO_2 of blood.
   - At the alveoli, venous blood has low oxygen and is exposed to low PCO_2 of alveolus, thus oxygen diffuses into red blood cells and form oxyhaemoglobin (bright red). As CO_2 diffuses from blood to alveolus, blood PCO_2 falls increasing further uptake of oxygen.
   - Oxyhaemoglobin remains unchanged till it reaches the tissues where it dissociates readily to release oxygen.

OXYGEN – HAEMOGLOBIN DISSOCIATION CURVE (OXYGEN DISSOCIATION CURVE)

- The percentage of haemoglobin that is bound with O_2 is called percentage saturation of haemoglobin.
- The relationship between the partial pressure of oxygen (PO_2) and percentage of saturation of the haemoglobin with oxygen (O2) is graphically illustrated by a curve called oxygen haemoglobin dissociation curve.
- Under normal conditions, the oxygen haemoglobin dissociation curve is sigmoid shaped or ‘S’ shaped. The lower part of the curve indicates dissociation of oxygen from haemoglobin. The upper part of the curve indicates the acceptance of oxygen by haemoglobin. When the partial pressure of oxygen is 255mmHg the haemoglobin gets saturated to about 50%. It means blood contains 50% oxygen. The partial pressure at which the haemoglobin

saturation is 50% is called P_{50}. At 40mmHg of partial pressure of oxygen the saturation is 75%. It becomes 95% when the partial pressure of oxygen is 100mmHg.

- Haemoglobin does not take up oxygen are low PO_2, but as oxygenation of pigment occurs, its affinity for more O_2 increases. In haemoglobin where 4 sub-units are present, acquisition of one molecule of oxygen increases the affinity of neighbouring haems for oxygen. This is known as co-operativity between active sites.



FACTORS AFFECTING OXYGEN DISSOCIATION CURVE]

i) Temperature: At higher temperature haemoglobin gives up oxygen more readily and dissociation curve shits to the right. This is of physiological importance because increased temperature means higher metabolic rate or higher oxygen requirement.

ii) pH: Increase in CO_2 or other acids lower the pH of plasma and shifts the dissociation curve to the right. At higher CO_2 concentration more O_2 is given up at any oxygen pressure.

iii) PCO_2: CO_2 lowers the oxygen affinity of haemoglobin even if the pH is kept constant. Oxygen dissociation curve shifts to the right and release more O_2 with increase in PCO_2

iv) 2,3-diphosphoglyceric acid (2,3-DPG) : It is present in the red blood cells of adult, formed from 3-phosphoglyceric acid. It competes for oxygen binding sites in haemoglobin molecule. As it binds to the β- chain of HbA, it causes right shift of dissociation curve resulting in higher P_{50}.

v) Lower CO_2 concentration, lower body temperature lower 2,3-DPG lower the P_{50} and the curve moves to the left.

BOHR EFFECT

- Shifting of the oxygen haemoglobin dissociation curve to the right by increasing carbon dioxide partial pressure is known as Bohr effect. It is named after Danish physiologist Christian Bohr.
- The presence of carbon dioxide decreases the affinity of haemoglobin for oxygen and increases release of oxygen to the tissues.
- The pH of the blood falls as its CO_2 content increases so that when PCO_2 rises the curve to the right and P_{50} rises.
- In the tissue, PO_2 is between 10 to 40 mmHg and PCO_2 is high around 45mmHg. So, an active tissue will have high PCO_2, low pH and raised temperature leading to the dissociation of oxygen. Oxygenated blood passing through inactive cells does not given up oxygen even if its PCO_2 is low but active cells readily gives oxygen as PCO_2 is very high.

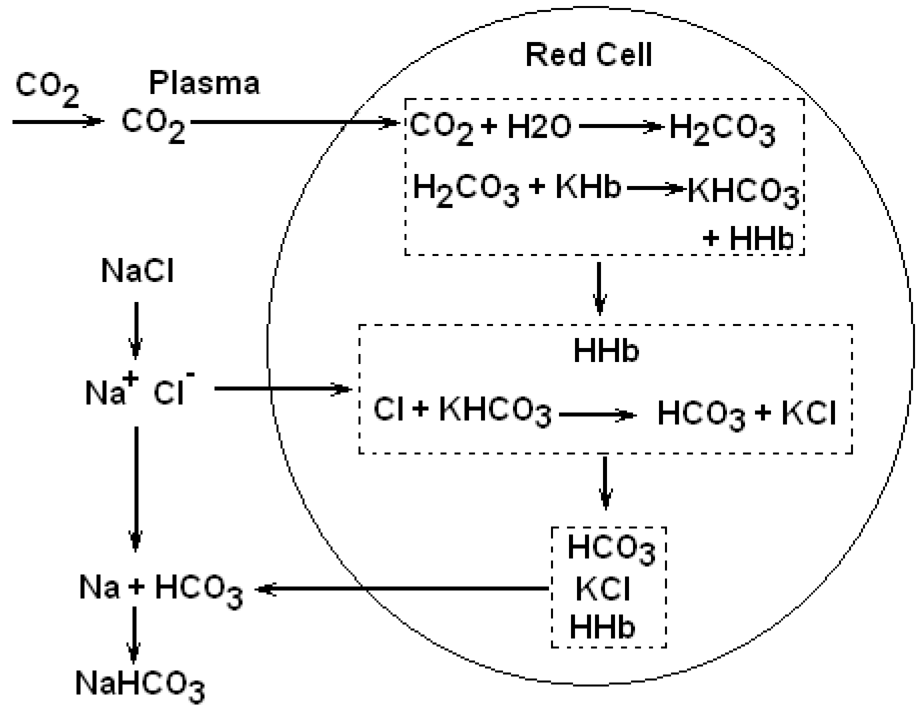
TRANSPORT OF CARBON DIOXIDE

I. IN DISSOLVED STATE
Because of its high solubility, about 7% carbon dioxide gets dissolved in the blood plasma and is carried in solution to lungs. Deoxygenated (venous) blood and oxygenated (arterial) blood carry about 2.7ml and 2.4ml of CO_2 per 100ml of blood in dissolved state in plasma respectively.

II. IN THE FORM OF BICARBONATE
   - The dissolved carbon dioxide in the blood reacts with water to form carbonic acid. This reaction is very slow in the blood plasma, but occurs very rapidly inside RBCs because a zinc containing enzyme, the carbonic anhydrase, present in RBCs, accelerates its rate about 5000 times.
   - Due to this, about, 70% of CO_2, received by blood from the tissues, enters the RBCs where it reacts with water to form carbonic acid (H_2CO_3).
   - Carbonic anhydrase is exclusively found in R.B.Cs. All other tissue contains it in traces except stomach and pancreas in which have considerable amount. This enzyme not only speeds up the formation of carbonic acid (H_2CO_3) but also rapidly converts it back to carbon dioxide and water when blood reaches the lungs.
   - Almost as rapidly as formed all carbonic acid of RBCs dissociates into hydrogen (H^+) and bicarbonate ions (HCO_3^-).
   - The most of bicarbonate ions (HCO_3^-) formed with RBCs diffuse out into blood plasma along the concentration gradient.
   - When the whole blood is saturated with carbon dioxide, the following changes are seen.

(i) The bicarbonate content of plasma and corpuscles increase.
(ii) The chloride content of plasma is diminished and that of the cells is increased.
(iii) The total base (cations) of both plasma and corpuscles remain unchanged.
(iv) The water content and the volume of corpuscles increase.

- When carbon dioxide is removed from a sample of blood, reverse changes take place. From these observations, it is evident that, when carbon dioxide enters blood, chlorine from plasma enters the RBCs, while the base (NA) is left behind. When carbon dioxide escapes the plasma and combines with the base (Na) again. Due to this alternate movement of chlorine ions, this phenomenon is called chlorine shift or Hamburger phenomenon.



III. AS CARBAMINOHAEMOGLOBIN

- In addition to reacting with water, carbon dioxide also reacts directly with amine radicals (NH_2) of haemoglobin to form an unstable compound carbamino-haemoglobin. This is a reversible reaction.
- A small amount of carbon dioxide also reacts in this same way with the plasma proteins. About 23% CO_2 is transported in combination with haemoglobin and plasma proteins

$$\underset{\text{Reduced haemoglobin}}{HHbNH_2} + CO_2 \rightleftharpoons \underset{\text{Carbamino haemoglobin}}{HbNHCOOH} + H^+$$

HAEMOGLOBIN AS BUFFER

- Addition of hydrogen ions would make the blood acidic. However, most of the hydrogen ions are neutralized by combination with haemoglobin, which is negatively charged, forming acid haemoglobin. This reduces the acidity of the blood and also releases additional oxygen.
- If the blood becomes too basic, acid haemoglobin dissociates, releasing hydrogen ions.

$$HHb \rightarrow H^+ + Hb$$

  Thus, the haemoglobin also acts as buffer, a substance that keeps the pH from fluctuating. The haemoglobin of the foetus has a higher affinity for oxygen than the mother's haemoglobin. After birth, the foetal haemoglobin is gradually replaced by adult haemoglobin.

RESPIRATORY PIGMENTS AND ANIMALS CONTAINING IT

1. Haeocyanin
   A copper containing blue pigment occur in plasma of crustaceans, snails and cephalopods.
2. Chlorocruorin
   It is an iron containing green pigment, occur in plasma of annelids polychaete.
3. Pinnaglobin
   It is a manganese containing brown pigment occurs in blood fluid of some mollusks (pinna).
4. Echinochrome
   Contains iron and occur in the coelomic fluid of sea urchin (echinoderm)
5. Vanadium
   Contains vanadium. Present in the blood of tunicates (urochordates). Ciona contains vanadium in plasma and Ascidia contains in green blood corpuscles (vanadocytes)
6. Myoglobin
   Haemoglobin of the muscle
7. Molpadin
   Occur in molpadia (echinodermata)

RESPIRATORY CENTRE

- It controls the rate of respiration. Respiratory centre is located in medulla oblongata and pons. It has the following well dispersed components.
  i) Dorsal Respiratory Group
     Located dorsally along length of medulla with neurons interconnected to sensory termination of glossopharyngeal (sensory signals from preripheral chemoreceptors) and vagus (sensory signals from lungs and stretch receptors of bronchi) nerves. The area is connected through nerves to phrenic muscles of diaphragm. Nervous signals

from this group brings about normal resting inspiration. Expiration occurs through elastic recoil of thoracic wall and lungs

ii) Pneumotaxic Area
It occurs in pons and is meant for switching off normal inspiration when the limit of lung filling is reached. The latter is however also dependent upon the strength of signal 0.5sec when signal is strong and 5 sec when signal is poor.

iii) Ventral Respiratory Group
It occurs ventrolaterally anterior to dorsal respiratory group. The group has two types of neurons, inspiratory and expiratory. They are normally inactive but when the respiratory drive is greater than normal, the group is activated. It results in deeper and quicker inspiration and expiration.

iv) Chemosensitive Area
It lies in the medulla near the place of entry of glassopharyngeal and vagus nerves. It is sensitive to blood carbon dioxide and hydrogen ion concentration. Chemosensitive areas are connected to other areas of respiratory centre.

RESPIRATORY DISORDERS

1. TUBERCULOSIS
Bacterial disease caused by Mycobacterium tuberculosis. Infection of several parts but common of lungs. Vaccination with B.C.G. (Bacillus – Calmette – Guerin)
2. PLEURISY (Pleuritis)
Inflammation of pleura or accumulation of pleural fluid. Presence of excess fluid in the pleural cavity is called hydrothorax. Presence of air in pleural space is called pneumothorax.
3. EMPHYSEMA
It is a permanent abnormal pathological inflation of air spaces distal to terminal bronchioles due to destruction of pulmonary tissues especially alveolar septa and flattening of alveolar ducts. There is little alveolar elasticity. Lung size increases but ventilation is poor. Emphysema develops due to infection, smoking and chronic bronchitis. The disease cannot be cured completely because it involves irreversible change in the alveoli. Bronchodilators, antibiotics and O_2 therapy are used to provide relief and retard progression of disease. Emphysema is preventable if care is taken to reduce exposure to smoke and air pollutants.
4. ASPHIXIA
Paralysis of respiratory centre due to excessive carbon dioxide commonly due to irreversible combination of carbon monoxide with haemoglobin to form carboxyhaemoglobin. It results in death. Common in closed rooms with coal burning, kerosene lamp.
5. PNEUMONIA
    - It is a disease of lungs with an incubation period of 1-3 days and characterized by accumulation of mucus/ fluid with dead WBCs in alveoli and bronchioles so that

breathing becomes difficult. It is of several types. Common pneumonia is caused by gram(+) nonmetal paired bacterium called Streptococcus or Diplococcus pneumonia. Other bacterium, fungi, virus, mycoplasma and even some protozoans also produce the disease.

- Three types of individual are more susceptible to disease; elders, infants, immune-compromised. The disease is of two types – bronchopneumonia (young children, elderly person) and lobar pneumonia (10-50 years)
- The disease is transmitted through droplets. There is sudden chill, chest pain, cough with rusty mucoid sputum, rise in temperature, rapid shallow breathing and reduced oxygen level of blood due to poor gaseous exchange. Abdominal distension is also common. Useful drugs are erythromycin, tetracycline, sulphonamide. Bronchiodilator drugs provide some relief untreated pneumonia leads to death.

6. HYPOXIA (Anoxia)
   Shortage of oxygen supply to the body due to:
   a) Normal shortage in air as on high mountain.
   b) Anaemia.
   c) Histotoxicity or poisoning of electron transport system.
7. HICCOUGH (Hiccup)
   Inspiratory 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 inspiratory whoop caused by Bordetella (Haemophilus) pertussis.
10. BRONCHIAL ASTHMA
    Due to narrowing of bronchi and spams in bronchial muscles. The disorder is generally due to hypersensitivity of bronchioles to foreign substances. There is intense coughing and difficulty in exhalation. Mucous glands becomes over active producing a lot of mucus that clogs bronchioles and bronchi. Exposure to allergens should be avoided. Bronchodilators, inhalers and antibiotics are given for relief and protection against infection.
11. HAY FEVER
    It is an allergic disorder of nasal lining. It develops due to hypersensitivity of the lining to pollen grains or any other foreign particles.
12. ATELECTASIS
    It is an inability of lungs to expand at birth. This is mainly due to deficiency of surfactants.

13. SILICOSIS
    It is due to long exposure to dust containing silicon compounds. Workers of glass industry, potters, gold and copper miners develop progressive fibrosis in the liver.
14. ASBETOSIS
    It is due to inhalation of asbestos – fibres, which may result in cancer of pleura.
15. DIPHTHERIA
    Infection of bacterium, corynebacterium diphtheria of upper respiratory tract that produces pseudomembrane in throat. Pseudomembrane obstructs breathing causing hypoxia.
16. BRONCHITIS
    Inflammation of bronchi and bronchioles due to hypertrophy and hyperplasia and sero-mucous gland and goblet cells. There is a regular coughing with thick greenish yellow sputum indicating infection and excessive secretion of mucus. It is commonly caused by viral infection of nasal tract followed by bacterial infection. The disorder is common in smokers and persons exposed to CO rich polluted air. Persons suffering from bronchitis should avoid smoke, irritating chemicals and pollutants. Bronchodilators provide symptomatic relief. Antibiotics are used to cure infection.
17. CYANOSIS
    Bluish colouration of skin and mucous membranes due to reduced haemoglobin in blood.
18. EPISTAXIS
    Nose bleed. Quite common due to any scratching of nasal membranes. Nasal membrane is highly vascular. Epistaxis can also occur due to hypertension.
19. PHARYNGITIS
    Inflammation of Pharynx
20. LARYNGITIS
    Inflammation of larynx.
21. SNEEZING
    An involuntary, sudden, violent and audible expulsion of air through mouth and nose.
22. YAWNING
    A deep involuntary inspiration with mouth open, often accompanied by act of stretching.
23. SARS
    It is a killer atypical pneumonia called severe acute respiratory syndrome. The disease is caused by variant of common cold corona virus which spreads by droplet and other methods. There is an initial fever (100.4^{O}F), headache, body aches, dry cough and then difficult breathing.
24. OCCUPATIONAL LUNG DISEASES
    i) Black lung: Affects coal workers
    ii) Chronic Beryllium disease (CBD): It affects workers in a variety of metallurgical occupations.

iii) Byssinosis brown lung disease: It often affects cotton and textile workers when bacteriua released from cotton or other material are inhaled and grow in lungs.
iv) Occupational asthma: It can affect people who work with variety of materials, like dyes, resins, leather, latex, rubber, etc.

- It is always advisable to undertake preventive measures in work place involving pollution risk by:
  (i) Reducing emission of harmful dust and chemicals
  (ii) Using protective gear and clothing.
  (iii) Short duties.
  (iv) Informing workers about risks and preventive measures.
  (v) Regular health check up.

MOUTH SICKNESS

- It is hypoxial or oxygen shortage syndrome, which occurs at altitude of 3500 meters and above. There is decrease in atmospheric pressure as well as oxygen content of atmosphere. Reduced atmospheric pressure, reduces the amount of air taken into the lungs during inspiration. Reduced oxygen contents reduces its partial pressure and rate of diffusion into the blood. Hypoxia increases. As a result, body obtains less O_2 and therefore, produces lesser energy. However, requirement of energy at high altitude is higher due to low temperature and increased physical strain. Effects of deficient availability of energy begins to appear within 8-24 hours.
- It is characterized by breathlessness, fast breathing, nausea, vomiting, cyanosis, headache, muscular weakness and mental fatigue. After sometimes, the symptoms subside due to increased concentration of 2,3-diphosphoglycerate in erythrocytes that attracts more oxygen to form HbO_2 even PO_2 is lower. Soon rise in haemoglobin and erythrocytes count shall start.

TERMS RELATED TO BREATHING

(i) Euponea: Normal breathing
(ii) Hypoponea: Slower breathing
(iii) Hyperponea: Rapid breathing
(iv) Apnoea: No breathing
(v) Dyspnoea : Painful breathing
(vi) Orthopnoea: Difficult breathing in horizontal position.
(vii) Tachypnoea: Rapid shallow breathing.
(viii) Polypnoea: Rapid deep breathing
(ix) Hypercapnia: Excess of CO_2 in blood.
(x) Hypocapnia: Low CO_2 concentration in blood.

Significance of cell reproduction

- All cells are formed by division of pre-existing cells
- Each new individual begins its life as a new single cell commonly the fertilized egg or zygote
- A large number of cells are being torn or killed every moment in the body of a multicellular organism through skin peelings, lining of digestive tract, old red blood corpuscles, e.g. 25 million/sec in an adult human body. They are being continuously replaced through formation of new cells.
- An injury is healed through formation of new cells by healthy cells around the area of injury.
- It is mode of multiplication in unicellular organisms. In multicellular organisms, cell reproduction is required to form propagules and gametes.
- The mechanism of cell reproduction or cell division is fundamentally similar in all the organisms showing kinship and unity of life

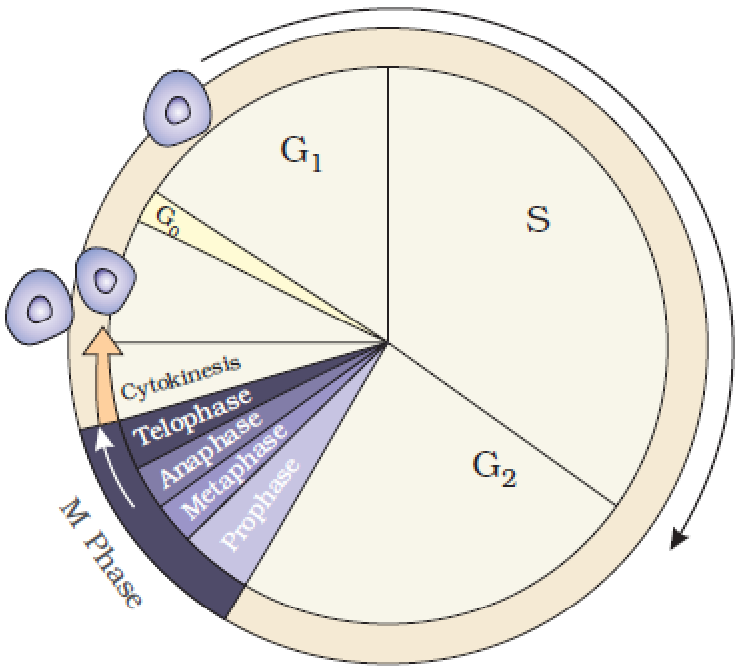
Factor controlling cell reproduction

- A number of factors are known to induce cell division. The important ones are as follows:
  - Minimum growth: A newly formed cell does not divide immediately. Some amount of minimum growth in cell and its component is required before a cell attains the ability to undergo division.
  - Surface –Volume ratio : Increase in cell size results in decrease of surface-volume ratio. This disturbs efficiency of surface exchange required for maintaining optimum metabolism. As it reaches a critical stage the cell undergoes division.
  - Nucleocytoplasmic or kernplasma ratio: Cell functions are controlled by nucleus. The size of nucleus does not change while that of cytoplasm increases during cell growth. As nucleocytoplasmic artio decreases, the cell is stimulated to divide
  - Mitogens: they are substances or factors which bring about cell division. Cytokinin is a plant hormone which functions as mitogen. There are several mitogenic substances known in human beings. E.g. EGF (Epidermal growth Factor), PDGF (platelet derived growth factor) and lymphokines.
  - There are some agents which inhibit cell division. They are called mitotic poisons. Example, azides, cyanides, chalones, colchicines. Colchicines is obtained from atucrocus (*Colchicum autumnale*) . It arrests cell division at metaphase due to non-formation of spindle.

CELL CYCLE

- Cell cycle (Howard and Pelc, 1953) is genetically controlled series of changes that occur in a newly formed cell by which it supplicates ins contents, undergoes, growth and division to form two daughter . it consists of two states or periods, a long nondividing growth I-phase and a short dividing M-phase. Both have substages. I-phase represents interphase.

- The regular sequence of G_1, S, G_2 (interphase) and M phase (mitotic phase) is called the cell cycle.
- Interphase is called 'resting stage", but it is in fact a period of great activity. Three important process, which are preparatory to cell division, take place during interphase. Thus it is also known as preparatory phase. These processes are
  - Replication of DNA along with the synthesis of nuclear proteins such as the histones
  - In animal cells, duplication of centriole takes place by the outgrowth of daughter centrioles from the parent centrioles, which are at right angle to each other.
  - Synthesis of embryo rich compounds, which provide energy for mitosis, and synthesis of proteins at the end of interphase
- Interphase (L.*inter*-in between, Gk-*phase*-stage) is intermitotic stage of cell division in which a series of changes occur in newly formed cell and nucleus undergoes certain changes to be fit for division. Non dividing state of mature cell or nucleus is called interphase. It is also called energy phase.
  Interphase of dividing cell has been classified into three subphases - G_1-Phase, S-phase and G_2-phase



G_1-phase

- G_1 phase is also known as first growth phase or post mitotic gap phase. It is the longest phase of cell division. In this phase different types of RNA (mRNA, tRNA, rRNA) and proteins are synthesized.

- All cell organelles (ER, mitochondria, Golgi complex, ribosomes, plasmid in plant cell) multiply. The duration of G_1 Phase varies from cell to cell. It is shorter in frequently dividing cells. G_1 phase cell has three options. A) Continuous cycle and enter S phase b) Stops cell cycle and enter quiescent phase or g_0 phase c) Stops cell cycle and undergoes cell differentiation
- The deciding factor for above option are availability of mitogen and energy rich compounds. This point is called check point . Once the check point of G_1 – phase is crossed, cell reaches a state called ante phase where by it will divide even under unfavorable condition. Cell cycle will go on further division till completion

S-phase

- S-phase is known as synthetic phase. In this stage replication of DNA takes place by the synthesis of histones. As a result each chromosome under goes replication producing two chromatids. Each chromosome carries a duplicate set of genes. A haploid cell (n) becomes diploid (2n) and a diploid cell (2n), thus becomes tetraploid (4n) at the end of S-phase. Repairing of damaged DNA also takes place.

G_2-phase

- G_2 is also called second growth phase or pre-mitotic gap phase. In this phase synthesis of DNA stops and synthesis of RNAs and proteins continues. All cell organelles multiply and spindle formation takes place. It lasts for 2-5 hours in most cells. Some proteins formed in this phase cause condensation of chromosomes to initiate mitosis

G_0-phase

- The phase in which cells fail to divide further (do not undergo S-phase after G_1-phase) and undergo differentiation is known as G_0 phase or quiescent stage. It occurs due to non-availability of mitogen and energy rich compounds. The cells remain metabolically active, grow in size and differentiate for particular function after attaining a particular shape.
- However some cells remain in undifferentiated state as reserve cells. They may proceed with cell division when required e.g. fibroblasts; it helps in healing of wounds and grow and divide again.

M-phase

- The process of cell division is found to be essentially the same in all living organism and the events are chiefly centered in the nucleus. Three type of cell divisions have been distinguished:
  - Amitosis or direct cell division
  - Mitosis or indirect cell division

  - Meiosis or reduction division

- Mitosis and meiosis are the two major types of cell division. The basic stage in both the types of divisions are almost identical.
- Amitosis is a direct division characterized by the splitting of nucleus followed by that of cytoplasm.
- Mitosis is a somatic cell division which takes place in vegetative cells. It maintains the chromosome number.
- Meiosis is a reduction division, occurring in the reproductive cells. The chromosome number are reduced to half.

AMITOSIS

- Amitosis (greek, *a*-without, *mitos* – thread, *osis*-state). It is a method of direct cell division in which the nucleus constricts into two daughter without showing differentiation of chromosomes and development of spindle. Nuclear division is followed by cytokinesis (division of cytoplasm)
- Amitosis was first described by Robert Remak (1855) in red blood corpuscles of chick embryo. The term was coined by Flemming (1882)

Occurrence

- It occurs through cleavage or constriction example cartilage cell degenerate cells meganucleus of *Paramecium*, cells of foetal membranes of vertebrates
- Moneran cell division is sometimes included under amitosis due to absence of spindle.
- Drawbacks
  As Amitosis does not distribute chromatin equitably, it results in structural and functional abnormalities in the cell.

MITOSIS

- Mitosis is a type of cell division in which chromosomes of parent cells are duplicated (by replication of DNA) and equally distributed (quantitatively and qualitatively) into two daughter nuclei. Term mitosis is derived from Greek word “Mitos” means thread or fibril
- Mitosis was first observed by Strassburger in plant cells (1870) and Boveri and Flemming in animal cell (1879). The term was coined by Flemming in 1882. It is also known as equational division due to equal distribution of chromosomes in daughter nuclei. It is often known as somatic cell division due to occurrence in somatic cells. It is about 1-5% of the total duration of cell cycle. On the basis of different types of cells and the species, mitosis takes 30 minutes to 3 hours for completion.
- In plants all meristematic regions are the sites of mitosis e.g. root ape, shoot apex, intercalary meristem, lateral meristem, leave, flowers, fruits, embryo, seeds etc.

- In animals embryo, skin, bone marrow etc are the sites of mitosis
- Mitosis is completed in two steps karyokinesis and cytokinesis.

Karyokinesis

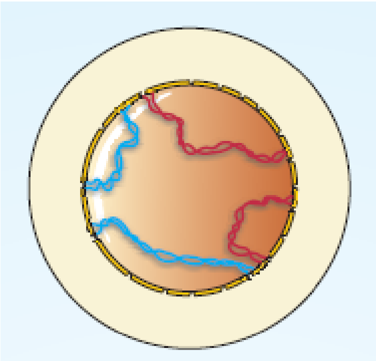
- Mitosis starts with the nuclear division of parent cell known as karyokinesis (Gk, *karyon* -nucleus, *kinesis* – movement) . The four phases of karyokinesis are prophase, metaphase, anaphase and telophase

Prophase

Prophase (Gk *Pro*-first, *phase* –stage) is often divided into three substages – early prophase, mid prophase and late prophase. It is the first stage of mitosis proper. It is the longest phase of Karyokinesis

Early prophase

- In this sub-stage nucleus and cell become spheroid and nucleus appears as boll of wool. Chromatin fibre condense to form elongated chromosome and this increases viscosity and refractivity of cytoplasm
- In animal cells duplicated centrioles. (S phase of interphase) start to move towards opposite poles of the cell. Each centriole radiates out fine microtubular fibrils called astral rays. In animal cells and cells of lower plants, fibrils appears like spokes of a wheel around each centriole to form an aster.



Early Prophase

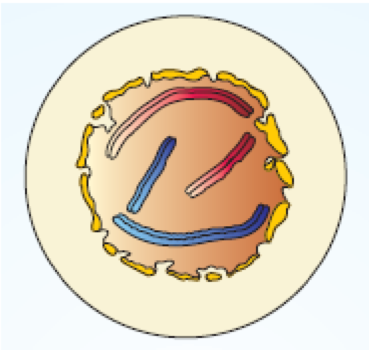
Mid prophase

- In mid prophase chromosomes shift towards the periphery and leave a clear central area. It becomes shorter and thicker. Each chromosome consists of two longitudinal threads called chromatids. Both chromatids are attached to each other by centromere and are known as sister chromatids

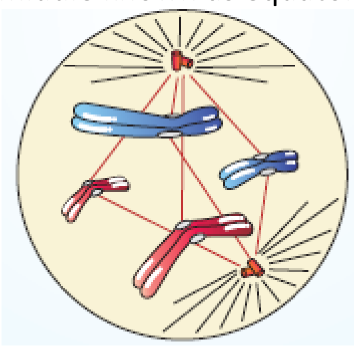
Late prophase

- In this substage spindle fibres start appearing around the nucleus. The size of chromosomes is much reduced as compared to early prophase . Spindle poles are formed without asters in plant cells and with asters in animal cells.

- Nucleolus and other cell organelles (like mitochondria, Golgi complex, ER, vacuoles etc) disappear. The presence of the spindle is essential for mitosis. If cells are treated with colchicines, which inhibits spindle formation, anaphasic movement of the two groups of chromosomes to the poles does not take place.



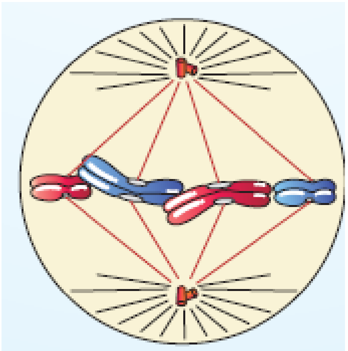
Prometaphase

- Prometaphase (Gk *Pro*- before, *meta*-second, *phase* – stage) is intermediate stage of prophase and metaphase and hence acts as connecting link between them. Nuclear membrane completely degenerate in this stage. So mixing of cytoplasm with nucleoplasm occurs. It is known as extranuclear mitosis or eumitosis.
- In many protozoan, fungi and some animal cells, nuclear membrane does not degenerate throughout cell division known as intranuclear or premitosis.
- A spindle fibres consists of 4-20 microtubules formed of protein tubulin. Spindle fibre converge at two end or pole. It has the maximum diameter in the middle known as equator.
- 

Metaphase

- In metaphase (Gk *meta*-after or second *phase* – stage) discontinuous fibres radiate out from two poles and get connected to the disc shaped structure at the surface of the cenromere called kinetochores. A kinetochore is complex protein structure that is analogus to ring for the microtubule hook; it is the point where microtubules attach themselves to the chromosome. Chromosomes or kinetochore fibres contract and bring chromosome over equator this phenomenon is called congression.

- Smaller chromosomes directed towards the centre while larger ones are peripheral in position on equator. The centromeres of all the chromosomes lie on the equator forming an apparent plate called metaphasic or equatorial plate while arms are directed towards the poles
- The kinetochores have two functions. The main function apparently is that they serve for the attachment of microtubules of the chromosomal spindle fibres. They might also be involved in the formation of the chromosomal spindle fibres during prometaphase and metaphase by serving as centres for polymerization of the protein of microtubules.
- Metaphase is the best phase to count total number of chromosomes in any species and details study of morphology of chromosomes. Idiogram (arrangement of chromosomes in a series of decreasing length) can be drawn in this stage.

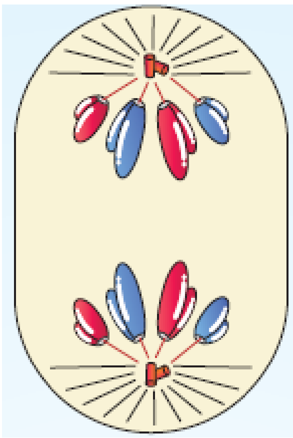


Anaphase

- In anaphase (Gk *ana* – up, *phase* – stage) chromosomes are arranged on the equatorial plate for a short period. The centromeres of chromosomes starts to divide into two, forming daughter chromosomes with centromere in each. Daughter chromosomes are repulsive so, migrate towards opposite poles. Spindle fibres attached to the centromeres shorten and pull the chromosomes to the poles. The velocity of anaphasic movement does not depend on the size of the chromosomes. In anaphasic movement of chromosomes, the centromeres lead the path while the limbs trails behind. So anaphasic chromes, the centromeres lead the path while the limbs trail behind. So anaphasic chromosomes appear as V-, L-, J- and I- shaped

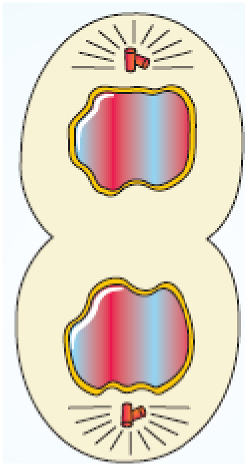
Type of chromosome	Shape	Centromere position
Metacentric	V	Median
Submetacentric	L	Subnedian
Acrocentric	J	Sub-terminal
Telocentric	I	Terminal

- At the end of anaphase two groups of chromosomes are formed, one at each pole. The number and types of chromosomes at each pole is the same as in the parent nucleus.



Telophase

- During telophase (Gk. Telos-end, phase –stage) of mitosis viscosity of cytoplasm decrease. A new nuclear membrane is formed (either from older nuclear envelop or ER) around each set of chromosomes. Chromosomes overlap one another forming chromatin. The nuclear organizer region of satellite chromosomes produce nucleolus for each daughter nucleus. Nucleoplasm surrounds in the area of chromatin. The gel state of spindle is converted into sol state and disappears.
- In this way two daughter nuclei are formed at the poles of spindle. Hence this phase is just reverse of prophase. Golgi complex and endoplasmic reticulum are reformed. Cytokinesis starts either by cleavage or constriction.



Cytokinesis

- Mitosis ends with division of cytoplasm known as cytokinesis. It is derived from greek word “cytos” means hollow or cell, “kinesis: means movement. It starts towards the middle of anaphase and is completed with the telophase. It is different in animal and plants. If nuclear divison takes place without cytoplasmic division, a syncytium is formed.

Animal cytokinesis

- The spindle gets charged into dense fibrous and vesicular structure on equator called mid body. In the middle region of cell, microfilaments starts to collected which induces the cell membrane to invigilate. The furrow forms and deepens centripetally and finally cleaves the parent cell into two daughter cells. This method of cytokinesis is known as cleavage method. All cell organelles (mitochondria, Golgi complex, lysosomes., ER, ribosomes etc) are also distributed between two daugheter cells.

Plant cytokinesis

- It differs from animal cytokinesis due to presence of rigid cell wall. In lower plants cytokinesis occurs by cleavages method (like animal cell) and in higher plants it takes place by cell plate method.
- In this method small vesicles of Golgi complex are collected at the equator. Here spindle persists for some time called phragmoplast. All vesicles fuse to form two sheets whih enclose a matrix or film. This film becomes solidified to form cell plate or middle lamella. It grows centrifugally and finally phragmoplast disappear. Cellulose, hemicelluloses and pectin are deposited on either side of cells plate. It forms primary wall.

  Difference between animal and plant cytokinesis

Animal cytokinesis	Plant cytokinesis
It occurs by cleavage	Commonly by cell plate formation
Spindle starts disapperaring	Spindle persists till half cytokinesis
A mid body is formed at the middle of the cell	Mid body is not found

Significance of mitosis

- Growth and development - A single cell zygote grows into full blown baby (6 $\times 10^{22}$ cells) by repeated mitosis. Plants are able to grow throughout their life due to mitotioc division in their apical and lateral meristems. Increases in tissue mass, results from increase in cell number called hyperplasmic. Hnece, mitosis is essential for growth and development of a multicellular organism.
- Maintenance of cell size: An overgrown somatic cell is induced to divide so that mitosis helps in maintaining a proper surface volume ratio. It has also a high nucleocytoplasmic ratio which is brought back to efficient level through divisions. These ratios are important for proper functioning of cell
- Genetic stability – All the daughter cells of a multicellular organism have the same number and type of chromosome as parent cells due to equitable

distribution of all the chromosomes. This helps in proper co-ordination among daughter cells.

- Healing and regeneration – For healing of wounds new cells are produced by mitosis. Some organisms are able to regenerate missing part of body or also whole organism though mitosis
- Reparing – the mechanism for replacing old or worn out cells is called repairing. In human body roughly 5 $\times 10^9$ cells are lost from skin surface, lining of alimentary canal, blood cell etc. these are replaced by new cells formed through mitosis.
- Evidence of basic relationship – The mechanism of mitosis are similar in the majority of organism, showing basic similarity and relationship among them

MEIOSIS

- Meiosis is a process of reductional division in which the number of chromosomes per cell is cut in half. In animals, meiosis always results in the formation of gametes, while in other organism it can give rise to spores. The word "meiosis" comes from greek world meioun, means "to make small", since it results in a reduction of the chromosome number.
- The term meiosis was coined by Farmer and Moore (in 1905). The division was first studied by Van Benedin (1887), Strassburger (1888), Sutton (1900) and Winiwater (1900). Meiosis I &II were differentiated by Gregoire. In 1911 the American geneticist Thomas Hunt morgan (1866 – 1945) observed cross-over in Drosophila melanogaster meiosis and provided the first genetic evidence that genes are transmitted on chromosomes
- Meiosis is essential for sexual reproduction and therefore occurs in all eukaryotes (including single –celled organisms) that reproduce sexually. Meiosis does not occur in archaea or bacteria, which reproduce via asexual process such as binary fission.
- During meiosis, the genome of diploid germ cell, which is composed of long segments of DNA packed into chromosomes, undergoes two rounds of division, resulting in four haploid cells. Each of these cells contain one complete set of chromosomes, or half of the genetic content of the original cell. If meiosis produces gametes, these cells must fuse during fertilization to create a new diploid cell, or zygote before any new growth can occur. Thus the division mechanism of meiosis is a reciprocal process to the joining of two genomes that occurs at fertilization. Because the chromosomes of each parent undergoes enetic recombination during meiosis, each gamete and thus each zygote, will have a unique genetic blue print encoded in its DNA. Together meiosis and fertilization constitutes sexually in the eukaryotes, and generate genetically distinct individuals in population.
- In lower plants, and in many protists, meiosis results in formation of haploid cells that can divide vegetatively without undergoing fertilization, referred to as spores. In these groups, gametes are produced by mitosis

- Biochemically, meiosis uses some of the same mechanism employed during mitosis to accomplish the redistribution of chromosomes. There are several features unique to meiosis, most importantly the pairing and recombination between homologous chromosomes, which enable then to separate from each other.
- The cells of a particular species have a constant number of chromosomes. In sexually reproducing organisms male and female gametes fuse together to form the zygote. If the gamete has the same number of chromosomes number remains constant from generation to generation. This is because of meiotic division which reduces the chromosome number to half, and counteracts the effect of fertilization. Thus fertilization and meiosis are compensating events.

Types of meiosis

- The cells in which meiosis takes place are called meiocytes. In animals, meiocytes are of two types, spermatocytes and oocytes. In higher plants, meiocytes are differentiated into microsporocytes and megasporocytes. Depending upon the stage when meiosis occurs, the latter is of three types - gametic, zygotic and sporic meiosis.

Gametic meiosis

- Meiosis is most of the animal take place during the formation of gametes (gametogenesis). It is termed as genetic meiosis. When two gametes fuse in fertilization, a diploid zygote is formed. Gametic meiosis results in diplontic life cycle

Zygotic meiosis

- In some lower plants meiosis takes place in the zygote and the resulting organism are haploid. It is called zygotic meiosis. Organism having zygotic meiosis have haplontic life cycle.

Sporic meiosis

- In plants, meiosis generally occurs at the time of sporogenesis (formation of spore or microspores and megaspores) It is called sporic meiosis or intermediate meiosi. Spores produce a new gametophytic phase in the life cycle. Gametes are formed by gametophytes. Because of the presence of two distinct multicelluar phase, diploid and haploid, life cycle of plant is diplohaplontic .

Phases of meiosis

- Because of meiosis is “a one-way” process, it cannot be said to engage in a cell cycle as mitosis does. However, the preparatory steps that lead up to meiosis are identical in pattern and name of the interphase of the mitotic cell cycle.

- Meiosis is a type of cell division that is vital for sexual reproduction. Meiosis takes place in the reproductive organs. It results in the formation of gametes with half the normal chromosomes number. Therefore, haploid sperms are made in the testis and haploid eggs are made in the ovaries. In flowering plants, haploid gametes are made in the anthers and ovules.
- Meiosis involves two divisions of the cell. These two division are termed meiosis I nad meiosis II. Each one includes prophase, metaphase, anaphase and telophase.
- Meiosis I consists of separating the pairs of homologous chromosomes, each made up of two sister chromatids, into two cells. One entire haploid content of chromosomes is contained in each of the resulting daughter cells; the first meiotic division therefore reduces the ploidy of the original cell by a factor of 2.

Meiosis I

- In meiosis I, the homologous pairs in a diploid cell separate, producing two haploid cells, so it is also referred to as a reduction division. Like mitosis, it is studied under for stages – prophase, metaphase, anaphase and telophase.

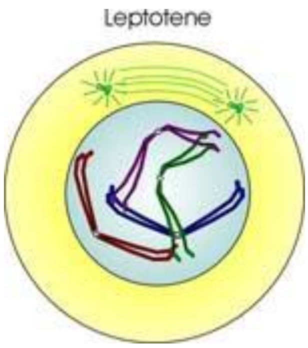
Prophase I

- Prophase I is more complicated and prolonged as compared to the siliar stage of mitosis. For the sake of convenience, prophase I is divided into five sub-phases: Leptotene, zygotene, pachytene, diplotenme and diakinesis. Another sub-phase called preleptoneme is sometimes recognized prior to leptonema. In this phase chromosomes are not distinguishable because of their thinness but sex chromosomes (if present) are often seen as heterochromatic (heteropyknotic) bodies.

Leptotene

- Leptotene also known as leptonema is a first stage of prophase I during which individual chromosomes begin to condense into long strands within the nucleus which are loosly interwoven. However the two sister chromatids are still so tightly bound that they are indistinguishable from one another.
- Leptotene chromosomes may be irregularly arranged or may be polarized towards the centrioles forming a ‘bouquet’. Electron microscope studies have shown that bouquet formation results when a group of chromosomes is attached close together on the nuclear membrane . In plant cells the chromosomes may sometimes form a tangle of threads, called the synizetic knot, on one side of nucleus.
- There are two sets of chromosomes in a diploid cell undergoing meiosis, one set contributed by the male parent and other by the female parent. These are

always two similar chromosomes, having the same size, form and structure. They are called homologous chromosomes. One of them is paternal chromosome and the other maternal chromosome.

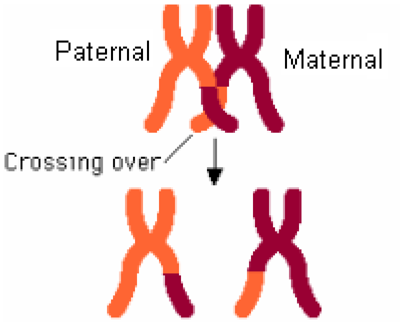


Zygotene

- During zygotene or zygonema the chromosomes become shorter anad thicker. The homologous chromosomes come to lie side by side in pairs . (G. zygon = yolk; tene = thread). This pairing of homologus chromosomes is known as synapsis or syndesis. A pair of homologous chromosomes lying together is called a bivalent. The chromatids are still not visible. A fibrillar, somewhat ladder-like , organelle, called synaptonemal complex, develops between the synapsed homologous chromosomes. It is thought to stabilize the paired condition of chromosomes till crossing over is completed.
- Pairing of two homologous chromosomes begins when their corresponding ends come together on the nuclear matrix. Pairing may occur in one of the following three ways-
  (i) Proterminal pairing : It starts at the ends and proceeds towards the middle
  (ii) Procentric pairing: it begins at the centromeres and progresses towards the ends.
  (iii) Random (intermediate) pairing: It commences at many point towards the ends.
- The synaptonemal complex is attached at both ends through its lateral element to the inner surface of the nuclear membrane. The central elements is not attached directly . Also arising from the lateral elemnent is another series of smaller loops. These loops fuse in the middle line to make up the central element.

Pachytene

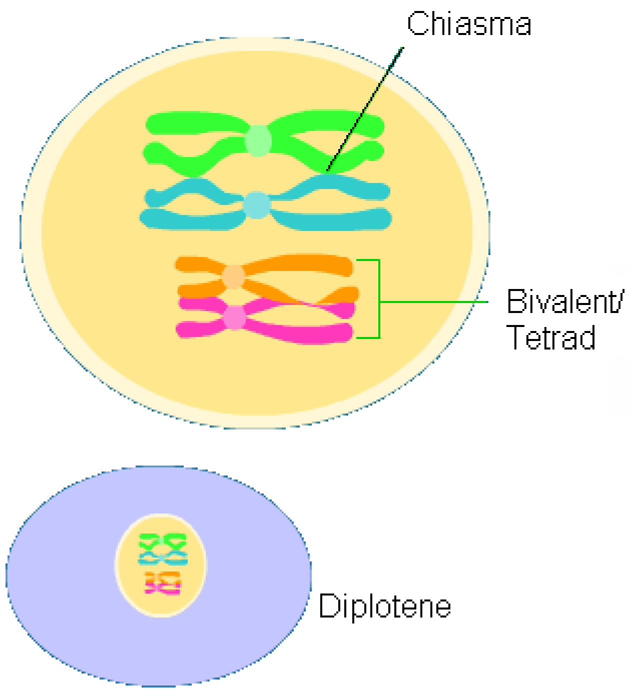
- Zygotene is followed by pachytene or pachynema. It is said to begin when synapsis is completed. It lasts from the completion of the synaptonemal complexes to the stage where their breakdown begins
- The synapsed chromosomes continue to become short and thick (G. pachus = thick, tene = thread). The chromatids of each synapsed chromosome slightly separate and become visible. The two visible chromatids of a chromosome are referred to as a dyad. A group of four homologous chromatids (two dyads) is called sister chromatids and those of two homologous chromosomes (bivalent) are termed non-sister chromatids.
- Crossing over (recombination) occurs during pachytene. Recombination involves mutual exchange of the corresponding segments of non-sister chromatids of homologous chromosomes. It takes place by breakage and reunion of chromatid segments. Breakage, called nicking, is assisted by an enzyme endonuclease and reunion, termed annealing, is aided by an enzyme ligase.
- It has been found that crossing over is a common event. Normally, each tetrad undergoes at least one recombination.



Diplotene

- During diplotene or diplonema the synaptic forces keeping the homologous chromosomes together come to an end. The homologous chromosomes start separating (G. diplos = double; tene = thread). This is called disjunction. It makes chromatids more distinct and the tetrads very clear. Separation of homologous chromosomes does not take place at the points called chiasmata (singular, chiasma). The chiasmata make the sites where crossing over occurred during pachytene (Gr . chiasma = crosspiece). They help in holding homologous chromosomes together.
- The number and position of chiasmata varies with the length of the chromosomes and with the species. Chiasmata are found in the meiosis of almost all eukaryotic organism. However, achiasmatic meiosis (meiosis without chiasma) has been reported in some organisms, e.g. males of higher dipteral (includeing Drosophila), Panorpa (scorpion fly), many mantids and roaches, some grasshoppers and scorpions. A chiasma formed at the ends of chromosomes is called termical chiasma. Chiasmata formed along the lengths of chromosomes are called interstitial chiasmata.

- During diplotene the chiasmata begins to be displaced along the length of the chromosome. The terminal chiasma slips off the ends of the chromosomes, and its position is taken up by an interstitial chiasma, which is now called the terminal chiasma. This process is called terminalization. As diplotene progresses the number of interstitial chiasmata becomes lesser in number. The terminalization may be due to electrostatic force or despiralization of chromosomes.
- When terminalization is completed the homologous remain in contact through the terminal chiasma. The degree of terminalization is expressed by the terminalization coefficient (T).
- The synaptonemal complexes mostly disappear during diplotene. In certain regions short segments may persist. The most common regions where the complexes persists are, near the ends of the bivalents where the lateral elements are attached to the nuclear membrane, and at the sites of chiasmata formation. With the disappearance of the synaptonemal complexes the axial filaments become unpaired.
- In diplotene, the chromosomes may unfold to nearly normal form and start transcription of mRNA and rRNA to build up food reverves in the cytoplasm. This process is most profound in the primary ooctytes of amphibians, reptiles and brids. In some species, the chromosomes enlarge greatly, assuming lampbrush form.



Diakinesis

- Diakinesis is not sharply differentiated from diplotene. The chromosomes become more conctracted. The bivalents are more evenly distributed in the nucleus and migrate towards the periphery. RNA synthesis stops. Nucleolus degenerates. A spindle begins to develop, with or without centrioles.

Prometaphase I

- The nuclear membrane disappears in prometaphase I and the chromosomes reach their maximum contraction. Spindle formation begins

Metaphase I

- The chromosomes now become arranged on a equator of the cell, The spindle is formed. Spindle fibres becomes attached to the centromeres of the two homologous chromosomes. The two centromeres of each bivalent lie on opposite side of the equatorial plate.
- The attachment of tetrads to the spindle fibres in metaphase I is different from that of mitotic metaphase chromosomes. Each homologous chromosome has two kinetochore, one for each of its two chromatids. Both the kinetochores of a homologous chromosome connect to the same spindle pole. The two kinetochores of its homologous join the opposite spindle pole. In metaphase I of meiosis there are bivalents, each bivalent consisting of two centromeres.

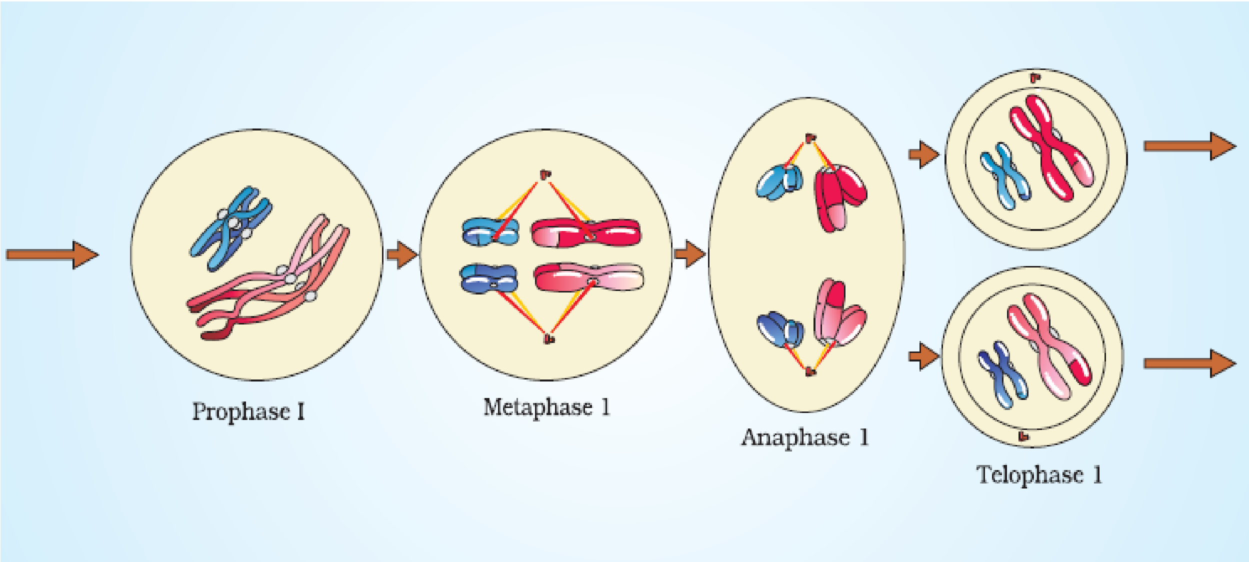
Anaphase I

- During anaphase I, from each tetrad two chromatids of a chromosome move as a unit (dyad) to one pole of a spindle, and the remaining two chromatids of its homologue migrate to the opposite pole.
- Thus, the homologous chromosomes of each pair, rather than the chromatids of a chromosome, are separated. As a result, half of the chromosomes, which appear in early prophase, go to each pole. It is here in the anaphase I that the real reduction in the poles is still double and consists of two chromatids. This is in contrast to the single-stranded chromosomes of mitotic anaphase
- The paternal and maternal chromosomes of each homologous pair segregate during anaphase I independently of the other chromosomes. Anaphase I is cytological event that corresponds to Mendel's law of independent assortment. Although the paternal and maternal chromosomes of a homologous pair have the genes for the same traits, either chromosome of a pair may carry different alleles of same genes. Therefore, independent assortment of homologous chromosomes in anaphase I introduces genetic variability.

Telophase I

- During telophase I the chromosomes at each pole of the spindle uncoil and elongate, but remain straight and often do not assume interphase form. The satellite chromosome develop forms around the chromosomes and nucleoli. The spindle and the astral rays gradually disappear.

- The cytoplasm divides at its middle by cleavage (constriction) in an animal cell and by cell plate formation in plant cell. This produces two daughter cell, each has received only one chromosome from each homologous pair. Thus it has half the number of chromosomes, but double the amount of nuclear DNA as each chromosome is still double.
- The daughter cells formed by meiosis I are called secondary spermatocytes or secondary oocytes in male and female animals.
- Cell enter a period of rest as interkinesis or interphase II. No DNA replication occurs during this stage. Protein and RNA synthesis may occur. It is important for bringing true haploidy.



Meiosis II

- The second meiotic division is essentially similar to mitosis. In this division, the two chromatids of each chromosome separate from each other and go to separate daughter cells. With the result, the number of chromosomes remains the same as produced by meiosis I, Meiosis II is, therefore, known as homotypic division. If however, differs from mitosis in that DNA does not duplicate, while centromere do so. It has 4 phases – Prophase II, metaphase II, anaphase II, and telophase II.

Prophase II

- Prophase II takes an inversely proportional time compared to telophase I. In this process we see the disappearance of nucleoli and the nuclear envelop again as well as the shortening and thickening of chromatids. Centrioles move to the polar region and are arranged by spindle fibres.

Metaphase II

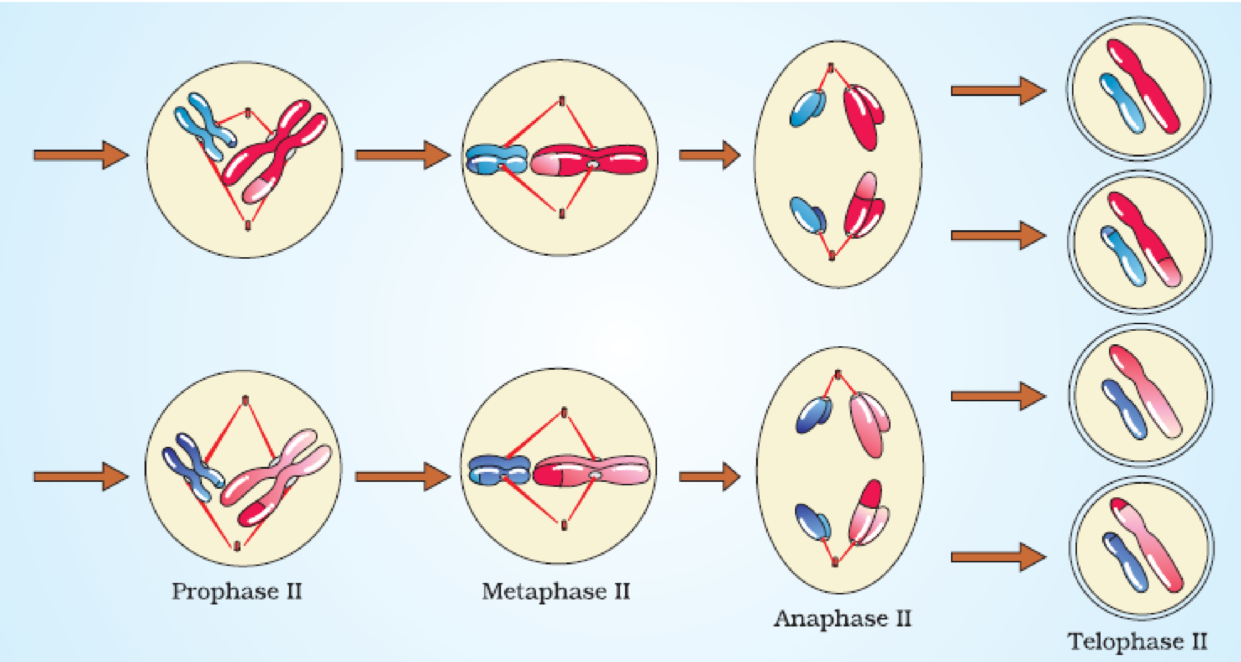
- In metaphase II the chromosomes become oriented on the equatorial plate and have the relationship to the spindle as in mitosis.

Anaphase II

- Anaphase II, where the centromeres are cleaved, allows the kinetochores to pull the sister chromatids apart. The sister chromatids by convention are now called sister chromosomes, and they are pulled towards opposite poles

Telophase II

- In telophase II the group of chromosomes at each pole of the spindle gets enclosed by a nuclear envelope. Nucleoli are laid sown, Astral rays and spindles are lost



Cytokinesis

- Cytoplasm divides at its middle by furrowing in an animal cell and by cell plate formation in a plant cell. This produces two daughter cells. The latter have half the number of chromosomes and half the amount of nuclear DNA. These cells are mature gametes in animals and spores in plants.
- Cytokinesis may occur after each nuclear division. In such cases, it is said to be of successive type. First the diploid parent cell divides by heterotypic division into two haploid cells, which then produce four haploid cells by homotypic division. The four daughter cells may form a linear or isobilateral tetrad. Often cytokinesis is delayed until both the nuclear divisions are completed, so that four cells are simultaneously formed, each with a haploid nucleus. The cytoplasmic division in such cases is said to be of simultaneous type

Significance of meiosis

- Formation of gametes – Meiosis forms gametes that are essential for sexual reproduction .
- Genetic information – It switches on the genetic information for the development of gametes or gametophytes and switches off the sporophytic information
- Meiosis facilitates stable sexual reproduction – Without the halving of ploidy, or chromosome count, fertilization would result in zygotes that have twice the number of chromosomes than the zygotes from the previous generation. Successive generations would have an exponential increase in chromosome count, resulting in an unwildy genome that would cripple the reproductive fitness of the species. Most importantly, however, meiosis produces genetic variety in gametes that propagates to offspring. Recombination and independent assortment allows for a greater diversity of genotype in the population. As a system of creating diversity, meiosis allows a species to maintain stability under environment changes.
- Crossing over- It introduces new combination of traits or variations.
- Mutations – Chromosomal and genomatic nutations can take place by irregularities of meiotic divisions. Some of these mutations are useful to the organism and are perpetuated by natural selection.
- Evidence of basic relationship of organisms – Details of meiosis are essentially similar in the majority of organisms showing their basic similarity and relationship.

ABNORMAL CELL GROWTH

- Cell division is a gene controlled process. The telomere of chromosomes contains repetitive sequence of six nucleotide. These regions code for an enzyme telomerase which control cell division. As cells go on dividing with each division the number of nucleotide decreases and ultimately cells stop dividing.
- Uncontrolled cell division may lead to the formation of undifferentiated aggregate of cells termed tumor or neoplasm.
- Uncontrolled cell division leads to hyperplasis, hypertrophy, metaplasis, neoplasia, and He La cell.
- The increased production and growth of normal cells in a tissue or organ is termed hyperplasia. It is an accelerated rate of cell division resulting from an increased level of cell metabolism. This generally results in an enlargement of tissue mass and organ size. It occurs only in tissues capable of mitosis such as the epithelium of skin, intestine and glands. Some cells do not divide and thus can not undergo hyperplasia, for example nerve and muscle cells.
- An increase in the size of a tissue or organ brought about by the enlargement of its cells is termed hypertrophy. When cells hypertrophy, components of the

cell increase in number with increased functional capacity to meeting increased cells needs. Hypertrophy generally occurs in situations where the organ or tissue can not adapt to an increased demand by formation of more cells. This is commonly seen in cardiac and skeletal muscles cells, which do not divide to form more cells.

- The process of conservation of normal tissue cells into an abnormal form in response to stress or injury or infection is termed metaplasia. It is a cellular replacement process.
- The new and abnormal development of cells that may be benign or malignant is termed neoplasia. There are two types of neoplasm – benign and malignant
  - Benign growth : the benign growth is restricted to a particular site of the body and the cells never spread out to different parts of the body e.g. simple tumor
  - Malignant growth : in malignant growth after the cells are being formed at a particular site, the cells move out different parts of the body and initiate similar type of growth. The stage of malignant growth in which the cells spread out through the body fluid to different parts of the body is termed metastasis. Malignant growth is also termed cancerous growth.
- He La cells (an aneuploid epithelial cells) are cell line culture of first human cancerous cells donated by Henrietta Lacks from their uterine carcinoma cells since 1952. These cells are maintained for use in studying cellular processes.

- Excretion is the elimination of waste products from the body of an organism. Waste products are unwanted and toxic by-product which are removed to maintain homeostalis and protect the body from their toxicity.
- Defaecation is eliminated of undigested food residue from alimentary canal while secretion is discharge of specially syntheised product. Example, hormone by endocrine gland, saliva from salivary glands.
- Osmoregulation is the regulation of water content and salt concentration in the body of an organism.
- Homostasis is maintenance of a constant favourable internal environment despite fluctuations in water content, solute concentrations formation of toxic waste metabolites.

OSMOLARITY

- It is solute concentration expressed as molarity or moles of solute per litre of solution. Unit of measurement is milliosmole (1000 of osmole which is amount of solute forming one mole of active particles), osmolarity of fresh water is less than 50 mosm/lt, fresh water vertebrates 200-300 mosm/lit, human blood 300 mosm/lt. While sea water has an osmolarity of about 1000 mosm/lit
- Two solutions of same osmolarity are isotonic, one with higher osmolarity or concentration is hypertonic, while the one with lower concentration or dilute solution is known as hypotonic.

METABOLIC WASTE PRODUCTS

1. Nitrogenous waste products.

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, xathine, guanine, trimethylamine oxide and allantonin.

2. Non-nitrogenous waste products

Oxalic acid, lactic acid

3. Excess chemicals

Sodium, calcium, magnesium, lead, chloride, phosphate, iodine, pigments, drugs, cholesterol, hormones, vitamins, wax etc.

4. Bile pigments

Bilirubin, biliverdin and urochrome are break down products of haemoglobin formed by liver

5. CO_2

6. Excess water

TYPES OF ANIMALS BASED ON EXCERTORY PRODUCTS

- Depending upon the forms in which the nitrogenous wastes are excreted from the body, the organisms are grouped under three categories, ammonotelic animals, ureotelic animals and uricotelic animals

AMMONOTELIC ANIMALS

- Animals excreting their nitrogenous wastes in the form of ammonia are known as ammonotelic animals and the phenomenon of excretion of ammonia is known as ammonotelism
- Ammonia is the first metabolic waste product of protein metabolism. It is highly soluble in water with which it forms ammonium hydroxide (NH_4 OH) which injures cells directly by alkaline caustic action. Hence, excretion of ammonia requires large amounts of water to be lost from the body. That is why such a mode of excretion is suitable for aquatic organisms, which have a constant access of water
- No energy is required to produce ammonia. Many aquatic animals like protozoans (e.g. amoeba, paramecium) sponge (sycon), cnidarians or coelenterates (hydra), liver flukes, tape worms, Ascaris, Nereis, earthworms, leech, most aquatic arthropods (Prawn) most aquatic mollusks (Pila), bony fish (Labeo), amphibian tad pole, tailed amphibian (salamanders) and crocodiles excrete ammonia.
- About 300 to 500 ml of water is required for elimination of 1 gm of ammonia.

URICOTELIC ANIMALS

- Animals which excrete their nitrogenous wastes mainly in the form of uric acid are known as uricotelic animals and the phenomenon of excretion of uric acid is known as uricotelism.
- Conversion of ammonia to uric acid (which requires more energy) and its subsequent elimination requires lesser amount of water as it is comparatively less soluble in water and less toxic as compared to ammonia. Hence, it is observed in terrestrial animals that do not have constant access to water or rather have limited access to water.
- Synthesis of uric acid from ammonia takes place in liver by ionosinic pathway.
- Uric acid is formed in the body by breakdown of purine and pyrimidine of muleic acid.
- Reptiles, birds, land snails and insects excrete uric acid in the form of pellet.
- About 10 ml of water is required for elimination of 1gm of uric acid

UREOTELIC ANIMAL

- Animals which excrete their nitrogenous wastes mainly in the form of urea are known as ureotelic animals and the phenomenon of excretion of urea is known as ureotelism.
- Urea can be stored in body for considerable period of time, as it is less toxic and less soluble in water than ammonia. It is eliminated in the form of urine.
- Urea formation requires expenditure of energy. I is formed in liver by ornithine cycle.
- About 50 ml of water is required to eliminate 1gm of urea.
- Ureotelism is exhibited by semi terrestrial animals. E.g. some earthworms, adult amphibians, cartilaginous fishes, semi aquatic reptiles like turtles, terrapins and alligators and mammals including man
- Sharks retain large amount of urea in their blood, therefore, blood osmotic pressure approaches that of sea water which minimizes water loss from their body

EXCRETORY ORGANS IN DIFFERENT ANIMAL GROUPS

1. Protozoans

Excretory organs: Plasmalemma, pellicle. Nitrogenous waste : Ammonia

2. Poriferans

Excretory organ: General body surface. Nitrogeneous waste : Ammonia

3. Coelenterates

Excretory organs: General body surface. Nitrogenous waste : Ammonia

4. Platyhelminths

Excretory organ: Protonephridium with flame cells. Nitrogenous waste : Ammonia

5. Aschelminths

Excretory organ: Renette cells (Ascaris). Nirogenous waste : Ammonia, urea

6. Annelids

Excretory organs:

i) Metanephridia (Nereis and leach)

ii) Metanephridia and chloragogen cells (earthworm)

Nitrogenous waste:

i) Ammonia

ii) Ammonia, urea on land

7. Molluscs

Excretory organ: Renal gland or organ of Bojanus (Pila and unio) and Keber's organ (Unio)

Nitrogenous waste: Ammonia in aquatic and uric acid in land forms

8. Arthropods

Excretory organs

i) Malphigian tubules, uricose gland, urate cells, nephrocyte.

ii) Malphigian tubules, coxal gland, hepato-pancreas and nephrocytes (spiders and scorpions)

iii) Green glands or antennary glands in a crustaceans.

Nitrogenous waste

i) Uric acid in land forms and ammonia in aquatic forms

ii) Guanine, some xanthine and uric acid

iii) Ammonia

9. Echinoderms

Excretory organs: Tubafeet (podia) and dermal branchiae (thin walls of gills).
Nitrogenous waste : Ammonia

10. Hemichordates

Excretory organ: Glomerulus (Balanoglossus)

11. Chordates

a) Urochordates

Excretory organ: Neural gland (Herdmania)

b) Cephalochordates

Excretory organ: Pharyngeal nephridia and Hatschek's nephridium (Amphioxus)

c) Vertebrates

Excretory organ: One pair of kidneys are main excretory organs. Lungs, liver skin and intestine are accessory excretory organs in many vertebrates.
Nitrogenous waste: Ammonia, urea, uric acid.

HUMAN EXCRETORY SYSTEM

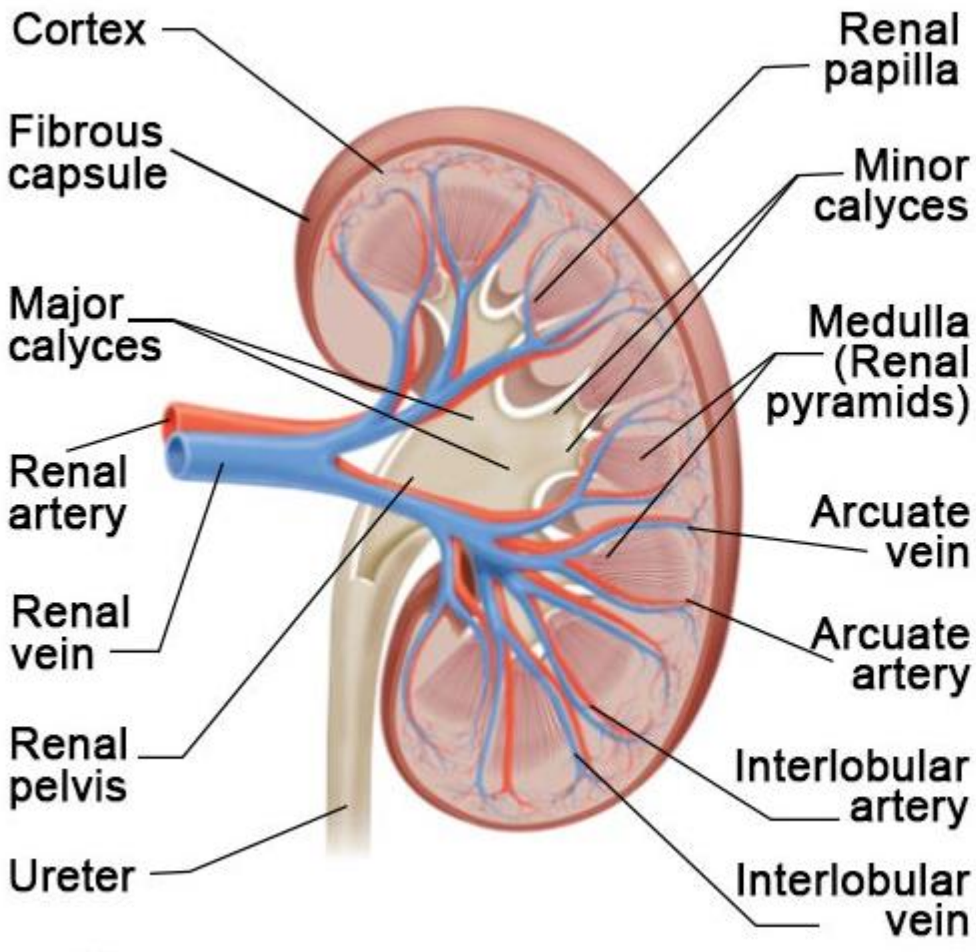
The mammalian (human) urinary system consists of two kidney which form the urine, two ureters which conduct the urine from kidney to urinary bladder, a urinary bladder for storage of urine and a urethra through which the urine is voided by bladder contractions.

KIDNEYS

- Kidneys are mesodermal in origin and arise from linearly arranged mesodermal somites
- They are reddish brown, bean shaped structures situated in the abdominal cavity just behind the vertebral column. The positioning of kidney is called retroperitoneal i.e. located outside peritoneal cavity
- They are situated between the levels of last thoracic and third lumbar vertebra close to the dorsal inner wall of the abdominal cavity. Last two pairs of ribs i.e. floating ribs protect the kidney from backside.
- An average sized kidney is about 10-12 cm in length, 5-7 cm in width and 3-4 cm in thickness. Weight is about 150gm in male and about 135gm in females. Usually, the right kidney is smaller than the left one and

positioned a bit lower as compared to the left kidney. Such a difference is seen as most of the portion of right side is occupied by liver.

- The kidney is covered by a layer of fibrous connective tissue, the renal capsule, which protects it from infection and injuries. Around the capsule there is a layer of fat, the adipose capsule and another outer fibrous membrane, the renal fascia. Both the fat and the fascia help to protect the kidney
- Internally the kidney consists of the outer dark region, the cortex and the inner light region, the medulla. Both the region contains uriniferous tubules or nephron



- The renal cortex is granular in appearance because the tubules here are much convoluted (proximal and distal convoluted tubules) and contain malphigian corpuscales.
- The medulla consists of 10 to 15 multilobular conical masses, the medullary pyramids or renal pyramids, whose bases are adjacent to the cortex are adjacent to the cortex and apices from the papillae. These papillae project into cup shaped channels called minor calyces (7-13 in

number). The minor calyces lead into major calcyces (2-3 in number). The major calyces join to form the pelvis which leads into the ureter.

- Between the medullary pyramids the substance of the cortex extends into the medulla and forms the renal columns of Bertin.
- The medial concave border of kidney contains a notch known as hilus through which the renal artery enters and the renal vein and ureter leave the kidney.

DIFFERENT TYPES OF KIDNEYS IN VERTEBRATES

a) Archinephric or Holonephric kidney

- It extends through the entire length of coelom. This hypothetical kidney is found in the larval of certain cyclostomes e.g. Myxine. It is supposed to give rise to all other kidney types.

b) Pronephric or head kidney

- It appears dorsal to the anterior end of coelom and is associated with pronephric tubules. In pronephric kidney glomerulus is external and naked. It is functional only in embryonic and larval stages and soon replaced by the next stage

c) Mesonephric or middle kidney

- It develops from middle part of the intermediate mesoderm. It is also called Wolffian body. It is functional in both larvae and adults of most fishes and amphibians.

In amniotes, it is functional in embryonic stage and gets replaced by metanephric kidney in adults

d) Opisthonephric or tail kidney

- The functional nephrons in this kidney belongs to the posterior region of coelom, which are displaced from their position

- It is found in sharks and caecilians.

e) Metanephric kidney

- In metanephric kidney, functional posterior nephreons are displaced from the original position to anterio lateral position. The nephrons of this kidney are highly differentiated. Which forms loop of henle in mammals. It is functional in all amniotes i.e. reptiles, birds and mammals

FUNCTION OF KIDNEY

The functions of kidney are as follows

i) Osmoregulation: Kidney removes excess of water from the body

ii) Elimination of nitrogenous waste: Kidney removes nitrogenous waste such as urea and uric acid from the blood.

iii) Maintenance of pH : Kidney removes excess of acids and alkalies from the blood to maintain proper pHof blood (about 7.4)

iv) Maintenance of salt contents: Kidney maintain proper amount of mineral salt such as sodium and potassium in the body.

v) Removal of other substances: Kidneys removes toxic substances, drugs, pigments, excess vitamins from blood.

vi) Maintenance of blood pressure: Kidney controls the fluid balance in the body, therefore, it maintains blood pressure.

vii) Secretion of rennin: kidney secrete an enzyme, the rennin (acts as harmone) which converts the aniotensinogen (produced by liver) into angiotensin. The latter stimulates adrenal cortex to secrete aldosterone (hormone). Which increases the rate of reabsorption of Na^+ in the nepherons.

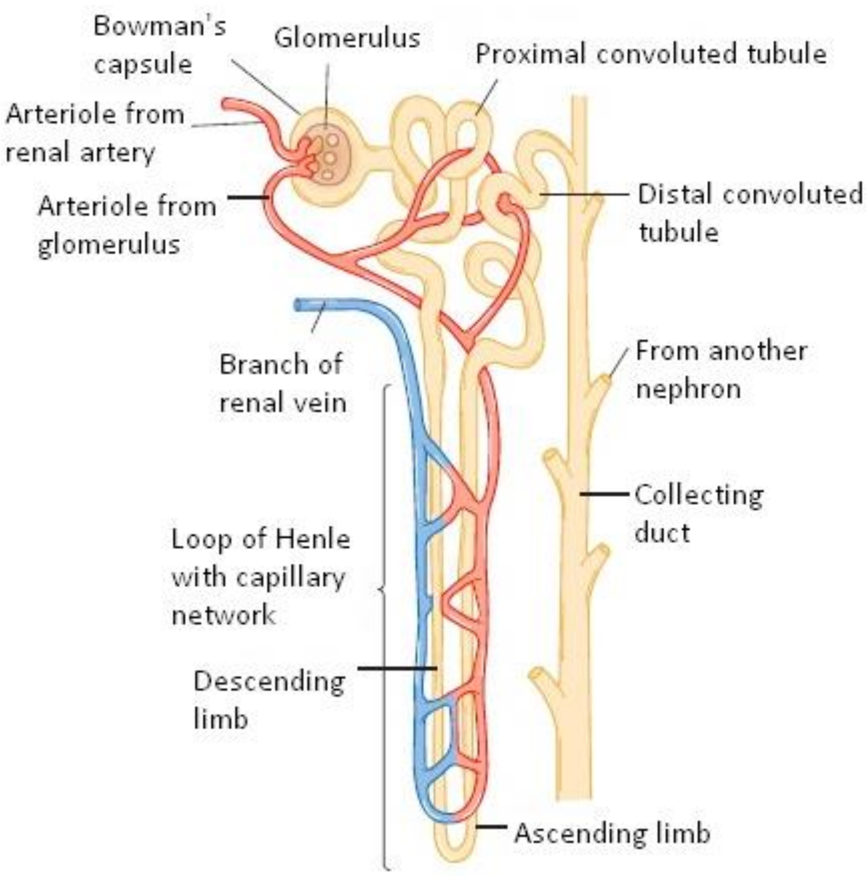
viii) Erythropoietin production: The kidney produces erythropoietix hormone which stimulates the formation of red blood corpuscles. The stimulus for secretion of erythropoietin is less oxygen in the blood (hypoxia) but it is also stimulated by male sex hormones and cobalt salt

ix) Homeostasis: Because kidney removes various unwanted materials from the blood it helps in keeping the internal environment of the body constant.

URETERS, URINARY BLADDER AND URETHRA

- Ureters are thin muscular tubes emerge out from the hilum of kidneys. Urine enters the ureter from the renal pelvis and is conducted along the ureter by peristaltic waves on its walls. Ureters are lined by flexible transitional epithelium and carry urine from the kidneys to urinary bladder.
- Urinary bladder is a sac-like structure which stores urine temporarily. Bladder has three parts. Apex, fundus (body) and neck. Body has triangular area called trigone. Neck region possesses two sphincter and involuntary external sphincter. Urinary bladder is also lined by flexible transitional epithelium.
- Uretha is membranous tube. Which conducts urine to the exterior. The urethral sphincters keep the urethra closed except during voiding of urine.
- Length of urethras in male is much longer than female.

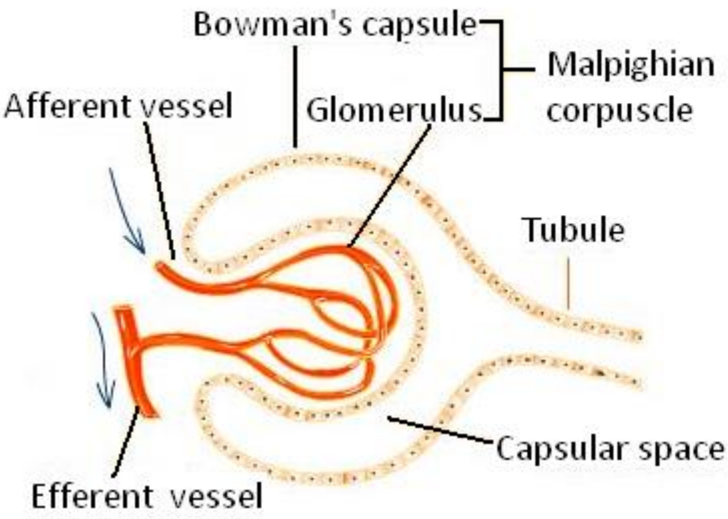
NEPHRONS



- Nephrons are the functional unit of kidney. A human kidney contains about one million thin, long, much convoluted tubular unit called nephrons or uriniferous tubules.
- Two types of nephrons present in kidney are : Cortical and juntamedullary nephrons. Cortical nephrons (about 85%) lie in the renal cortex their glomeruli lie in outer cortex. They have a shorter loop of Henle and peritubular capillary network. They do not have Vasa recta. They control plasma volume when water supply is normal. Tuxtamedullary nephrons (about 15%) lie at the junction of renal loop of Henle and Vasa recta. They control plasma volume when water supply is short.
- A nephron consists of two parts – an initial filtering component, the renal corpuscle or Malphigian corpuscle and long tubule, the renal tubule – both made of simple cuboidal epithelium.

Renal Corpuscle

- Malphigian corpuscle is named after Marcello Malpighi
- The renal corpuscle filters out large solutes from the blood and delivers water and small solutes to the renal tubule for modification
- The renal corpuscle is composed of a capillary network called glomerulus and a Bowman's capsule or glomerular capsule
- Bowman's capsule and glomeruli are absent in marine fishes and desert amphibians hence their nephrons are called aglomerular.



- Bowman's capsule is named after Sir William Bowman, a British surgeon and anatomist. It is a double layered, cup-shaped structure. The lumen of capsule is continuous with the narrow lumen of renal tubule. Bowman's capsule consists of two layers- outer parietal layer (simple squamous epithelium) and inner visceral layer (layer of special epithelial cell) called podocytes containing filtrate filters.

- Glomerulus is a capillary network within the Bowman's capsules. Blood enters glomerular capillaries through afferent arterioles and leaves through efferent arterioles. The diameter is much more than that of efferent arteriole.
- The walls of the afferent and efferent arterioles contain the rennin-secreting juxtaglomerular cell.

RENAL TUBULE

- Attached to each Bowman's capsule is a long, thin tubule with three distinct regions – proximal convoluted tubule (PCT), loop of Henle and distal convoluted tubule (DCT)

Proximal convoluted tubule

The first region of renal tubule is called the proximal convoluted tubule. It is about 14 m long and lined by a single layer of brush bordered cuboidal epithelium which increase surface area and contains mitochondria. Which provide energy for reabsorption of salts by active transport.

Henle's loop

- Henle's loop is a U-shaped tube, which plays a significant role in maintaining high osmolarity of tissue surrounding the loop
- The loop of Henle consists of a descending limb and ascending limb
- Descending limb of loop of Henle is lined by feat cells i.e. simple squamous epithelium. It is permeable to water and impermeable to electrolytes. Due to this the filtrate moving down through the limb becomes concentrated.
- Ascending limb of loop of Henle is comparatively thicker and is composed of flattened cuboidal epithelium. It is impermeable to water and permeable to electrolyte like K^+, Cl^- and Na^+

Distal convoluted tubule

- It is situated in the cortex region of kidney and it is about 4.5 – 5.5 mm long. The diameter of this region is 20 – 50 μm and it is lined by cuboidal epithelium. The epithelium here is with elevations but without any true brush border. Conditional reabsorption of Na^+, water and HCO_3^- takes place in this segment.

Collecting duct

- The last part of nephron is called collecting duct which is 20mm long and lined by the cuboidal cells. Several collecting tubules of different nephron join successively to form the duct of Bellini or papillary duct, which opens at the apex of renal pyramid.

NEPHRON'S BLOOD SUPPLY

- There is an intimate association between the blood vessels and the nephrons of the kidney. This association permits both extensive filtration from the blood and selective reabsorption back into the blood.
- After entering each kidney, the renal artery branches repeatedly forming smaller and smaller arteries, until tiny arterioles reach each of the 1 million nephrons. An afferent arteriole delivers blood to glomerulus for filtration, an efferent arteriole drains filtered blood away from the same glomerulus.
- The efferent arteriole connects to the second network of capillaries, the peritubular capillaries, which are closely associated with the nephron tubule. It is into these peritubular capillaries that water, ions and nutrients are reabsorbed from the filtrate in the nephron tubule. From the peritubular capillary network arise the capillaries of vasa recta, which extends parallel to the loops of Henle and collecting ducts in the medulla. The vasa recta consist of descending capillaries and ascending capillaries. All the capillary network join to form renal venules which join to form renal vein that opens into the inferior vena cava.

URINE FORMATION IN KIDNEY

- The process of formation of urine is called uropoiesis.

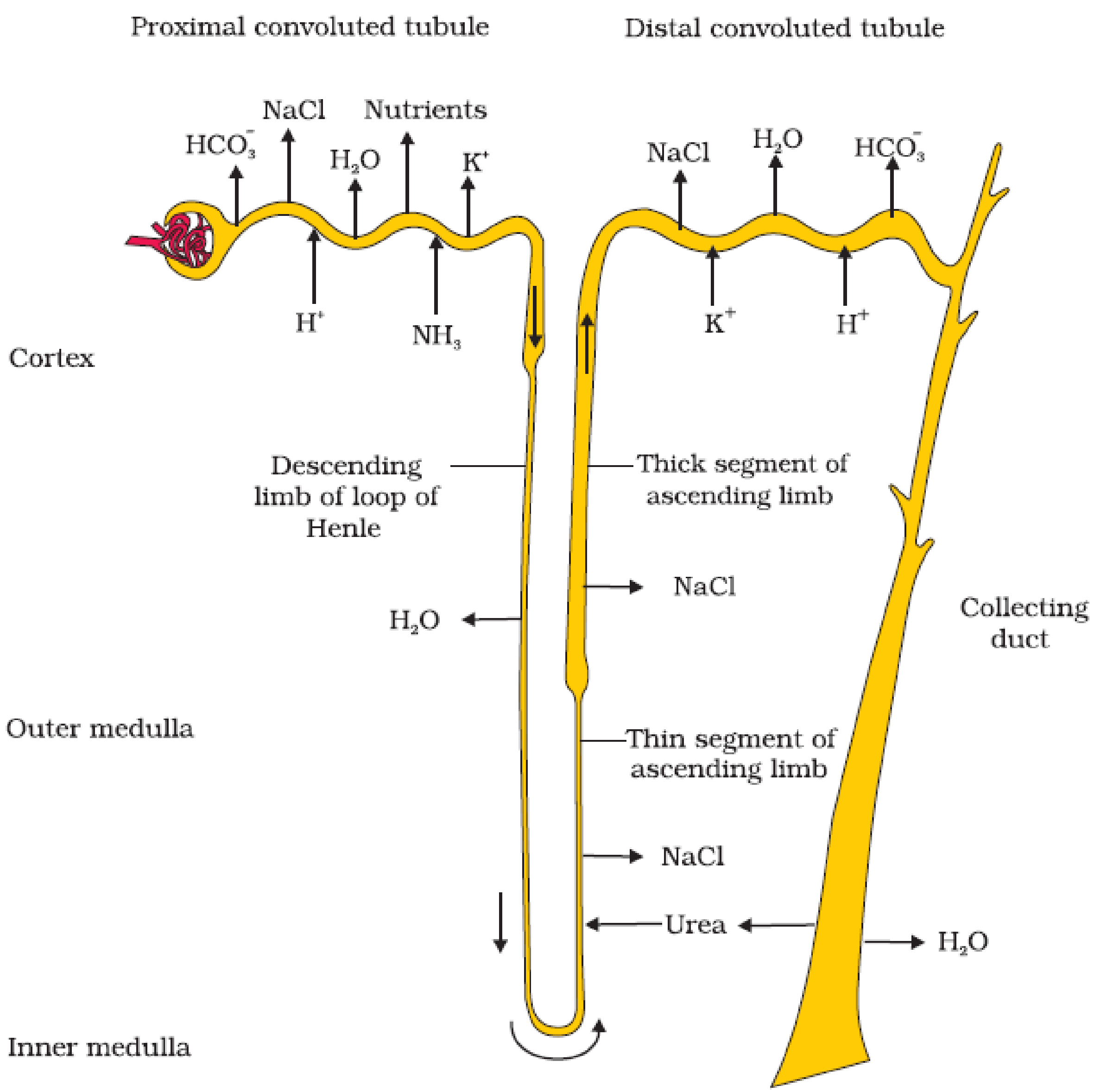
- Formation of urine by the kidneys can be divided into following three steps

i. Glomerular filtration or ultra filtration
ii. Selective reabsorption
iii. Tubular secretion

GLOMERULAR FILTRATION OR ULTARFILTRATION

- The blood pressure is largely responsible for ultrafiltration. In kidney, the glomerular capillary is known as high pressure bed, which the peritubular network are known as low pressure beds.
- The pressure of blood is about 100 mm of Hg in glomerulus, it falls to about 70mm of Hg in glomerulus while it goes down to the extent of about 18 mm of Hg in efferent arteriole. Within the peritubular network, the pressure around PCT is about 14mm of Hg and around DCT is 6mm of Hg, while it is lowest around the collecting tubule is about 2mm of Hg. When blood enters the glomerulus, the blood pressure forces out water and dissolved blood components through the filtration membrane.
- The resulting fluid is called filtrate. The glomerular filtrate contains essentially all the constituents of blood except the blood cells, proteins, certain drugs, pigments, dyes, etc., if present in the blood.
- The amount of filtrate formed by the kidneys per minute is called Glomerular Filtration Rate (GFR). GFR of healthy individual is 125mL/minute i.e., 180L/day.

SELECTIVE REABSORPTION



- From the Bowman's capsule, the glomerular filtrate enters the PCT. After ultrafiltration, rest both the processes proceed simultaneously into the tubular region. About 65% of glomerular filtrate is normally reabsorbed in PCT before reaching the loop of Henle.
- These include glucose, amino acids, vitamins, hormones, sodium, potassium, chlorides, phosphates, bicarbonates, most of water and some urea. Out of these

a) Na^+ and K^+ are reabsorbed through the active transport.
b) Glucose and amino acids are reabsorbed through passive transport.
c) Reabsorption of water takes place through osmosis.
d) Cl^-, urea and other solutes are reabsorbed through simple diffusion.

Besides, reabsorption, secretion of certain substances (Actively) also takes place in PCT like creatinine, hippuric acid, pigments, drugs along with H^+ and NH_3. Here, reabsorption means transportation of substances from the filtrate to back in the blood (flowing in peritubular network) through tissue fluid. Similarly, tubular secretion means transport of substances from blood towards the filtrate through the tissue fluid (from peritubular network to renal tubules).

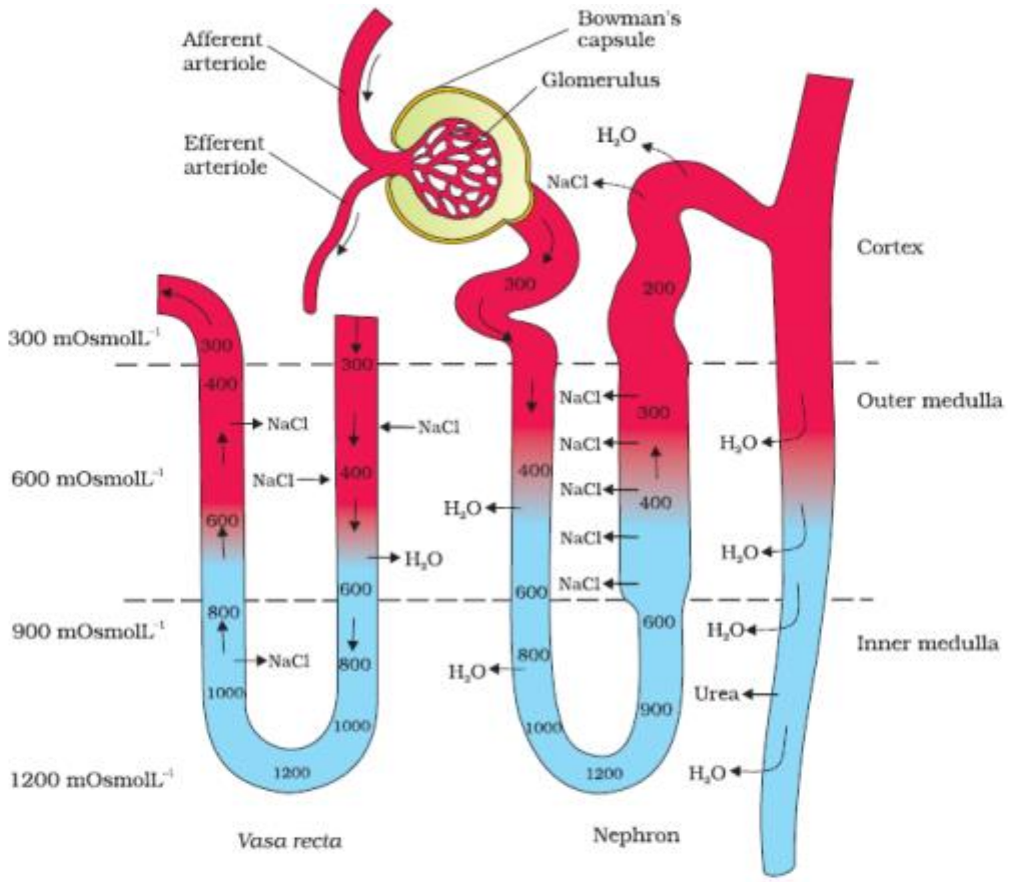
TUBULAR SECRETION

- The substances not reabsorbed in the selective reabsorption excrete in to the filtrate by the process of secretion. Tubular secretion is opposite to tubular reabsorption. The tubular cells secrete substances like H^+, K^+ and ammonia into the filtrate. Through K^+ ions enters the filtrate from the glomerulus and are almost totally reabsorbed but they are also secreted into the lumen of distal convoluted tubule and collecting ducts. The active secretion of K^+ ions is coupled with the active reabsorption of Na^+ ions. Most of the other substances that enters the tubule by tubular secretion move by the active transport.
- Tubular secretion plays a minor role in the function of human kidneys, but in animals like marine fishes and desert amphibians whose nephrons do not possess developed glomeruli, urine is formed mainly by the tubular secretion of urea, creatinine and mineral ions. The process of reabsorption involves both active and passive pathways.

COUNET CURRENT MECHANISM OF URINE CONCENTRATION

- Higher vertebrates (birds and mammals including man) have evolved a counter current mechanism to excrete hypertonic urine (urine more concentrated than blood) for conserving body water, so necessary for land life. The counter current refers to the fact that the fluid flows in opposite direction in the two sides of the loop, down one side and up the other. Henle's loop and capillary loop (vasa rectae) plays an important role in this mechanism.

- As the filtrate passes through the ascending limb of the loop of Henle, it loses NaCl to the interstitial fluid on the renal medulla by diffusion in the narrow region of the limb, and Na^+ and Cl^- ions by active transport in the wide region of the limb.
- The increased concentration of the solutes in the interstitial fluids draws out water by osmosis from the narrow region of the descending limb and also from the collecting duct, both being permeable to water. The water then quickly enters the vasa rectae and is carried away. This maintains high concentration of solutes in the interstitial fluid around the loop of Henle and the collecting duct, and turns the isotonic glomerular filtrate into a hypertonic urine.
- The endothelial cells forming the walls of the vasa recta are freely permeable to ions, water and urea.
- As the blood flows in the descending capillary of the vasa recta towards the renal medulla, water is drawn out from the blood plasma by osmosis due to the progressive increase in the concentration of the interstitial fluid sodium and chloride ions and urea enter the plasma by diffusion.
- As the blood flows in the ascending capillary towards the renal cortex, the reserve occurs, that is, water reenters the plasma and Na^+, Cl^- and urea leave it due to a progressive decrease in the concentration of the interstitial fluid.



REGULATION OF KIDNEY FUNCTIONS

CONTROL BY JUXTAGLOMERULAR APPARATUS (JGA)

- JGA works through Renin Angiotensin Aldosterone Sysytem (RAAS). The system normally operates when blood pressure is decreased in the afferent arteriole of glomerulus which is characterized by fall in glomerular filtration rate. At that time, rennin is released from JG cells.
- Renin works on a plasma protein angiotensinogen (produced by liver) and converts it to angiotensin I.
- Angiotensin I is then converted into angiotensin II.
- This angiotnesin II then increases the blood pressure by causing the aretrioles to constrict and increases blood volumes in the two ways.

i. By increasing water and NaCl reabsorption in PCT.
ii. By stimulating adrenal glands to secrete aldosterone, which works on DCT for the same cause.

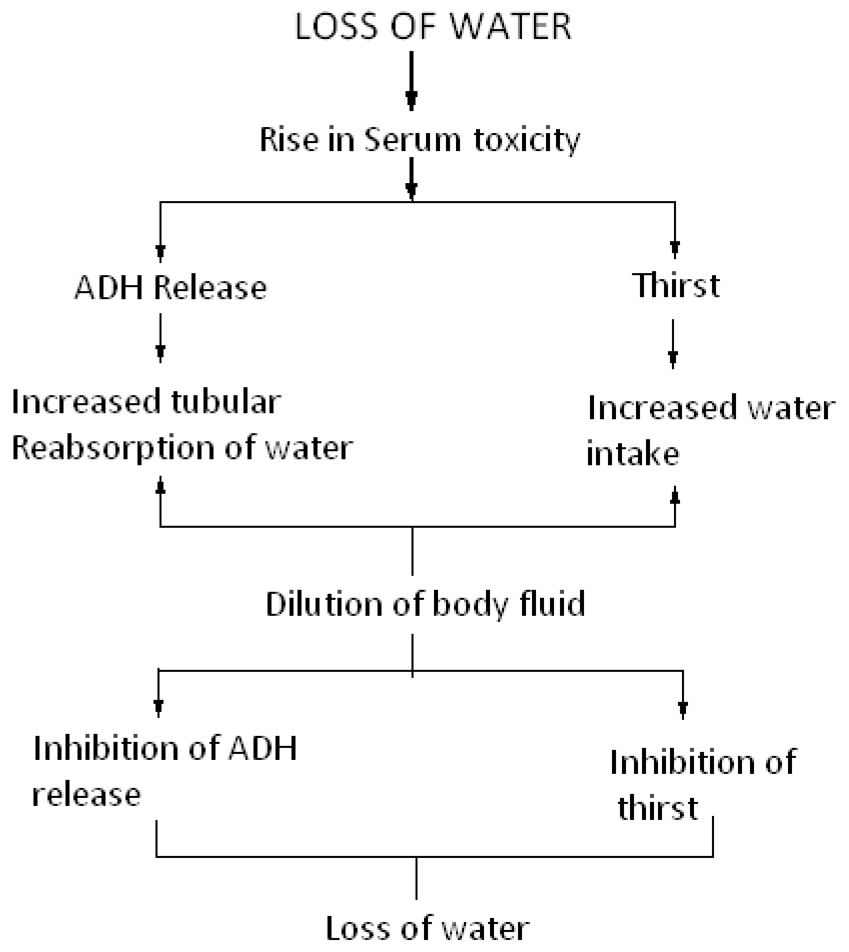
ATRIAL NATRIURETIC FACTOR

- This factor works opposite to RAAS when there is higher blood volume and pressure by causing vasodilation. Walls of atria(heart) produces a peptide hormone Atrial Natriuretic Factor (ANF) which inhibits rennin secretion by juxtaglomerular cells and ADH by pituitary gland. It inhibits NaCl reabsorption and concentration of urine.
- Birds cannot make urine as hypertonic as mammals can do. Reptiles produce only hypotonic urine.

CONTROL BY ANTIDIURETIC HORMONE (ADH)

- ADH is secreted by neurohypophysis and produced by the hypothalamus of brain. The release of this hormone is normally seen when osmoreceptors in hypothalamus detect an increase in osmolarity of blood. In this situation, the osmoreceptors cells also promote thirst. It also increases the reabsorption of water in DCT and collecting duct.
- Excess of water in the body fluids signals the posterior pituitary lobe to stop release of the hormone vasopressin or antidiuretic hormone (ADH). Deficiency of this hormone lowers the permeability of the cells of the distal convoluted tubule and the collecting duct, thereby decreasing the reabsorption of water. However, active reabsorption of Na^+ from the filtrate continues in these regions of the nephrons. More filtration and less reabsorption of H_2O and normal reabsorption of Na^+ produce abundant urine and this brings down the volume of body fluids to normal.
- In case, the volume of the body fluids falls below normal, as in excessive bleeding, profuse sweating due to heavy muscular work or high temperature glomerular filtration slows down due to decrease in blood pressure and filtration pressure in the glomerular capillaries. This stimulates the posterior pituitary lobe to release ADH. This hormone increases the reabsorption of water in DCT and collecting tube.
- Continued Na^+ active reabsorption, makes the interstitial fluid hypertonic and this also favours reabsorption of water. Less filtration and more reabsorption of water lead to the discharge of small amount of hypertonic urine. This raises the volume of the body fluids to normal. In order to prevent the loss of Na^+ in the urine, these must be reabsorbed.

Reabsorption of sodium is controlled by a hormone aldosterone produced by the cortex of the adrenal glands.



MICTURITION

- The expulsion of urine from the urinary bladder is called micturition. It is a reflex process, but in grown up children and adults, it can be controlled voluntarily to some extent.
- The release of urine occurs by the contraction of smooth muscles of urinary bladder wall (due to pressure exerted by pressure receptors present on the wall) and relaxation of the urethral muscle sphincter around the opening of bladder. As the bladder wall is stretched by the gradual filling of the bladder, stretch receptor in the wall generate nerve impulses. These impulses are carried by sensory neurons to the spinal cord and brain, producing the sensation of fullness (around 500 mL).
- The sphincters are then released by the inhibition of motor impulses allowing the smooth muscle of the ladder wall to contract under

autonomic control. The neutral mechanism causing micturition is called micturition reflex.

COMPOSITION OF URINE

- Urine is transparent, amber coloured, hypertonic fluid with a slightly acidic pH (6.0).
- The yellow colour of the urine is due to the pigment urochrome, which is a breakdown product of haemoglobin from worn out RBCs.
- Volume of urine depends upon intake of fluids, external temperature and physical activities. Human excrete 1-2 litres urine per day.
- The urine of standing gives a pungent smell due to conversion of urea into ammonia by bacteria.
- Urine consists of Water- 96%, Urea- 2 to6%, uric acid- 0.3%, salts- 1.5%, traces of cretinine, ammonia, creatine, hormone, water soluble vitamins, etc.

ACCESSORY EXCRETORY ORGANS

1. Liver

Urea is formed in the liver which is eliminated through kidneys. Liver cells also degrade the haemoglobin of worn out red blood corpuscles into bile pigments (bilirubin and biliverdin).

Liver cells also excrete cholesterol, certain products of steroid hormones, some vitamins and many drugs. Liver secrete these substances in the bile. The bile carries these substances to the intestine and are passed out with faeces.

2. Skin

It helps the body to get rid of excess of water, salts and waste such as ammonia in aquatic animals.

The mammalian skin posses sweat gland and sebaceous glands that play excretory roles.

3. Intestine

Epithelial cells of colon excrete excess salts of calcium, magnesium and iron along the faeces.

4. Lungs

It helps in removing gaseous form of excretory wastes like CO_2 and little amount of water vapour.

5. Salivary glands

Heavy metals and drugs are excreted in the saliva.

DISORDERS OF EXCRETORY GLANDS

1. Renal calculi

Excessive hormonal imbalance, excess uric acid formation, excess milk intake, dehydration, metabolic disturbances are responsible for renal calculi or renal stones. They are forms by the precipitation of uric acid or oxalate.

2. Cystitis

It is an inflammation of the urinary bladder that may be caused by bacterial infection.

3. Nephritis (Bright's disease)

It is the inflammation of renal pelvis, calyces and interstitial tissue due to local bacterial infection. Bacteria reach in these organs through urethra and ureter. Inflammation affects the counter-current mechanism and the victim fails to concentrate urine. Symptoms of this disease are back pain and frequent and painful urination.

4. Polyuria

Amount of urine passed out is more than normal.

5. Haematuria

Presence of blood in urine.

6. Anuria

Failure of kidney to form urine.

7. Pyuria

Presence of pus or WBCs in urine.

8. Glycosuria

Presence of glucose in urine due to diabetes mellitus.

9. Ketosis

Presence of ketone in urine due to metabolism of fatty acids instead of glucose during diabetes, starvation and pregnancy.

10. Uraemia

Urea accumulation in blood is comparatively high.

11. Diuresis

It is a condition in which excretory volume of urine is increased.

ARTIFICIAL KIDNEY

- Artificial kidney called haemodialyzer is a machine that is used to filter the blood of damaged kidneys. The process is called haemodialysis. It may be defined as the separation of small molecules from large molecules in a solution by interposing a semi permeable membrane between the solution and water.
- Haemodialyser is a cellophane tube suspended in a salt water solution with same composition as the normal blood plasma, except that no urea is present. Blood of the patient is pumped from one of the arteries into the cellophane tube after cooling it to 0^0C and mixing with an anticoagulant (heparin).
- Pores of cellophane tube allow urea, uric acid, creatinine, excess salts and excess H^+ ions to diffuse from the blood into the surrounding solution. The blood this purified is warmed to body temperature and mixed with antiheparin to restore it to normal clotting power.

- It is then pumped into a vein of the patients. Plasma proteins remain in the blood as the pores of cellophane are too small to permit the passage of their large molecules.

Large and diverse communities of biota have thus, occupied distinct climatic zone forming ecosystems. The concept of biodiversity first appeared in 1980. It is, in fact, the shortened form of two words – " biological" and " diversity". It was coined by W.G. Rosen in 1985. Biodiversity (G.K: bios= life, diversity = forms) or biological diversity can be defined as the vast array of species of micro-organisms, algae, fungi, plants, animals occurring on the earth either in the terrestrial or aquatic habitats and the ecological complexes of which they are a apart. It is so because environmental conditions of the area as well as the range of tolerance of the species determine whether or not a particular species can occur in that area.

MAGNITUDE OF BIODIVERSITY

India with about 45,000 species of plants and twice as many species of animals is one of the 12 mega diversity countries of the world. The major area where numerous species are believed to be unknown to science are tropics and coral reefs. Scientists estimate the number of species present in tropics by comparing species richness between tropics and temperate areas. For most groups of organisms, inventories are nearly complete for temperate areas

On this basis, scientists have calculated that the total number of species in the world is anywhere between 5.50 million. The most intriguing question of biodiversity is that more than 70% of all species are animals while plants accounts for only 22%. Amongst animals, insects are the most numerous (about 70%) with present estimate of 7 out of 10 animals. Further the knowledge about protists, archaebacteria and viruses is quite fragmentary.

LEVEL OF BIODIVERSITY

1. Genetic diversity
   - It is the diversity in the number and type of genes as well as chromosomes present in different species and the variations in the genes and their alleles in the same species. On average a bacteriophage has 100 genes, *Drosophila melanogaster* 13000 genes and *Homo sapiens* 30,000 – 40,000 genes.
   - Variation in the genes of a species increase with increase in size and environmental parameters of the habitat. Genetic diversity is useful in adaptation to changes in environmental conditions. It helps in speciation or evolution of new species. Lower genetic diversity within a species or variety may be useful for uniformity in yield as well as higher yield. However it is liable to undergo degradation and prone to mass scale destruction at the hands of fungal or insect attacks
2. Species diversity
   - It is the variety in the number and richness of the species of a region. The number of species per unit area is called species richness. Number

of individuals of different species represents species evenness or species equitability.

- Communities where species are represented more or less number of individual exhibit evenness. Others where one or more species have more individual than other show dominance or unevenness. Species diversity is the product of species richness or evenness or equitability odum et al (1960) calculate species diversity as number of species per thousand individuals while Menhinick (1964) calculates it as number of species in relation to square root of total number of individuals. Diversity index commonly used in ecological studies is Shannon index.

3. Community and Ecosystem diversity

It has three types

(i) Alpha diversity (within community diversity) It is a species diversity. α – diversity is dependent upon species richness and evenness. There is a lot of competition, adjustments and inter relationships amongst members of the same community. Variations are limited.

(ii) Beta diversity (Between communities diversity). It is diversity which appears in a along gradient of habitat within geographical area replacement of species with the change in communities due to different microhabitat, niches and difference in environmental condition.

(iii) Gamma diversity. It is diversity presents in ranges of communities as represented by diversity of habitats/ ecosystems over a total landscape geographical area.

Ecosystem diversity is the variety of forms in the ecosystem due to diversity of niches, tropic levels and ecological process like nutrient recycling, food webs, energy flow, role of dominant species and various biotic interactions. Diversity helps in producing more productive stable ecosystems which can tolerate various stresses like prolonged drought

INDIA AS MEGADIVERSITY REGION

- India has attained a unique distinction as it has been assigned the status of megadiversity nation.
- The country has 10 biogeographical regions namely, Trans Himalaya, Himalaya, Desert, Semi-arid, Western Ghats, Deccan peninsula, Gangetic Plain, Coasts, North-East and Islands.
- India has 89 national parks, 492 wild life sanctuaries, 14 biosphere reserves, 6 wetlands and 5 world heritage sites. The country has also 27 tiger reserves.
- The largest biogeographical region is Deccan peninsula and the most biodiversity rich region are Western ghat and north-east.

- 33% of flowering plants, 10% of mammals, 36% reptiles, 60% of amphibians and 53% fresh water fish are endemic. The richest regions are the Himalayas, Western Ghats. Indian Islands and North-Eastern Hills

PATTERNS OF BIODIVERSITY

LATITUDINAL AND ALTITUDINAL GRADIENTS

(i) Latitudinal gradient

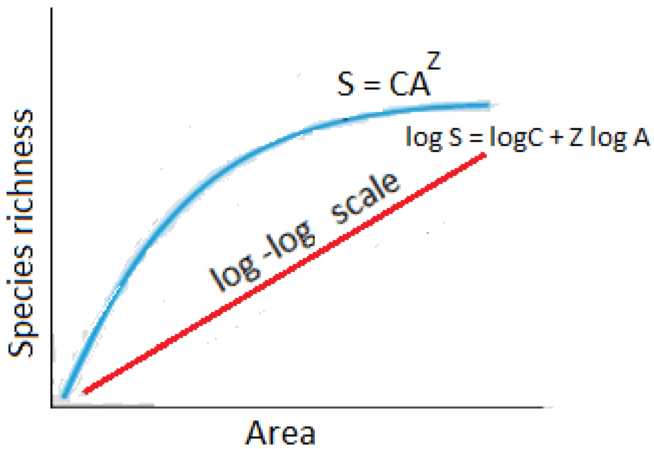
- There is little biodiversity at the poles. It increases in temperate areas but reaches the maximum in tropical rain forests. It is because the tropical rain forest have favourable, conditions with no catastrophes. Harsh conditions exist in temperate areas during the cold season only while very harsh conditions prevail for most of the year in arctic regions. Number of vascular species is 118-236/0.1 ha in tropical forests and 21-48 species 0.1 ha in temperate forests. Their number would 10/0.1 ha in arctic regions.

(ii) Altitudinal gradient

- A decrease in species diversity occurs as we ascend a high mountains due to drop in temperature and greater seasonal variability.

SPECIES - AREA RELATIONSHIP

German naturalist and geographer Alexander von Humboldt found that within a region the species richness increased with increasing area but upto a certain limit. The relationship between species richness and area turned out to be rectangular hyperbola for a wide variety of taxa whether they are birds, bats, fresh water fishes or flowering plants. On a logarithmic scale it is a straight line.



Here S is species richness, 2 is slope of line or regression coefficient, C is y-intercept while A is area.

Regression coefficient is generally 0.1-0.2, regardless of taxonomic group or region e.g. plants in Britain birds in California or mollusks in. New York. However, when the species area relationship is considered for a very large area like whole continent, retrogression coefficient or slope of the line comes to have Z value of 0.6 – 1.2, e.g. frugivorous birds and mammals of tropical forests of different continents with a steeper line of 1.15.

IMPORTANCE OF BIODIVERSITY

1. Source of food
   There are over 3000 species of food plants, out of which only 150 species are commercialized, 85% of the food output is produced by less than 20 species. Two third of food is being produced by three carbohydrates rich crops-wheat, corn (maize) and Rice. Utilisation of more and more food plants has to be made.
2. Source of fats and oils
   The major plants are soyabean, coconut, cotton seed, peanut and sunflower besides a number of others like sesame, safflower, mustard and oil palm. Few species of oil are being investigated e.g. Bitter colocynth, jojoba seed yield high performance lubricants.
3. Fibres
   The major sources are cotton, flax, jute, hemp, sun hemp, rosella, agave and coir. Search for new superior fiber yielding plants is a continuing process
4. New varieties
   Domesticated commercial species are improved for various traits, especially disease resistance by crossing them with wild relatives. Rice was made resistant to four main diseases crossing it with wild species (*Oryza nivara*) from India. Similarly, Potato has been made resistant to late blight (trait from *Solanum demissum*) Potato Mosaic Virus Y (trait from *solanum stoloniferum*), Fusarium and five races of cyst nematodes (trait from *Solanum spegazzini*)
5. Drugs and medicines
   A number of drugs are based on plant products. Rosy periwinkle (charanthus roseus = Vinca rosea) yields alkaloids (Vicristine and vinblastine) which are useful for treatment of leukaemia. The same are now being synthesized chemically. Some other plant derived drugs are Morphine (*Papaver somniferum* for pains), quinine (from bark of cinchona ledgeriana for malaria), taxol (from bark of Yew; *Taxus brevifolia* and *Taxus baccata* for treating cancers), reserpine (from Rauvolfia serpentine for treating blood pressure and schizophrenia) etc. 25% of all drugs are currently being obtained from 120 species of plants. Traditional systems of medicine all over the world uses thousands of local/ wild plants for treating various maladies. Innumerable synthetic products can be manufactured from plant chemical. They are called botanochemicals.
6. Aesthetic value

Biodiversity has a lot of aesthetic and attraction value. Ecotourism, bird watching, wildlife, pet keeping and gardening are all rewards of aesthetic value of biodiversity.

7. Cultural benefits
   Historically people having linked themselves with certain specific plants and animals. Majority of the Indian homes have specimens of *Ocimun sanctum* (Tulsi) growning in pots. Trees of *Ficus religiosa* (Peepal) and *Prosopis cineraria* (Khejri) are held sacred. They are planed and worshipped. Many birds are considered sacred. Snakes are worshipped. Every country and state takes pride in recognizing a particular plant and particular animal as symbol of national and state pride and cultural heritage.
8. Ecosystem services
   Maintenance and sustainable utilization of useful products and services of various ecosystems as well as individual species require the presence of biodiversity. Forest and oceanic systems control climate and maintain gaseous composition of atmosphere. Amazon rain forest have been called lungs of planet earth since they give out 28% of total oxygen. Biodiversity is essential for natural pest control maintenance of populations of various species, pollination by insects and birds, nutrient cycling, conservation and purification of water, formation and protection of soil etc. The services are valued at 16-54 trillion dollars per year.

THREATS TO BIODIVERSITY

The world is facing accelerated rate of species extinction, largely due to human interference. There are four major causes the evil quartet

i) Habitat loss and fragmentation: Overpopulation, urbanisation and industrialization require additional land every year. It can come through destruction or fragmentation of natural habitat through filling wetlands, ploughing grasslands, cutting down trees, burning a forest and clearing some area of vegetation. Animals requiring large territories are badly affected. Migrating animals would go astray and get killed.

ii) Over –exploitation: Excessive exploitation of a species, whether a plant or animal reduces size of its population so that it becomes vulnerable to extinction. Dodo, passenger pigeon, three subspecies of Tiger and Stellar sea cow have become extinct in the last 500 years due to over-exploitation by humans. Many marine fish populations are declining around the world.

iii) Alien species invasions
Non native or alien species are often introduced inadvertently for their economic and other uses. They often become invasive and drive away local species. Island ecosystems are most vulnerable due to small size and small number of species.

Water hyacinth (Eichhornia crassipes) was introduced in India waters to reduce pollution. It has clogged water bodies including wetlands at many places resulting in death of several aquatic plants and animals. Nile perch (a predator fish) was introduced in lake Victoria of South Africa. It killed and eliminated ecologically unique assemblage of over 200 native species of small Cichlid fish.

iv) Co-extinctions
Certain obligatory mutualistic relationship exist in nature e.g. Promuba yucca-selles and Yucca. Extinction of one will automatically cause extinction of other. If the host fish becomes extinct, all the parasites exclusively found on it will also become extinct.

WILDLIFE CONSERVATION

Wildlife conservation is necessary for lot of reasons

i) Balance of nature : There is a balance of nature in an ecosystem. The different living organisms live in equilibrium. The food web consists of an interlocking system of food chain, the destruction of any species of wildlife in an ecosystem can disrupt the entire balance of nature.
ii) Commercial value of wildlife: We have a rich variety of wild life. Government established national parks and sanctuaries attract many tourists from abroad. This is valuable source of foreign exchange. Surplus animals are exported to foreign zoos and parks, also earning foreign exchange.
iii) Biological studies : Naturalists and behavior biologists can study the ecology, physiology and behavior of wildlife in their natural habitats, thus contributing to our knowledge of biology
iv) Sport and recreation: The sport of hunting is now greatly restricted, because of the declining number of animals. Wildlife centers, however, provide good recreation in the form of camping and trekking.

CONSERVATION OF BIODIVERSITY

There are two types of conservation strategies – in situ (on site) and ex situ (off site)

IN SITU CONSERVATION

It is conservation and protection of the whole ecosystem and its biodiversity at all levels in order to protect the threatened species. However it is not economically feasible to conserve all biological wealth and all the existing ecosystems

Hot spots

They are areas with high density of biodiversity or megadiversity which are also the most threatened ones.

Ecologically hot spots are determine by four factors

(i) Number of species/ species diversity
(ii) Degree of endemism
(iii) Degree of threat to habitat due to its degradation and fragmentation
(iv) Degree of exploitation: Mayers (1988) initially identified 12 hot spots with 14% of plant species in an area of only 0.2%. Today the number of hotspots identified by ecologists is 34 covering an area less than 2% of land surface with about 20% of human population living there India has three hot-spots : Indo Burma, Himalayas and Western ghats-srilanka. India is even otherwise a country of mega biodiversity with 2.4% of land area and having 8.1% of global diversity

Protected areas

They are ecological / biogeographical area as where biological diversity alongwith natural and cultural resources is protected, maintained and managed through legal or other effective measures. They are delimited on the basis of biological diversity e.g. cold desert (Thar), wetland (Assam) saline swampy area (sunderbans) etc. Protected areas include national parks, sanctuaries and biosphere reserves.

National park

They are areas maintained by government and reserved for betterment of wildlife cultivation, grazing, forestry and habitat manipulation are not allowed. There are 89 national parks in India occupying nearly 1.1% of geographical area

Sanctuaries

They are tracts of land with or without lake where wild animals / fauna can take refuge without being hunted other activities like collection of forest products, harvesting of timber private ownership of land, tilling of land etc are allowed.

Biosphere reserves

They are multipurpose protected areas which are meant for preserving genetic diversity in representative ecosystems of various natural biomes and unique biological communities by protecting wild populations, traditional life style of tribal and domesticated plant (animals genetic resources)

Creation of biosphere reserve was initiated in 1975 under MAB programme of UNESCO. Till 2002, 408 biosphere reserves had been established in 94 countries. In India, 17 biosphere reserve have been set up by now. Each biosphere reserve has

i) Core or Natural zone: No human activity is allowed. The area is undisturbed and legally protected ecosystem

ii) Buffer zone: It surrounds the core area. Limited human activity is allowed like resource use strategies research and education

iii) Transition zone: It is the outermost or peripheral part of biosphere reserve where an active cooperation is present between reserve management and local people for activities like settlements, cropping recreation, forestry and other economic uses without disturbing ecology. Transition zone has different parts like forestry, agriculture, tourism and restoration region. Restoration region is degraded area which is selected for restoration to near natural form.

Importance of biosphere reserves includes:

i) Restoration – Biosphere reserve help in restoration of degraded ecosystems and habitat

ii) Conservation – They are means of conserving genetic resources, species, ecosystems and landscapes without uprooting the local people.

iii) Development – They ensure culturally socially and ecologically sustainable economical development

iv) Monitoring- there is a regular monitoring of development and conservation progress

v) Education and Research – Each biosphere reserve supports education and research in various ecological aspects of the ecosystem / biome. There is also exchange of information about research, restoration, conservation and development aspects at the national and global levels.

MAB program

Man and biosphere program is an international biological programme of UNESCO which was started in 1971 but was introduced in India in 1986. MAB has studied human environment impact of human interference and pollution on abiotic and biotic components and conservation strategies for present as well as future.

EX SITU CONSERVATION

Offsite collections

They are live collections of wild and domesticated species in botanical gardens, zoos etc. Currently, they are more than 1500 botanical gardens and arboreta (gardens with trees and shrubs) laving more than 8000 species. Many of them have seed banks, tissue culture facilities and other ex-situ technologies. The number of zoological parks is more than 800. They have about 3000 species of mammals, birds, reptiles and amphibians. Most of them have well managed captive breeding programmes. Captive breeding is resorted to in those cases where the number of surviving individuals is so small that there is no realistic chance of in situ survival. As the number of surviving increases, individual are selectively released in the wild.

Offsite collection can be used to restore depleted populations, reintroduce species in the wild and restore degraded habitats.

Gene Bank

They are institutes that maintain stocks of viable seeds (seed banks), live growing plants (orchid), tissue culture and frozen germplasm with the whole range of genetic variability.

(i) Seed banks: Seeds are of two types orthodox and recalcitrant.

- Orthodox seeds are those which can tolerate reduction in moisture content (up to 5%), anaerobic conditions and low temperature of -10°C to -20°C or even lower for prolonged periods e.g. cereals, legumes. At intervals seeds are allowed to germinate from plants and develop fresh seeds for storage
- Recalcitrant seeds are those seeds which get killed on reduction of moisture and exposure to lower temperature e.g. Tea, cocoa, jackfruit, coconut. They can be stored for shorter duration after treatment with fungicides in room having air and normal oxygen.

(ii) Orchards: Plants with recalcitrant seeds are grown in orchards where all possible strains and varieties are maintained e.g. Litchi, oil palm, rubber tree etc.

(iii) Tissue culture: It is carried out through callus formation, embryoids, pollen grain culture and shoot tip culture for those plants which are either seedless, have recalcitrant seed, variable seed progeny or where clone is to be maintained. The method is useful in maintaining a large number of genotypes in small area rapid multiplication of even endangered species and for hybrid rescue. Shoot tip culture maintains virus free plants. It is used for international exchange of germplasm in vegetatively multiplied cultures e.g. Banana, Potato.

(iv) Cryopreservation: Preservation at -196°C (liquid nitrogen) can maintain tissue culture, embryos, animal cell/tissue, spermatozoa indefinitely. The cryopreserved material is revived through special technique when required

BIODIVERSITY ACT (2002)

For protection of India's rich biodiversity and associated knowledge against their use by foreign individuals and organizations without sharing the benefits arising out of such use and to check biopiracy.

Biology Researchers and Invention

www.gneet.com

SrNo	Researcher	Invention
1	Alexander Fleming	Penicillin was discovered February 14, 1929 6 August 1881 – 11 March 1955
2	Howard Martin Temin	American virologists, worked on virus Retrovirus After receiving the Nobel Prize in 1975
3	Adolf Engler and Karl A.E. Prantl	Proposed that monocots are more primitive than dicots. Propose Phylogenetic system of classification with- Hutchinson who had been the first to use phylogenetic principles
4	T.O. Diener	discovered Free infectious RNA
5	Takhatjan	Gave phylogenetic classification of plant kingdom of Flroa Armenia
6	Huxley	Father of Neotaxonomy The term " New Systematics" was introduced 1940
7	A.V. Leeuwenhoek	first saw and described a live cell. Bacteria were discovered. he is commonly known as "the Father of Microbiology"
8	William Bertram Turill	Proposed three phase of taxonomy, alpha, beta and omega Mathematical classification of leaf shapes.
9	Carolus Linnaeus	Sweden First great taxonomist Father of taxonomy *Systema Naturae* Tenth edition was published in - 1758 He proposed An artificial system of classification Binomial nomenclature, Scientific classification
10	Theophrastus	Father of botany. First to use Artificial system of classification
11	Zinder and Lederberg	Discovered a new type of gene transfer mediated by a virus. They called this process transduction.
12	Herbert F. Copeland	Four kingdom classification was proposed
13	W.N. Staley	Tobacco mosaic virus/ virus was crystallized for the first time ,also showed that TMV remains active even after crystallization.
14	Aristotle	Known as 'Father of Zoology' Author of book "Scala Naturae" First to discover Fertilization
15	Jean-Baptiste Lamarck	Book "Philosophie Zoologique" published in1809 Proposed the idea of fixity of species
16	Bentham and Hooker	Natural classification

17	Robert Harding Whittaker	Latest classification of biological kingdom 5-kingdom classification in 1969
18	Ernst Haeckel	The scientist who created the group Protista for both unicellular plants and animals Coined many terms in biology, including anthropogeny, ecology, phylum, phylogeny, stem cell, and Protista , **plastid** The biogenetic law of "Ontogeny repeats phylogeny"
19	Comte de Buffon	Written encyclopedic *"Histoire Naturelle"* The book having binomial nomenclature for the first time
20	Camp and Gilly	The term "biosystematics" was coined in 1943
21	Ernst Mayr	A species was defined as a "species are groups of interbreeding natural populations that are reproductively isolated from other such groups." Was awarded the Balzan Prize in 1983, the International Prize for Biology in 1994, and the Crafoord Prize in 1999. three prizes, regarded as triple crown of biology Also known as Darwin of 20th century
22	John Ray	Scientist who developed 'key' for identification of animals Coined the term species
23	Paul Ehrlich	gave 'rivet popper hypothesis'
24	Sir J.C. Bose	Proposed a Pulsation theory of ascent of sap Is mechanism for the ascent of sap in 1927
25	Engelmann	Discovery of Action spectrum of photosynthesis was in 1883
26	Daniel Israel Arnon	The process of photophosphorylation was discovered
27	Otto Heinrich Warburg.	A decrease in photosynthetic rate with increased availability of oxygen is called .- Warburg effect
28	Hatch and Slack	discovered alternate method of carbon fixation C4 - cycle
29	Peter Dennis Mitchell,	awarded the 1978 Nobel Prize for Chemistry for his discovery of the Chemiosmotic mechanism or Chemiosmosis of ATP synthesis
30	Melvin Calvin	Scientist awarded Nobel Prize in 1960 for tracing the path of carbon in photosynthesis
31	Frederick Frost Blackman	Blackman proposed the limiting factors determines the rate of photosynthesis in 1905
32	Jan Ingenhousz	Who discovered that green plant parts and light are essential for photosynthesis
33	Ernst Munch	Put forward Pressure Flow Hypothesis or Mass flow hypothesis in 1930.
34	Katherine Esau	books *Plant Anatomy* and *Anatomy of Seed Plants*

35	Hans Krebs	Invented urea cycle and tricarboxylic acid (TCA) cycle or citric acid cycle is named after him as Kreb cycle
36	Marshall and Warren	2005 Nobel Prize was awarded discovery of Bacterium Helicobacter pylori causing peptic ulcer.
37	Edward Jenner	Father of Immunology - The term vaccine was introduced
38	James Phipps and Ali Marvow	pioneer of smallpox vaccine
39	Louis Pasteur	Louis Pasteur and Émile Roux, developed the first rabies vaccination in 1885 The theory that life only comes from the reproduction of preexisting life. This was proven by Louis Pasteur in 1862. Swan-Necked Flask Experiment in the early 1860s to prove that particles in the air (germ theory).
39	Henry Charlton Bastian	The term biogenesis was coined
40	August Weismann	Proposed theory of "continuity of germplasm"
41	Miller and Urey	Oparin - haldane's view on the origin of life was first experimentally proved by experimental proof that organic compounds formed the basis of evolution
42	Karl Ernst von Baer	Introduced von Baer's law to explain the details of embryo development
43	Hardy – Weinberg	Genetic equilibrium - Which initiated study in population genetics and related fields
44	Darwin	Theory of pangenesis " Origin of Species is wrote in 1859 Reproductive fitness Origin of species
45	Sewall Wright	introduced Concept of genetic drift
46	Father Saurez	One of the greatest advocates of the theory of special creation was -
47	Thomas Robert Malthus.	Famous book of Population Gave the principle that population tends to multiply more rapidly than food supply – He gave a statement "Human population grows in geometric ratio while food materials increases in arithmetic proportion
48	Oparin-Haldane	The chemical evolution of life
49	Hugo de Vries	Used Evening Primrose (Oenothera Lamarckian) for Mutation theory basically suggesting a form of saltationism.

		Mendel's work was got republished in 'Flora' by - De vries
50	Lederberg	replica plating experiment to show the genetic basis of adaptation
51	Van Helmont	Supported theory of spontaneous creation
52	Birbal Sahni	Famous Paleontologists/ palaeobotanist of India Who worked on Fossil plants
53	Thomas Hunt Morgan	Gave Mutation theory based on work over Oneothera lamarckiana was awarded Nobel prize for contribution of the role that the chromosome plays in heredity Scientist who was awarded Nobel prize for finding genes to be linearly arranged on chromosomes Described the phenomenon of linkage and crossing over
54	Oparin and Sidney Fox	Coacervates were experimentally produced
55	Theodosius Dobzhansky	Wrote the book " Genetics and Origin of Species" in 1937 his 1973 essay "nothing in biology makes sense except in the light of evolution"
56	Francesco Redi	founder of experimental biology, he disapproved abiogenesis for the first time
57	Herbert Spencer	first used the phrase 'Survival of fittest'
58	Joel Asaph Allen	Given Allen's rule -predicts that endothermic animals with the same body volume should have different surface areas that will either aid or impede their heat dissipation. Warm blooded animals of cold climate have small extremities.
59	Gause	Gave Law related to Competitive exclusion
60	W. W. Garner and H. A. Allard	discovered photoperiodism
61	Moore	The term phytochrome was introduced by –
62	Nawaschin	Who discovered double fertilization in *Lilium and Fritillaria* - (1898)
63	J.B. Farmer and J.E.S. Moor	Coined the term meiosis in 1905
64	Rudolf Ludwig Carl Virchow	Proposed the famous generalization " all cells are derived from pre-existing cells". "Omnis cellula e cellula" He coined scientific terms, chromatin
65	Howard and Pelc	Discovered Cell cycle

66	Oscar Hertwig	Discovered Meiosis
67	Hayes and Lederberg	Discovered Plasmids
68	Christian de Duve	The discoverer of lysosome
69	Robert Brown	In 1811, discovered – Nucleus Microtubules were discovered
70	Robert Hook	coined the term cell in – 1665 Author of historically significant book Micrographia
71	Schleiden and Schwann	proposed cell theory in 1838 – 39
72	Singer SJ, Nicolson GL	Put forward Fluid mosaic model of cell membrane
73	Metchnikoff	Put forward phagocytosis theory.
74	Keith R. Porter, Albert Claude, Brody Meskers and Ernest F. Fullam	Ribosomes were first seen
75	Benda	Gave name mitochondria
76	Waldeyer	Coined the term chromosome
77	Singer and Nicolson's	Proposed fluid mosaic model "extrinsic proteins are loosely associated with intrinsic proteins and can be easily separated"
78	Walther Flemming	Coined the term chromatin
79	Dr. Joachim Hämmerling	proved the existence of morphogenetic demonstrated that the nucleus contains the genetic information and controls development
80	Knoll and Ruska	constructed the first scanning electron microscope (SEM)
81	Karel Purkinje	Coined term protoplasm
82	George Beadle and Edward Tatum	proposed that genes control production of enzymes
83	Francis Crick	Proposed central dogma
84	Seymour Benzer	Coined the terms cistron, recon and muton–
85	Hershey and Chase	Experiment that proved DNA to be genetic material of bacteriophage
86	Friedrich Miescher	Discovered Nucleic acids
87	Jacob and Monod	operon model of gene regulation and organisation of procaryotes was proposed Nobel Prize for operon model
88	Nirenberg and Mathaei	Whose experiments cracked DNA and discovered triplet nature of genetic code

89	Holley	Proposed Clover leaf model of tRNA in 1968.
90	Francis Crick	Who proposed Wobble hypothesis
91	Hargobind Khorana	Discovery of DNA ligase. Who deduced code for amino acids from Serine and leucine was a awarded Nobel Prize
92	Taylor	Pea chromosome replication to be semiconservative
93	Johannsen	Coined the terms phenotype and genotype gene
94	Hershey and Chase	Experiments on Viral DNA
95	Holley, Nirenberg and Khorana	Discovered Genetic code
96	Meselson and Stahl	Experimental proof of semiconservative replication of DNA -
97	Watson , Crick and Wilkins	Shared the Nobel Prize for DNA structure in 1962
98	Matthew Meselson and Franklin Stahl	Invented the technique of density gradient centrifugation and used this to prove that DNA is replicated semi-conservatively
99	George Gamow	Triplet code, solving the problem of genetic coding gave rise to important models of biological degeneracy
100	Frederick Griffith	demonstrated bacterial transformation, whereby a bacterium distinctly changes its form and function.
101	Rosalind Franklin	contributions to the understanding of the molecular structures of DNA, RNA, viruses,
102	Beadle and Tatum	Genes carry information for making proteins
103	Jacob and Monod	operon concept
104	Howard Martin Temin	Nobel Prize for Reverse transcription shared with Renato Dulbecco and David Baltimore.
105	Severo Ochoa	Who was awarded Nobel prize for in vitro synthesis of polyribonucleotides in 1959
106	Avery, MacLeod and McCarty	Found out DNA transforming principle of Pneumococcus
107	Landsteiner	Blood groups
108	Alfred Russel Wallace	Theory of Organic evolution
109	Barbara Mc Clintock	is famous for her work on – Maize; Nobel Prize for discovering "mobile genetic elements" or jumping gene/transposable DNA elements 1983
110	Mary Lyon	Lyon's hypothesis is connected with - Number of barr bodies
111	Walter Sutton	Discovered chromosomal basis of heredity
112	Henking	X-chromosome or X-body was first observed (1891)
113	C.B. Bridges	in 1922 proposed the Genic Balance Theory for sex determination

114	H. J. Muller	Nobel prize for X-rays induce sex-linked recessive lethal mutations – 1927
115	Reginald Punnett and Edith Saunders	discovered genetic linkage
116	E.O.Wilson	the father of sociobiology" and "the father of biodiversity"
117	Gregor Johann Mendal	known as the "father of modern genetics" Austrian monk work was rediscovered in – 1900 btCarl Correns from Germany
118	Karl Lohmann	Discovered ATP
119	Fischer	Key and lock hypothesis of enzyme action
120	Buchner	Biocatalysts were found accidently in Yeast extract by
121	Arber and Nathans	Nobel Prize in 1978 for working on enzymes
122	Eduard Adolf Strasburger	Given modern laws of plant cytology: "New cell nuclei can only arise from the division of other nuclei." and originated the terms cytoplasm and nucleoplasm.

TOPIC INDEX

1.0 Circulatory system

- It is the movement of body fluids inside the body of animals so as to transport materials from the region of the formation to the region of utilization or disposal. A circulatory system is a complex of structures involved in the flow of body fluids of an organism so as to accomplish transport of materials

- Circulation of body fluids can be of the following types
  1. Intracellular circulation
     It occurs inside the individual cells through Cyclosis or cytoplasmic streaming. Examples: Paramecium, Amoeba.
  2. Extracellular circulation
     In multi-cellular animals, the living cells are bathed in an intercellular or extracellular fluid which circulates in the body for transport of materials
     extracellular circulation can be
     a) Extra-organismic circulation: Outside water circulates in the body of an organism
     b) Intra-organismic circulation: It involves circulation of body fluid

  i) Parenchymal circulation
     In flatworms, fluid-filled spaces present in parenchyma tissue between the body wall and internal organs are used in the distribution of substances.

  ii) Coelomic Circulation
     Coelomic fluid is employed in the transport of substances,Pseudocelom is used for this purpose in roundworms. Hemocoel does so in arthropods

  iii) Blood vascular system
     It contains blood and a pumping structure (heart) for circulation of materials inside the body. Lymphatic system accompanies blood vascular system.

1.01 Functions of circulatory system

use a different system for the transport of gases.

- Respiratory pigment, if present, is dissolved in the plasma, no red corpuscles are present.

3.0 Closed circulatory system

- The closed circulatory system is a type of blood vascular system in which blood remains confined and flows inside blood vessels only, never coming in direct contact with body cells. It occurs in most annelids, cephalopod, and vertebrates. Annelids are the simplest animals to have closed circulatory system.
- Flow of blood is

branchialArteriovenous heart occurs in lungs fishes amphibians, reptiles, birds, and mammals because it receives both venous (deoxygenated and arterial (oxygenated) blood. there is double circulation, pulmonary (to and fro lungs) and systematic (to and fro other body parts)

- In amphibians, there are two auricles/ atria.
- In amphibians, there are two auricles/ atria, one ventricle, a sinus venosus and cons/ truncusarteriosus. Mixing of oxygenated and deoxygenated blood occur in the ventricle.
- In reptiles, the heart has two atria and an incompletely divided ventricle. Sinus venous is present but conusarteriosus has merged with ventricle and aorta.
- In crocodiles, the ventricle is almost completely divided through mixing of blood does occur
- The heart is completely four-chambered in mammals and birds with neither sinus venous nor conusarteriosus. There are two atria and two ventricles. There are two atria and two ventricles. The left part of the heart is connected with oxygenated blood

(scarlet red) and right part with deoxygenated blood (purple red)

3.02 Artery

It is a blood vessel that carries blood away from the heart towards an organ. Artery generally contains oxygenated blood (deoxygenated in the pulmonary artery). The blood flows in an artery under alternate increased pressure and with jerks. Arteries are deep-seated with thick elastic wall and comparatively, narrows lumen. They become empty after death. Valves are absent. The wall is made up of three regions tunica external, tunica media or tunica adventitia is an outer coat made of loose connective tissue with abundant white (collagen) and fewer yellow (elastin) fibers as well as longitudinal smooth or unstriped muscle fibers. There is a well-developed external elastic lamina on the inner side. The middle coat or tunica media is thick having unstriped circular muscles and elastic connective tissue. The inner coat, tunica interna or tunica intima is also made of connective tissue. It has a number of folds. The lumen is lined by an endothelium of elongated flat thin artery, tunica external, tunica media and tunica interna. Tunica Externa is the outer coat with loose connective tissue, abundant white, and fewer yellow fibers. It is well developed but external elastic lamina is not much differentiated. Tunica media is comparatively thinner in vein with a few smooth circular muscles. Tunica interna is similar to the artery but with fewer folds, less developed internal elastic membrane and less elongated endothelial tissues. Semilunar valves are made of folds of endothelium with some enclosed connective tissue.

3.04 Capillary

It is a very fine blood vessel where the wall is made of a single layer of the endothelium of tessellated cells. A fine intercellular cleft occurs between the adjacent endothelial cells. Basement membrane lies on the outside. Blood capillaries are formed by arterioles. They join to produce venule. The lumen of blood capillary is so fine that red blood corpuscles can pass through it in a single file. The WBC can come out of them through the process of diapedesis. Because of their extremely thin walls, blood capillaries take part in the exchange of materials between blood and tissue fluid. In lungs, they pick up oxygen and give out CO_2 through diffusion. All the blood capillaries are not functional all the time. Some of them work only at the time of intense activity. Their working is controlled by precapillary sphincters present in the area of their origin.

3.05 Arteriovenous anastomosis

It is a direct vascular connection between an arteriole and venule bypassing capillary supply. The connection occurs in certain exposed parts like fingertips, nose, pinnae, eyelids, lips, tongue etc. It is meant for controlling blood supply and temperature of the exposed parts.

3.06 Vascular plexus

Anastomosis of blood vessels is like arteries in certain regions to provide extra blood e.g. cutaneous plexus, papillary plexus, and nasal plexus.

5.0 Blood

It is complex mobile fluid connective tissue of reddish colour in which the fluid matrix is not synthesized by the contained cells. An adult human has 5-5.5 liters of blood. pH is 7.4. Blood consists of two parts, plasma and blood corpuscles (formed elements)

5.01 Plasma

- It is a slightly alkaline non-living intercellular substance which constitutes about 60% part of the blood. It is a pale yellow but transparent and clear fluid.

iii) Maintenance of blood pH

iv) Body immunity

v) Prevention of blood loss

vi) Conducting heat to skin for dissipation

vii) Uniform distribution of heat all over body

5.01.02 Blood glucose

- Usually blood glucose level is about 80-100 mg per 100 ml of blood 12 hours after a normal meal
- It blood glucose level exceeds 180 mg per 100 ml, it starts appearing in the urine. This condition is called glycosuria. If it

- Hemoglobin is a conjugate protein which is made up of a protein called globin and a non-protein group heme (=haeme) hence the hemoglobin.
- Hemoglobin is oxygen-carrying pigment. 100ml of blood of a normal man contains 15g of hemoglobin and of normal woman an average of 13g of hemoglobin
- Erythropoiesis is the process by which red blood cells are produced. In human adults, this usually occurs within the bone marrow.

monomorphic nucleus).

→ The life of granulocyte is normally 40 to 8 hours circulating in the blood and another 4-5 days in the tissue

→ Monocytes have a short lifespan of 10-20 hours. The lymphocytes have life span of few days or months or years

→ Granulocytes are of three types (neutrophils, basophils, eosinophils) while agranulocyte are of two types (Monocytes and lymphocytes)

- Monocytes

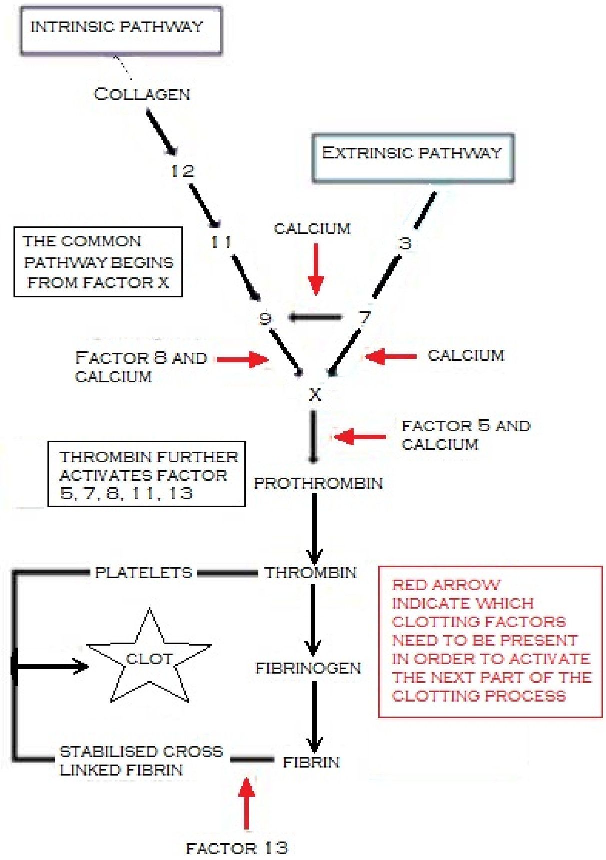
  Largest leucocytes, 10-18 µmkidney-shaped nucleus, 5-6% of total leucocytes motile, Phagocytic, scavengers, production of interleukin and pyrogen.

  5.02.04 Thrombocytes(blood platelets)

  → There are about 250,000 platelets in cubic millimeters of blood. Increase and decrease in the number of platelets is known as thrombocytosis and thrombocytopenia respectively.

- → Second step: The prothrombinase inactivates heparin in the presence of calcium. Prothrombinase catalyzes the breakdown of Prothrombin into an active protein called thrombin and some small, peptide fragments.
- → Third step: Thrombin acts as an enzyme and first brings about depolymerization of these monomers. Later thrombin stimulates polymerization of these monomers into long insoluble fibers – like polymers called fibrin. The thin, long and solid fibers of fibrin from a dense network upon the wound and trap blood corpuscles to form a clot. The clot seals the wound and stops bleeding. Soon after the clot seals the wound and stops bleeding. Soon after the clot starts contracting and a pale yellow fluid, the serum, starts oozing out. This serum is blood plasma minus fibrinogen and blood corpuscles.

Vitamin K is essential for blood clotting as it is necessary for the synthesis of Prothrombin in the liver


INTRINSIC PATHWAY
COLLAGEN
12
EXTRINSIC PATHWAY
THE COMMON PATHWAY BEGINS FROM FACTOR X
11
CALCIUM
3
9
7
FACTOR 8 AND CALCIUM
CALCIUM
X
FACTOR 5 AND CALCIUM
THROMBIN FURTHER ACTIVATES FACTOR 5, 7, 8, 11, 13
PROTHROMBIN
PLATELETS
THROMBIN
RED ARROW INDICATE WHICH CLOTTING FACTORS NEED TO BE PRESENT IN ORDER TO ACTIVATE THE NEXT PART OF THE CLOTTING PROCESS
CLOT
FIBRINOGEN
STABILISED CROSS LINKED FIBRIN
FIBRIN
FACTOR 13

Factor III

Name :Thromboplastin / Tissue Factor

Source: Platelets (intrinsic) and damaged endothelium (cells) lining the blood vessel (extrinsic).

Pathway: Both extrinsic and intrinsic

Activator: Injury to blood vessel

Action: Activates factor VII (VIIa).

Factor IV

Name: Calcium

Source: Bone and absorption from food in gastrointestinal tract

Source: Endothelium lining blood vessel and platelets (plug)

Pathway: Intrinsic

Activator: Thrombin

Actions: Works with Factor IX and calcium to activate Factor X.

Deficiency: Hemophilia A

Factor IX

Name : Christmas factor / Plasma thromboplastin component (PTC) / Antihemophilic factor B into thrombin. This reaction is made faster by activated Factor V.

Factor XI

Name : Plasma thromboplastin antecedent (PTA) / antihemophilic factor C

Source: Liver

Pathway: Intrinsic

Activator: Factor XII + prekallikrein and kininogen

Actions: Works with calcium to activate Factor IX.

Deficiency: Hemophilia C

Factor XII

Name: Hageman factor

Source: Liver

Pathway: Intrinsic

Activator: Contact with collagen in the torn wall of blood vessels

Actions: Works with prekallikrein and kininogen to activate Factor XI. Also, activates plasmin which degrades clots.

Factor XIII

Name:Fibrin-stabilizing factor

Source: Liver

Activator: Thrombin and calcium

Actions: Stabilizes the fibrin mesh network of a blood clot by helping fibrin strands to link to each other. Therefore it also helps to prevent fibrin breakdown (fibrinolysis).

Prekallikrein

Source: Liver

Pathway: Intrinsic

Actions: Works with kininogen and Factor XII to activate Factor XI.

Kininogen

Source: Liver

Pathway: Intrinsic

Actions: Works with prekallikrein and Factor XII to activate Factor XI.

7.0 Functions of blood

i) Transport of food materials: Blood transports the digested food from the alimentary canal to the different body cells

ii) Transport of respiratory gases: Oxygen is carried from the respiratory organs to the tissues and carbon dioxide from the tissue to the respiratory organ by blood.

iii) Transport of hormones: Hormones are carried by blood from the endocrine glands to the places of use

iv) Transport of excretory matter: Blood transport the excretory matter to the kidney or other excretory organs.

v) Transport of heat: Blood allows the transfer of heat from the deeper tissue to the surface of the body where it can be lost.

the healing of the wound.

xii) Maintenance of physiological co-operation: Blood maintains a physiological co-operation between parts of the body by circulating from one to other parts.

8.0 Blood group

- Karl Landsteiner reported first time ABO blood groups in a human being (1900). AB blood group was found out by de Castellan and Steini (1902)
- If a blood transfusion is made between an incompatible donor and recipient, the reaction of antigen on the cells and antibodies in the plasma produce clots that clog capillaries.

Blood Group	Genotype	Antigens In RBC	Antibodies in blood plasma	Receive blood	Donate blood	Percentage Humans

A	I^AI^A or I^AI^O	A	B	A, O	A, AB	41%
B	I^BI^B or I^BI^O	B	A	B, O	B, AB	10%
AB	I^AI^B	AB	None	O, A, B, AB (Universal Recipient)	AB	4%
O	I^OI^O	None	a, b	O	O, A, B, AB (Universal Donor)	45%

8.01 Rh (rhesus) blood group

- A protein named Rhesus antigen is present on the surface of red blood corpuscles in many persons. It was discovered in 1940 by Landsteiner and Wiener in the blood of Rhesus monkey, hence its name have the effect.

Oswal Hope Robertson is the creator of the first blood bank.

8.02 Importance of blood groups

i) Knowledge of blood group is essential for blood transfusion

ii) Rh compatibility is required for both marriage and transfusion in order to prevent erythroblastosis

iii) Preliminary information about disputed parentage and progeny is provided by blood grouping.

iv) Blood grouping is used in the forensic identification of blood stains.

9.0 Human Heart

- It is a reddish conical muscular mesodermal hollow organ of an about 12cm length 9 cm breadth, weighs about 300gm and lies behind the sternum in the mediastinum space of holder cavity in between the two lungs. Broader base is upwards.
- The mammalian heart comprises of four complete chambers two ventricles and two auricles (atria)

- Heart wall consists of connective tissue, blood vessels, and cardiac muscle fibers. The latter form a cross – connected network for smooth passage of constriction wave. The cardiac muscle or myocardium does not tire due to
    - a) Alternate rest and activity
    - b) Non- formation of lactic acid
- The heart is covered by a double fibrinogenous sac or pericardium. It has two components outer non-distensible tough fibrous pericardium (prevents excessive expansion of heart) and inner thin serous pericardium.
- Serous pericardium has two thin secretory membranes,

  (i) outer parietal have two sub layers

  a) Outer: Fibrous connective tissue

  b) Inner : Simple squamous epithelium

  (ii) and inner visceral or epicardium made up of simple squamous epithelium

(v) Limits heart motion

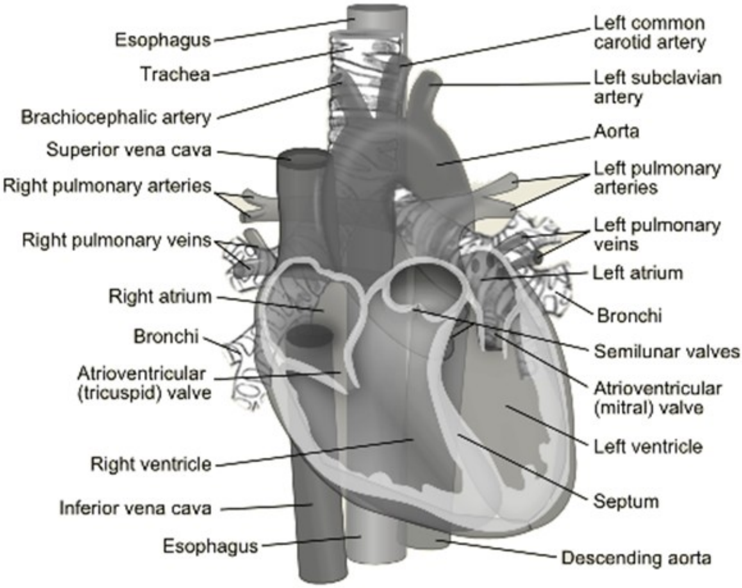
(vi)Reduces friction between the heart and surrounding tissues

(vii) Protects the heart against infection

- There is a depression or coronary sulcus between atria and ventricles, interatrial sulcus (two parts, anterior and posterior) between two ventricles. Coronary arteries are housed in these sulci. They supply blood to walls of the heart.
- Atrial appendages are protruded part of atria which overhangs the ventricles. Low ridges occur internally in the region of the

ridges or columnae carnea and a few large muscular projection or papillary muscles/ musculuspapillaris).

- Right ventricle contains a moderator band that extends between upper papillary muscle and inter-ventricular septum. Atria opens into ventricles through atrioventricular apertures is guarded by valves. Right atrial- ventricular aperture is guarded by tricuspid valve possessing three flaps and left atrioventricular aperture is guarded by bicuspid and mitral valve possessing two flaps.
- The flaps of the valves are held in their position by fine inelastic cords or chordaetendineae connected to papillary muscles. Left ventricle opens into the aorta. The opening is guarded by an aortic semilunar valve between two.



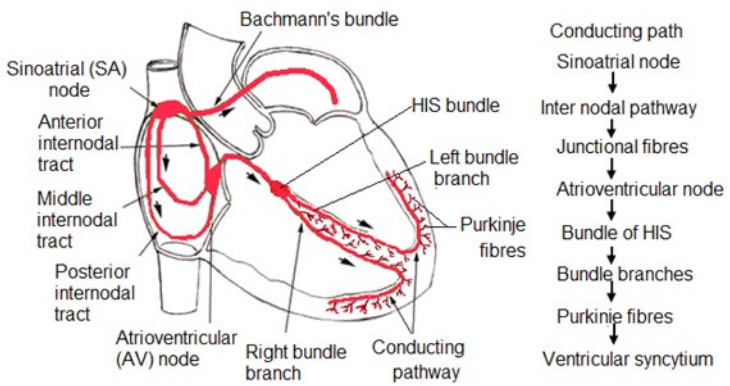
10.0 Conduction of heart beat

- The automatic rhythmicity of the heart is its ability to contract spontaneously at a regular rate
- In practice, this represents apex or ventricular beat with an advantage of 72/minutes in an adult human. It is high in infants and low in aged persons. Similar heart beat is fast in small animals (200/min in Rabbit and 500/min in Sparrow) and low in large animals (25 /min in elephant) as well as cold-blooded animals (64/min in frog).

the ventricles.

- This wave of contraction next reaches the atrioventricular (AV – node) or pacesetter is stimulated to emit an impulse of contraction spreading to the ventricular muscle in the atrioventricular bundle and the Purkinje fibers.
- The atrial muscle fibers are separated from those of the ventricles by a fibrous tissue ring. These are no functional continuity between the atria and ventricles. They only conducting tissue between the atria and the ventricles is the atrioventricular bundle or the Bundle of His).
- The atrioventricular bundle (Bundle of His) was discovered by His (1983) and consists of a set of specialized muscle strands originating from AV node and pass downwards into the inter-ventricular septum. This bundle then divided into the left and right bundle branches, one going to each ventricle.

- Within the myocardium of the ventricles, the branches break up into a network of fine branching, anastomosing filaments of fibers known as Purkinje fibers.
- The bundle of His and the Purkinje fibers convey the impulse of contraction from the AV node to the myocardium of Ventricles.



10.01 Pace-maker

- SA node is called natural pacemaker of heart as impulse generated by it spreads to booth atria and through AV node to ventricles for their rhythmic contraction.
- Disruption or insufficiency of any component of this impulse conducting system results in slowing down or irregularity of heart rhythm or independent contraction of atria and ventricles. Failure of the atrial impulse to pass into ventricles for a few seconds to few hours is called ventricular escape or

vena cava-right atrium and allowed to rest against the tip of the right ventricle.

- A pacemakeris liable to be influenced by microwave ovens, metal detectors, electric shaver's cell phone etc.

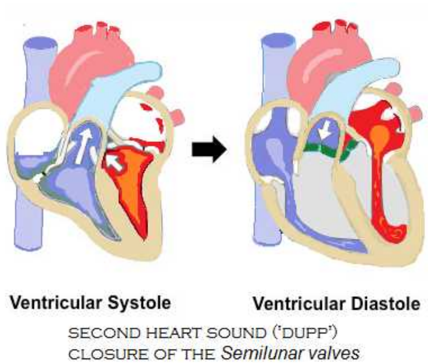
10.02 Cardiac cycle

- The cardiac cycle consists of one heart or one cycle of contraction and relaxation of the cardiac muscle. The contraction phase is called the systole while the relaxation phase is called diastole.

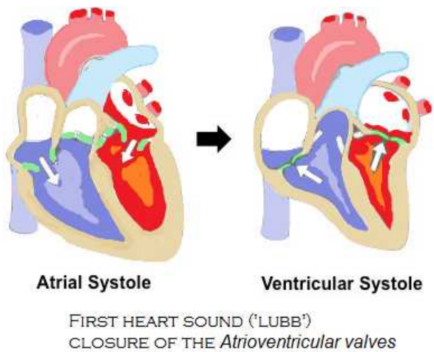
pulmonary trunk and aorta as the semilunar valves open.

Beginning of ventricular diastole: The ventricles relax and the semilunar valves are closed. This causes the second heart sound.

Complete ventricular diastole: The tricuspid and bicuspid valves are open when the pressure in the ventricles falls and blood flows from the atria into the ventricles. Contraction of the heart does not cause this blood flow. It is due to the fact that this blood flows. It is due to the fact that the pressure within the relaxed ventricles is less than that in atria and veins atrioventricular valves (tricuspid and bicuspid valves)



- Dup (S_2, second sound, diastolic sound) is the second heart sound which is sharp high pitched, of shorter duration (0.1 sec) and is produced due to the closer of semilunar valves at the base of great arteries. A pause or gap occurs between the second sound and the first sound of next cycle. It coincides with ventricular diastole.
- Incomplete closure of valves due to disease or other defect produces abnormal heart sound called murmur. Heat sounds are listened by means of an instrument called stethoscope.



12.0 Cardiac output

- The volume of blood pumped by each ventricle per minute is called the cardiac output
- It is determined by multiplying the heart rate by the volume of blood ejected by each ventricle during each beat, which is called the stroke volume.

Cardiac Output = Heart Rate × stroke volume

= 72 beats /min × 0.08 litre/ beat = 5.5 litres/min

- Cardiac index is the minute volume per sq.m. of body surface area. Its normal value is 3.3 litre/min/sq.m

13.0 Regulation of heart beat

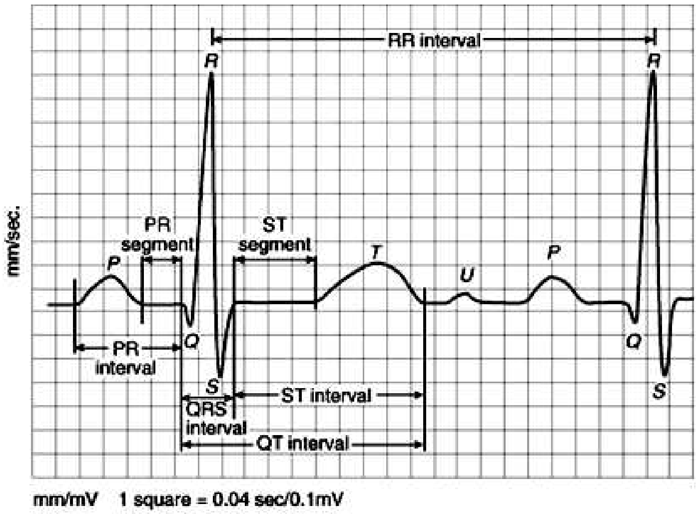
13.01 Neural regulation

The cardiac center lies in the medulla oblongata of the brain. The cardiac center is formed of cardio-inhibitor and cardio-accelerated parts. The former decreases the rate of heart beat and the latter accelerates it. The cardio-inhibitor is connected with the heart through vagus nerve (it carries – parasympathetic nerve fibers) and cardio accelerator through sympathetic nerve fibers. Sensory fibersextended from the receptors present in the superior vena cava aorta and carotid sinuses to the cardiovascular center in the medulla oblongata. The impulses received from the aorta and carotid sinuses decrease the heart rate, whereas the impulses from Vena Cava increase the heart rate.

13.02 Hormonal regulation

Adrenaline and noradrenaline hormones are secreted by the medulla of the adrenal glands. Noradrenaline accelerates the heart beat under normal conditions while adrenaline does this function at

"father of the electrocardiography



P-R interval is lengthened. This is due to the inflammation of atria and AV node

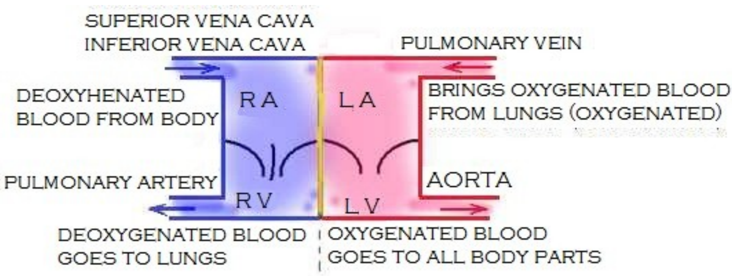
- The enlarged Q and R waves indicate a myocardial infarction (heart attack). The S-T segment is elevated in acute myocardial infection and depressed when the heart muscle receives insufficient oxygen.
- T wave is flat when the heart muscles receive insufficient oxygen as in atherosclerotic heart disease. It may be elevated when the body's potassium level is increased.
- When ECG of person to be recorded, four leads (metal electrodes) are attached to the arms and legs. It is done after lining and putting special jelly, which improves electrical conduction. With the help of rubber suction cup, an additional electrode is placed on the chest. Now the electrocardiograph is switched on which detects and amplifies the electrical current of the heart and transmits to the recording pen. The latter draws a wavy line that is called deflection wave.

stroke or CVA. Damage to optic arteries leads to blindness while a similar damage to renal vessels causes nephritis. It leads to renal failure.

15.02 Hypotension (hypopiesis)

It is low blood pressure with systolic below 110 mmHg and diastolic below 70 mmHg
Hypertension is caused by low metabolic rate, starvation, anemia, chronic vasodilation of arterioles, lower pumping activity, valvular defects, nervous disorders, Addison's disease.
There is an increasing relationship between the rate of heart beat and blood pressure. The phenomenon is called Marley's law of heart

16.0 Double circulation



Double circulation is the passage of same blood twice in the heart through separate pathways for completing one cycle. It causes only 25% of the blood being oxygenated at one time.
Double circulation consists of two parts, pulmonary circulation, and systematic circulation.

1) Pulmonary circulation: The movement of blood between heart and lung is called pulmonary circulation. Deoxygenated blood from the body enters right atrium. It is passed to the rightventricle and then into a pulmonaryarch sending to lungs for oxygenation. From lungs, the oxygenated blood is brought into left atrium

oxygenated blood to forelimbs, chest and spinal cord. Carotids supply oxygenated blood to neck, face, mouth, eyes, scalp, and brain

- Dorsal aorta has two parts, thoracic and abdominal. Thoracic aorta gives out esophageal (to the esophagus), phrenic (to the diaphragm), branches to back and intercostals (to intercostal muscles) in the thoracic cavity. Abdominal aorta supplies blood to visceral organs and lower extremities. It first gives out thick celiac artery with branches like hepatic (liver), gastric (stomach), splenic (spleen), duodenal (duodenum) and pancreatic (pancreas). Below celiac, abdominal aorta gives out a superior mesenteric artery (small intestine), two super renal (adrenal or suprarenal glands), two renal (kidneys), two genitals and inferior (posterior) mesenteric artery (large intestine) and then divides into two iliac (pelvic region and lower limbs)
- 4% of arterial blood passes into the heart, 10% to the liver, 8% to the brain, 15% of thedigestive tract and the remaining for rest of the body.

18.0 Venous system

- It comprises all the veins that bring blood to the heart. The venous system consists of pulmonary veins, coronary sinus, portal system and venae cavae. Pulmonary veins are four in number, two from each lung. They bring oxygenated blood to the left atrium. Coronary sinus collects deoxygenated blood from all the walls of the heart. It opens into the right atrium. Superior vena cava is formed by two brachiocephalic veins each of which receives deoxygenated blood from a jugular vein (from head and neck), subclavian vein (upper limb) and internal thoracic vein (part of the chest). Before opening into

It comprises lymph, lymphatic capillaries, lymphatic vessels, lymphatic nodes and lymphatic ducts.

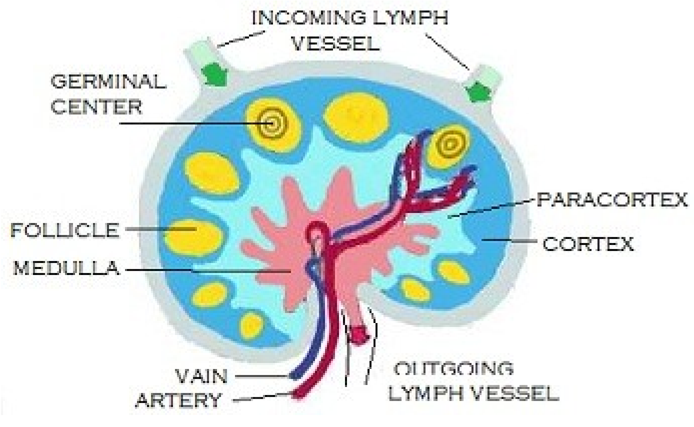
20.01 Lymph

Lymph, a colourless fluid is a part of tissue fluid, which in turn, is a part of blood plasma. So the composition of tissue fluid and lymph is same as that of blood plasma but it lacks RBCs and large plasma proteins. As compared to the tissue fluid, the lymph contains very small amount of nutrients and oxygen but contains abundant them to extent that they end blindly. Moreover, they have extremely thin walls. They are composed of a single layer of endothelial cells. The lymphatic capillaries of intestine absorb the digested fats. They are milky in appearance and are, therefore, called the lacteals.

20.03 Lymphatic vessel

The lymphatic capillaries unite to form large lymphatic vessels. They are composed of an outer coat of fibrous tissue, middle coat of muscular tissue and an inner lining of endothelial cells. The lymphatic vessels have numerous valves.

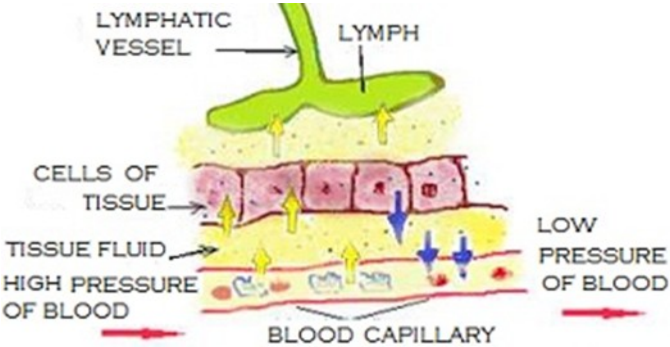
20.04 Lymph node



- These are small oval or bean-shaped structures located along the length of lymphatic vessels. Lymph nodes are most discharges its lymph into the right subclavian vein.

20.07 Lymph movement

The lymph flows in lymphatic vessels very slowly. Forcing out of fluid from the blood capillaries sets up some pressure in the tissue fluid. This establishes a pressure gradient in the lymphatic, causing the flow of lymph in the latter. Movements of viscera and contractions of the body muscles help considerably in squeezing the lymph along. The valves present in lymphatic vessels prevent its backflow. Movement of villi assists flow of lymph in the lacteals. Gravity helps in moving the lymph down the lymphatic vessels of head and neck.



20.08 Functions of lymph

The lymph or lymphatic system serves functions as:

- It drains excess tissue fluid from the extracellular spaces bin to the fluid.
- Some of the fluid from the digestive tract is absorbed into the lymph. The lymphatic vessels store this fluid temporarily and release it gradually so that the kidney does not face a sudden pressure of urine execration.
- It carries carbon dioxide and nitrogenous waste materials that diffuse into the tissue fluid to the blood.
- It takes lymphocytes and antibodies from lymphatic nodes to the blood.
- It transported fat that is digested and absorbed in the intestine to the blood in the form of chylomicron droplets.
- It destroys the invading microorganisms and foreign particles in the lymphatic nodes.

ii) Reservoir of red corpuscles

iii) Formation of agranulocyte

iv) Production of antibodies

v) Storage of iron

vi) Erythropoiesis

vii) Disposal of foreign elements

20.10 Thymus

The thymus is also a lymphatic organ. It lies in the upper chest near the neck. It is prominent in children but begins to degenerate in early childhood. It educates the lymphocytes in the foetus to distinguish cells from foreign cells.

2. Atherosclerosis:

It is wall thickening and narrowing of the lumen of medium and large arteries. In atherosclerosis, yellowish plaques (atheromas) of cholesterol and other lipids are deposited within tunica intima and inner part of tunica media were smooth muscles abound. They are mostly caused by low-densitylipoproteins or LDL which can pass through the endothelium. Plaques grow. The smooth muscles also proliferate probably caused by the release of platelet-derived growth factor (PDGF). This occurs due to the roughness of inner arterial lining. Thickening of arterial

fragments, air, calcium etc. coming from a larger blood vessel is forced into a smaller or narrow blood vessel resulting in its blockage and hence obstruction of blood circulation.

11. Myocardial Infarction: Complication due to reduced blood supply to heart wall-pain, pallor, perspiration, nausea, ECG changes.
12. Heart Burn (Pyrosis). The sensation of burning occurring in waves in esophagus tending to rise upward towards neck often with reflux into the mouth. It has nothing to do with the heart.

13. Varicose Veins: Unnatural permanently distended veins.
14. Hematoma: Localized collection of usually clotted blood in a tissue or organ due to injury and rupturing of the blood vessel.

22.0 Distinguish

22.0.01 Blood and Lymph

	Blood	Lymph
1	Blood is pumped throughout the body by the heart	lymph is moved along through the normal function of the body.
2	Blood transports oxygen throughout the body	Lymph removes waste from the system.
3	Blood flows through the body in a circular motion	The movement of lymph is in a single direction.
4	Blood contains red blood cells, white blood cells and platelets	Lymph is a whitish and clear liquid
5	You can see blood if there is damage to the vessels	Lymph cannot be seen with the naked eyes.
6	The kidneys purify the blood	lymph is purified in the nodes itself.

22.0.01 Open and closed circulatory System

	Open Circulatory System	Closed Circulatory System

22.0.03 Mitral Valve and Aortic Valve

	Mitral Valve	Aortic Valve
1	mitral valve is located between the left atrium and the left ventricle	the aortic valve is located between the left aorta and the left ventricle.
2	the mitral valve has only two.	The aortic valve has three flaps, like the other valves
3	The mitral closes when the aortic valve opens and vice versa	The aortic valve closes when the mitral valve opens and vice versa
4	The mitral valve may fall prey to a mitral valve prolapse, which refers to a loosening of the muscles	aortic valve is more susceptible to a narrowing and causes lesser flow to the next chamber. This is called an aortic valve disease.

22.0.04 SA node Vs AV node

	SA node	AV node
1	SA node stands for sinoatrial node.	AV node stands for the atrioventricular node.

2	SA node is known as the pacemaker of the heart.	AV node is also known as pace setter of the heart.
3	SA node is the first component of conducting a system of the heart.	AV node is the second component of conducting a system of the heart.
4	SA node is controlled by the autonomic nervous system (ANS). It is innervated by the parasympathetic nervous system by the Vagus nerve.	AV node is controlled or influenced by the impulses from SA node.
5	SA node is located in the superior lateral wall of the opening of superior vena cava (SVC).	AV node is located in the posterior septal wall of right atrium just near to opening of the coronary sinus.
6	SA node has the rate of impulse discharge of almost 90-100 beats per minute.	AV node normal firing rate is 40-50 times per minute.

22.0.05 Systole Vs Diastole

		diastolic pressure indicates that the heart is approaching towards failure.

22.0.06 Neurogenic heart Vs Myogenic heart

	deposition of plaque (consists of cholesterol, lipids, calcium, white blood cells and clumps of platelets)	flexible walls due to loss of elasticity of the arterial musculature.
2	narrowing passageway causes the blood pressure to rise and may lead to a heart attack or stroke.	buildup of blood as it tries to flow through the arteries, leading to high blood pressure.
3	Plaques are formed due to proliferation of smooth muscles of the inner wall of arteries	No plaque formation, but arteries are stiff and rigid due to calcification
4	Takes place in Lumen of large and medium size arteries of body	Can take place in medium to small arteries of limbs
5	blood pressure to rise and may lead to a heart attack or stroke.	high blood pressure causes a breakdown of the arteries in the body and may cause the heart to become overworked

22.0.09 Artery and Vein

	Artery	Vein

1	Arteries carry oxygenated blood, away from the heart except pulmonary artery	Veins carry deoxygenated blood, towards the heart except pulmonary veins
2	These are mostly deeply situated in the body	These are superficial and deep in location
3	These are thick-walled, highly muscular except arteries of cranium and vertebral column	These are thin-walled

	generated by the SA node, causing atrial depolarization	their normal state
3	It is atrial origin	It is ventricular origin
4	It last for 1sec	It lasts for 5 sec

20.0.11 Lymphocytes and Leukocytes

	Lymphocytes	Leukocytes
1	lymphocyte is a type of leukocyte	Leukocyte is a white blood cell
2	Lymphocytes cells are produced from lymphoid progenitor cells, which is another stem cell line.	All leukocyte cells except lymphocytes are produced from myeloid stem cell which is a stem cell line.
3	The major function of lymphocytes is to take care of adaptive immunity	all other leukocytes take care of innate immune system in the human bodies.
4	lymphocytes may be further categorized into B cells and T cells, which are responsible for cell-mediated and humoral immune response.	leukocytes are: neutrophils (40% - 75%) eosinophils (1% - 6%) basophils (less than 1%) monocytes (2%-10%) lymphocytes (20%-45%)

That's all folks!

सर्वे भवन्तु सुखिनः सर्वे सन्तु निरामयाः । सर्वे भद्राणि पश्यन्तु मा कश्चिद्दुःखभाग्भवेत् ॥

All should/must be happy, be healthy, see good; may no one have a share in sorrow.

Chemical Coordination and Integration

Notes for

NEET AND AIIMS

Examinations

TOPIC INDEX

- Body functions are controlled and regulated by two neuro endocrine system, nervous and endocrine.
- Nervous regulation is very fast, taking only milliseconds and limited to only a part of target. Hormonal regulation is a bit slower but influence all the sensitive cells of target tissue.
- Nervous system is also known to stimulate endocrine system.
- Endocrine system is a system of isolated 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. The branch of science that is connected with the study of

endocrine glands, hormones and their effects is known as endocrinology.

- "Thomas Addison" is known as father of Endocrinology

1.0Types of glands

- Glands is an organ, tissue or cell that secretes a chemical from performing a particular functions.

(i) **Exocrine glands**: 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. Example, sebaceous glands, sweat gland, salivary glands, gastric glands, intestinal gland.

(ii) **Endocrine glands**: 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 duct less glands.

(iii) **Heterocrine gland**: It is a gland that has both exocrine and endocrine region, the former pouring their secretion through ducts and latter pouring their secretion directly into blood.

(iv) Mixed organs: It is an organ which has both an endocrine activity and a metabolic or cytogenic activity. Example; gonads

- Target cell/ organ: It is organ/ cell on which the product of another system acts. In hormonal system there can be three types of targets- primary, secondary and final. For example, the primary target of TRH (Thyrotropin Releasing Hormone) is anterior pituitary which releases

TSH(Thyrotropin or Thyroid Stimulating Hormone) that has thyroid as secondary target. The secondary target or thyroid releases thyroxine which controls metabolic relations of different body cells (final target).

2.0Hormones

- Hormones are secreted in minute quantities and are transported through blood to different parts of the body or target organs.
- When some hormones work together to control a process, this is called synergism e.g. FSH and LH.
- When two hormones work against each other to control a process, this is called antagonism eg. Insulin and glucagon and calcitonin and parathormone.
- Hormones receptors are found either exposed on the surface of the cell or within the cell, depending on the type of hormone. In very basic terms, binding of hormone to receptors triggers a cascade of reactions within the cell that affects function.
- The secretion of hormones is regulated by feed back mechanisms
- Synthesis and release of some hormones is regulated by nerves and the hormones may also influence nerve activities.

2.01Properties of hormones

(i) They have low molecular weight.

(ii) They are soluble in water and blood.

(iii) They have no cumulative effect.

(iv) They can act in very low concentration.

(v) They are non-antigenic.

(vi) They are organic catalysts.

(vii) They may act slowly or quickly.

(viii) Hormone controlled reactions are not reversible.

(ix) Their excess or deficiency leads to disorders.

(x) They do not provide energy or building materials

(xi) Hormones are produced in inactive form called prohormones. Eg. Proinsulin→ Insulin

(xii) It is also called messenger because it has effect at a site different from the site it is synthesized.

(xiii) Hormones, unlike enzymes do not catalyze any reaction.

2.02 Classification of hormones

(i) Amino acid derivative hormones

The hormones epinephrine (adrenaline), norepinephrine (noradrenaline) and thyroxine are derived from amino acid tyrosine.

(ii) Peptide hormones

The hormones oxytocin and vasopressin are composed of peptides.

(iii) Protein hormones

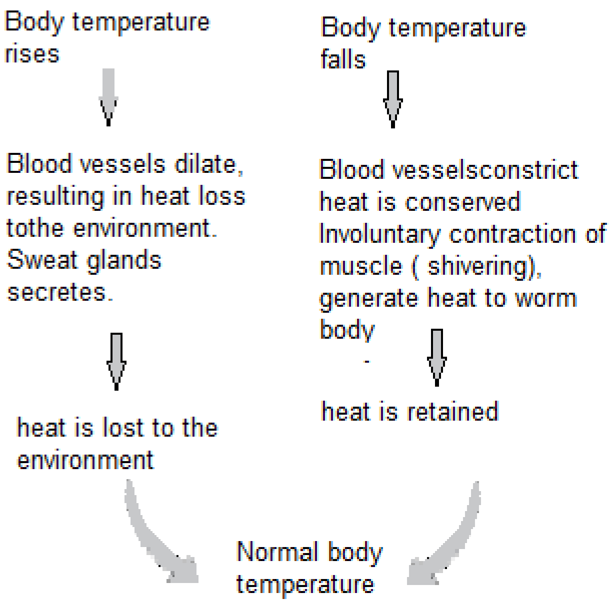
The somatotropic, thyrotropic and gonadotropic hormones, insulin, glucagon, parathormone, human chorionic gonadotropin, human chorionic somatomammotropin (HCS) andrelaxin are made up of proteins.

(iv) Steroid hormones

The hormones secreted by the adrenal cortex, testes and ovaries are composed of steroids. Placental estradiol and progesterone are also steroid hormones.

2.03 Role of hormones in homeostasis

- Homeostasis means keeping the internal chemical environment of the body constant. Hormones help maintain homeostasis by these integrated action and feedback control



•.The regulation of the amounts of water and minerals in the body. This is known as osmoregulation. This happens primarily in the kidneys.

• The removal of metabolic waste. This is known as excretion. This is done by the excretory organs such as the kidneys and lungs.

• The regulation of body temperature. This is mainly done by the skin.

• The regulation of blood glucose level. This is mainly done by the liver and the insulin and glucagon secreted by the pancreas in the body

3.0 Mechanism of hormone action

- All hormones produce their specific effects on the target tissues /cells by binding to the specific proteins called as hormone receptors. These receptors are located on target tissues only. There are basically two types of receptors present in target tissues. These are:

1. Membrane bound receptors
2. Intra cellular receptors

- The hormone receptors present on the cell membrane of the target cells are called membrane – bound receptors.
- The receptors present inside the target cell are called intracellular receptors. The binding of hormone to its receptors leads to the formation of hormone –receptor complex. The formation of this complex leads to some biochemical changes in the target tissue. The target tissue metabolism and the physiological functions are regulated by the hormones.

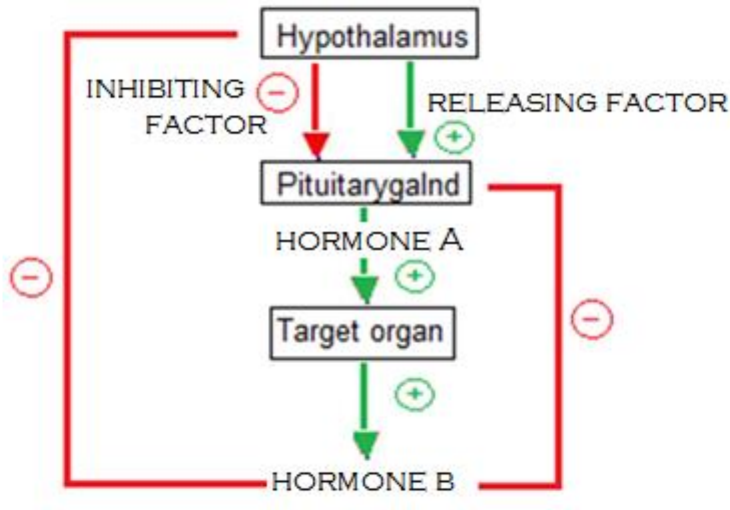
3.1 Hormone Feedback system

Negative feedback control

•In this, synthesis of hormonal slows or halts when its level in the blood rises above normal. Eg. Blood – glucose homeostasis. Secretion of hormone may be under the negative feedback control of a metabolite.
•For instance, increase in blood-glucose level on eating a carbohydrate-rich meal, stimulates pancreas to secrete insulin. Insulin stimulates the target cells to take up glucose, which is utilized in cell respiration or is stored as glycogen. This lowers the blood-glucose level to normal.
•With the fall in blood-glucose level, insulin secretion decreases.

Positive feedback control

•In the positive feedback control an accumulating biochemical increases its own production.
•For example, uterine contraction at the onset of labour stimulates the release of the hormone, oxytocin, which intensifies uterine contractions.
•The contraction further stimulate the production of oxytocin. The cycle of increase stops suddenly after the birth of the baby.



3.02Peptide hormone action

- The hormones that are derivatives of amino acids, polypeptides or proteins are formed of large molecules are called peptide hormones. These being insoluble in lipids cannot enter the target cell.
- These act at the surface of target cell as primary messengers and bind to the cell surface receptor forming the hormone receptor complex. This mechanism was discovered by Nobel Prize winner EW Sutheland in 1950. It involves following steps:

(i) Hormone called first messenger attaches to the cell surface receptors proteinon the outer surface of plasma membrane of the target cell, forming a hormone receptor complex.

(ii) These complex activates the enzyme adenyl-cyclase

(iii) Adenylcyclasecatalyses the conversion of ATD to cyclic AMP(Cyclic adenosine monophosphate or cAMP) on the inner surface of plasma membrane.

(iv) cAMP serves as the 'second messenger' or intercellular hormonal mediator delivering information inside the target cells. This activates appropriate cellular enzyme by cascade effect. This induces the cell machinery to perform its specialized function.

(v) Ca^{2+} may be involved along with cAMP.

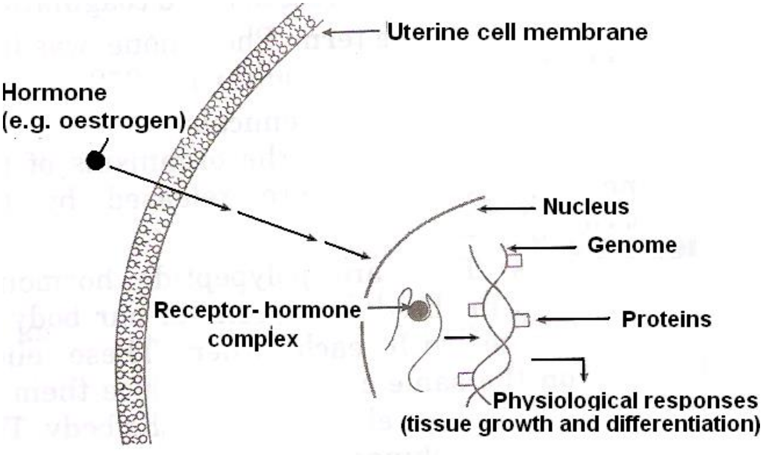
(vi) cAMP has a very short existence. It is rapidly degraded by the cAMPphosphodiesterase.

- Water soluble hormones, such as amines, peptides, proteins and glycoproteins exert their control through cyclic AMP. These are quick acting hormones and produce immediate effect.

3.03Steroid hormone action

- Steroid hormones and thyroid hormones do not bind to the cell surfaces receptors. Being lipid soluble, these are able to enter the cells and their nuclei and influence the gene action.
- The hormone binds the receptors forming a hormone – receptors complex. It binds to the transcription factors that in turn bind to DNA and particular gene is activated and transcribed. Their transcription leads to the synthesis of a specific protein to influence the metabolism of recipient cell.
- Thus, the peptide hormones activate existing enzymes in the cell, while steroid hormones bring about the synthesis

of new enzymes. Steroid hormones act slowly than peptides but have a more sustained effect on metabolism



4.0 Pineal gland

- It is a stalked small rounded gland named so after its resemblance with pine cone. Pineal gland is found behind the anterior choroid plexus on the epithalamus. It has a variable size. Weight is about 150 mg. The gland is richly vascularised. Unlike lower animals, human pineal gland is devoid of light sensitive cells. The gland is neurosecretory transducer and functions as biological clock, calcification occurs in middle age. It has pineal and glial cells. The gland secretes two biogenic amine hormones.

  (i) Serotinin: Also by disintegrating blood cells. Constricts (vasoconstriction) blood vessels at a place of injury.

  (ii) Melatonin: The hormone develops pale skin colour in amphibians. Its release is governed by diurnal dark-light cycle. Light inhibits melatonin secretion. The effect is routed through retinal neurons – hypothalamus – pinal gland. Melatonin concentration is maximum in midnight and minimum during noon. The hormone controls sleep, mood, ovarian cycle, delay, puberty, opposes FSH and LH hormones.

5.0 Hypothalamus Gland

Floor of diencephalon has nuclei of grey matter with neurosecretory cells producing neurohormons. Some of them are poured into adenohypophysis(anterior and intermediate pituitary) through hypophysial portal system while two hormones (oxytocin and ADH) are directly taken by nerve cells into neurohypophysis (posterior pituitary) cell bodies of the secretory neurons of oxytocin and ADH hormones are located within supraoptic and paraventricular nuclei of hypothalamus. Their unmyelinated nerve fibres form hypothalamohypophysical tract in infundibulun which ends in neurophypophysis. The hormones are transported as neurophysinbound secretorygranules through the nerve fibres. Hormones poured in adenohypophsis function as releasing or inhibiting hormones. They are peptide in nature.

1. Thyrotropin Releasing Hormone (TRH)
   Stimulates anterior pituitary to secret thyrotropin or thyroid stimulating hormone.
2. Adrenocorticotropin Releasing Hormone (ARH)
   Stimulates anterior pituitary to secrete adrenocorticotropin hormone.
3. Gonadotropin Releasing Hormone (GnRH)

Stimulates secretion of gonadotropins by adenohypophysis which are of two types, FSH and LH.

4. Somatotropin Releasing Hormone or Growth Hormone Releasing Hormone (SRH or GHRH)
   Stimulates production of growth hormone or somatotrophic hormone by anterior pituitary.
5. Somatostatin or Growth Hormone Inhibiting Hormone (GHIH)
   It inhibits adenohypophysis to secrete growth hormone.
6. Prolactin Releasing Hormone (PRH)
   The anterior pituitary is stimulated to secrete prolactin.
7. Prolactin Inhibiting Hormone (PIH)
   The hypothalamic hormone stops synthesis of PRH by anterior pituitary. Hormone prolactin is under predominant inhibitory control through neurotransmitter dopamine produced by tubero-infundibular neurons.
8. Melanocyte Stimulating Hormone Releasing Hormone (mSH – RH)
   The releasing hormone induces intermediate pituitary to secrete mSH
9. Melanocyte Stimulating Hormone Inhibiting Hormone (mSH – IH)
   The inhibiting hormone stops synthesis of mSH.

6.0 Pituitary glands

- The pituitary or master gland acts as a regulating unit of the activity of most of the other endocrine glands. It is the most protected gland and lies in a bony cavity called as hypophysial fossa or shell turcica of besiphenoid bone. This gland is attached to hypothalamus by infundibulum.

- The gland consists of two parts: adenohypophysis and neurohypophysis.

6.01 Hormones secreted by adenohypophysis

- The adenohypophysis is formed of two lobes i.e. anterior and intermediate lobe. These both lobes are formed by embryonic buccal cavity (Rathke's pouch). Adenohypophysis contains three types of cells. These are basophils acidophils, chromophils.
  a) Growth Hormone or Somatotropin Hormone (GH or STH)
     i) It stimulates body growth, protein and fat and carbohydrate metabolism
     ii) Hyposecretion of this hormone causes dwarfism during the skeletal growth period.
     iii) Hypersecretion of this hormone during the period of skeletal growth causes gigantism characterized by excessive growth of bones, with the enlargement of internal organs as well.
     iv) Hypersecretion in adulthood causes acromegaly. Here, the bones becomes abnormally thick due to ossification of periosteum and thickening of soft tissues as well.
  b) FSH or Follicle Stimulating Hormone.
     i) It is produced by the basophilic cells, along with galactose mannose etc.
     ii) Function: In females → growth of ovarian follicles up to ovulation

In males → Development of seminiferous tuble and maintenance of spermatogenesis.

c) LutenizingHormone or interstitial cell stimulating hormone (LH or ICSH)

i) It is produced by basophilic cells. The hormone stimulates the testis to secrete the male sex hormones, testosterone and the corpus luteum in ovaries to secrete female sex hormones called progesterone.

d) Prolactin

It is produced by acidophilc cells. This hormone stimulates lactation (milk production) and has a direct effect on the breasts immediately after parturition.

e) Adrenocorticotropic Hormone

i) It is secreted by the corticotropic cells of anterior pituitary.

ii) It stimulates the flow of blood to the adrenal cortex, increases the concentration of cholesterol and steroids within the gland and increases the output of steroid hormones, especially cortisol.

iii) Hyposecretion causes acute psoriasis and dermatitis (the diseases of skin)

iv) Its hypersecretion causes cushing's disease characterized by obesity, skin pigmentation increases, excessive hair, demineralization of bone and loss of sexual function.

f) Thyroid stimulating hormone or TSH

It is secreted by special basophilic cells. The hormone promotes growth and function of thyroid gland. It secretion is stimulated by a hypothalamic thyrotropin release factor (TRF)

g) Lipotropin Hormone

It is in the form of a complex with I, II and β-Lipotropins. It stimulates fatty acid liberation from adipose tissue. Hyposecretion causes obesity and hypersecretion causes thickness.

6.02 Hormones secreted by neurohypophysis

- The neurohypophysis is formed by the posterior lobe of pituitary gland. This lobe is developed from the diencephalon of brain. It is a part, developed from hypothalam and remains connected to it. Its cells are called pituicytes.
- These are called supraoptic and paraventicular nuclei. The hormones of nerohypophysis are transported from hypothalamus to the gland via specialized portal system called hypophysial portal system. This lobe secretes two hormones. Which are synthesized in hypothalamus.

a) Oxytocin

A peptide hormone, initiates vigorous uterine constrictions in females at the time of child birth, milk secretion by mammary glands, contraction of smooth muscles and stimulates adenohypophysis to secrete prolactin.

b) Vasopressin or ADH (Antidiuretic hormone)

i) Increases reabsorption of water in kidneys resulting in the decrease in the rate of urine production. Its other function include contraction of arterioles, capillaries.

ii) It reduces heart rate and helps in micturition as well. Hyposecretion of this hormone causes diabetes insipidus. Water balance is distributed unless fluid intake is greatly increased to compensate for excess loss.

6.03 Pituitary disorders

a) Gigantism

It is caused by excess of growth hormone from early age. It is characterized by large and well proportioned body.

b) Simmond’s disease

It is caused due to the atrophy or degeneration of anterior lobe of pituitary gland. In this disease, the skin of face becomes dry and wrinkled and shows premature ageing.

7.0 Thyroid gland

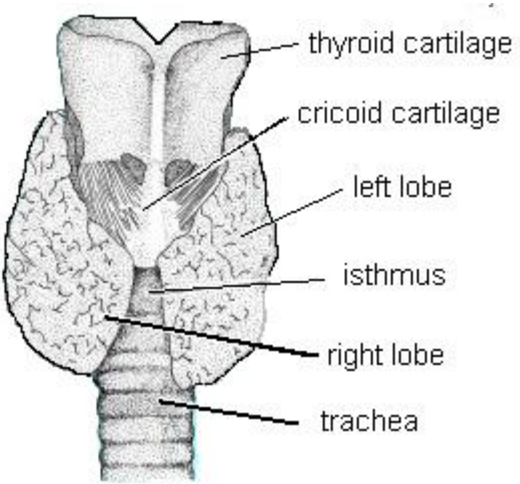
- Thyroid gland (largest endocrine gland) is present in the neck between the trachea and larynx. It is bilobed with a connecting isthmus.
- The microscopic structure of the thyroid gland shows thyroid follicles composed of cubical epithelium and filled with a homogenous material called colloid. Small amount of loose connective tissue forms stroma of thegland. Besides containing blood capillaries, the stroma contains small clusters of specialized parafollicular cells or ‘c’ cells.
- Thyroid hormones are produced by the secretory cells lining the follicle and stored in the colloid until needed. So

each follicle accumulates a storage form of the circulating thyroid hormone- thyroglobulin

- Thyroglobulin is a large protein molecule that contains multiple copies of one amino acid tyrosine.
- Thyroid gland produces two hormones-thyroxine(T_4) and tri-iodothyronine (T_3) together called thyroidal hormone. Bothe are iodinated forms of an amino acid called tyrosine. T_3 and T_4 contain 3 and 4 iodine atoms respectively. T_3 is more potent and active than T_4.
- Thyroid hormones
  - (i) Increases the metabolic rate of the body and enhance heat production and maintain BMR (basal metabolic rate)
  - (ii) Promote growth of body tissues and mental faculties.
  - (iii) Stimulates body differentiation.
- The deficiency of thyroid hormone secretion(hypothyroidism) during infancy causes cretinism and myxoedema ina adults.
- Symptoms of cretinism includes slow body growth and mental development, low heart rate blood pressure and body temperature, pot belly pigeon chest and protruding tongue.
- Symptoms of myxoedema or Gull's disease includes puffy appearance, lack of alertness, intelligence and initiative, slow heart beat, low body temperature and reproductive failure.
- Simple goiter (Iodine deficiency goiter is the enlargement of thyroid gland accompanied with cretinism or

myxoedema. It is caused due to dietary deficiency of iodine.

- 21st October is celebrated as Iodine Deficiency Disorder Day
- Exophthalmic goiter or Grave's disease is caused due to over secretion of thyroid hormones. It is an autoimmune disease in which the person produces antibodies that mimic the action of TSH but are not regulated by normal negative feedback control. Its symptoms includes protrusion of eye balls, loss of weight, rise in body temperature, rapid heartbeat, nervousness, tremor and tastelessness.
- Hashimoto's disease- In this disease all aspects of thyroid hormone are impaired. It is an autoimmune disease in which the thyroid gland is destroyed by autoimmunity.
- Thyroid gland also secretes non-iodinized calcium lowering hormone call calcitonin or thyrocalcitonin from parafollicular cells lying scattered in between the thyroid follicles.
- Calcitonin is hypocalcemic and hypophosphatemic peptide hormone of parafollicular or c-cells of extra-follicular part of thyroid. It checks excess plasma Ca^{2+} and phosphate by decreasing mobilization from bones and prevention of re-absorption in nephrons. The hormone has an opposite effect to parathormone produced by parathyroid. Deficiency of calcitonin results in osteoporosis or loss of bone density

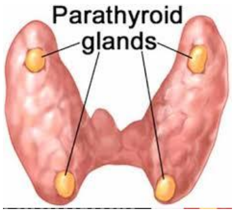


8.0 Parathyroid gland

- Parathyroid gland is present as four small pouches, two of each are embedded in the posterior surface of each lobe of thyroid gland. The gland is developed as epithelial buds from third and fourth pairs of pharyngeal pouches. The hormone secreted by parathyroid gland is parathormone or collip's hormone.
- It is a linear polypeptide with about 84 amino acids and molecular weight of 9500 Daltons.
- The two types of cells present in parathyroid gland are
  (i) Oxyphil cells or Chief cells or principal cells
  These cells contain prominent Golgi apparatus, endoplasmic reticulum and secretory granules. They are involved in the synthesis and secretion of parathormones.
  (ii) eosinophils

These cells contain oxyphil granules and large number of mitochondria in cytoplasm. Their function is unknown.

- Parathormone (PTH) acts directly on bone to increases bone reabsorption and mobilize Ca^{2+} ions in the blood. It is a hypercalcemic and hypophosphetemic hormone.



8.01 Disorders of pyrathyroid gland

(a) Hyperparathyroidism

Excess secretion of parathormone, usually by benign tumours of all the gland, causes reabsorption of calcium from bones, raising the blood calcium level.

The effects may be formation of renal calculi complicated by pyelonephritis and renal complicated by pyelonephritis and renal failure, muscle weakness, general fatigue, calcification of soft tissue, osteoporosis.

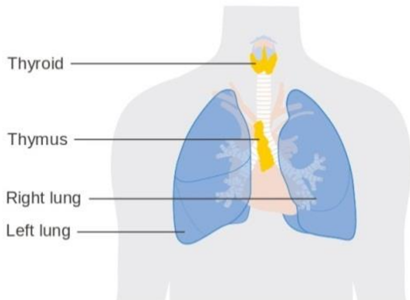
(b) Hypoparathyroidism

Parathormone deficiency causes an abnormally low level of ionized calcium in the blood. This reduces absorption of calcium from the small intestine and reabsorprtion from bones and glomerular filtrate lead to tetany

In tetany, there are very strong painful spasms of skeletal muscles, causing characteristics bending inwards of the hands forearms and feet.

9.0 Thymus gland

- The thymus gland is located in the upper part of the thorax near the heart. It is a soft, pinkish, bilobed mass of lymphoid tissue. It is a prominent gland at the time of birth but it gradually atrophies in the adult.
- Hassall's corpuscles are spherical or oval bodies present in thymus. They are phagocytic in function.
- Thymus secretes a hormone named thymosin which stimulates the development of and differentiation of T-cells, increasing resistance to infections. It also hastens attainment of sexual maturity.



10.0 Adrenal glands

- There are two adrenal glands, situated on the upper side of each kidney enclosed within the renal fascia. They are about 4cm long and 3cm thick. Internally, the gland is differentiated into cortical and medullary tissues. The gland was discovered by Eustachius and its endocrine nature was suggested by WB Canon. It has two parts adrenal cortex and adrenal medulla.

10.1 Adrenal cortex

- The adrenal cortex produces three groups of hormones from cholesterol. They are collectively called adrenocorticoids.
  These are given below

(a) Glucocorticoids

- Cortisol and corticosterone are the main glucocorticoids. They are essential for life. Their secretion is stimulated by Adrenocorticotrophic hormone from the anterior pituitary and by stress.
- Glucocorticoids have widespread effects on body system. The main functions include the regulation of carbohydrate metabolism promotion of the formation and storage of glycogen and promotion of sodium and water reabsorption from the renal tubules. They are released during allergic reactions.
- They secreted by zonafasiculata, middle zone of adrenal cortex. It consists of cells arranged in long, straight columns.

(b) Mineralcorticoids

Aldosterone is the main mineralocorticoid. It is secreted by zonaglomerulosa, outer zone that constitutes about 15% of the gland and has closely packed cells arranged in spherical clusters and arched columns.

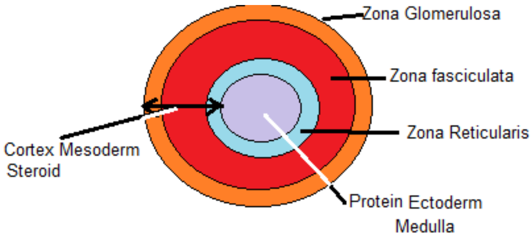
- Its functions are associated with maintenance of the electrolyte balance in the body.
- The amount of aldosterone produced is influenced by the sodium level in blood. If there is a fall in the sodium blood

level, more aldosterone is secreted and more sodium is reabsorbed.

(c) Sexcorticoids (androgen)

- Zonareticularis is the inner zone and consists of cells arranged in branching cords which secrete sexcorticoids.
- They are associated with deposition of protein in muscles and retention of nitrogen.
- These hormones are secreted as DHEA (Dehydroxyepiandrosterone). Which is a precursor of both testeosterone and oestrogens.

Regions of Adrenal cortex



10.2 Adrenal medulla

- The adrenal medulla is completely surrounded by the cortex. It is an outgrowth of tissue from the same source as the nervous system and its functions are closely allied to those of the sympathetic part of the autonomic nervous system.
- It is stimulated by its extensive sympathetic nerve supply to produce adrenaline or epinephrine and noradrenaline or norepinephrine in the ratio of 1:4. These are commonly called as catecholamines.

(a) Adrenaline : It is associated with potentiating the conditions needed for fight or flight.

- When the body is under stress, homeostasis is disturbed. The immediate response is sometimes described as preparing for fight or flight
- These hormones increasesalertness, pubillary dilation, sweating etc. Both these hormones increases heart beat, strength of heat contraction and rate of respiration.

(b) Nor-adrenaline: This is the postganglionic chemical transmitter of the sympathetic nervous system. The main function of nor-adrenaline is the maintenance of blood pressure by causing general vasoconstriction, except of the coronary arteries.

11.0 Hormones disorders

(a) Hypersecretion of glucocorticoids

- Hyper secretion of cortisol (cushing’s syndrome) has a wide variety of effects but they may not all be present at the same time. These include.

- Painful adiposity of the face (moon face), neck and trunk
- Excess protein catabolism, causing thinning of sub-cutaneous tissue and muscle, wasting, especially of the limbs.
- Suppression of growth hormone, causing arrest of growth in children.
- Osteoporosis and kyphosis, if vertebral bodies are involved
- Susceptibility to infection due to reduced febrile response, depressed immune response and phagocytosis, impaired migration of phagocytes.
- Insomnia, excitability, euphoria, psychotic depression.
- Hypertension menstrual disturbances, peptic ulceration

(b) Hyposecretion of glucocorticoids

Inadequate secretion of cortisol causes diminished gluconeogenesis, low blood glucose, muscle weakness and pallor.

(c) Hypersecretion of mineralocorticoids

Excess aldosterone (conn's syndrome) affects kidney function, causing

- Excessive reabsorption of sodium chloride and water causing hypertension
- Excessive excretion of potassium causing hypokalemia, which leads to cardiac arrhythmia and muscle weakness.

(d) Hyposecretion of mineralocorticoids

Hypoaldosteronism results in failure of kidneys to regulate sodium, potassium and water excretion, leading to

- Blood sodium deficiency and potassium excess
- Dehydration, low blood volume and low blood pressure

- Addison's disease is due to the hyposecretion of all adrenal cortex hormones. There is electrolyte upset with low plasma Na^+ through increased urinary elimination and high plasma K^+, reduced blood volume, lower blood pressure, marked anaemia, hypoglycaemia, great muscular weakness, nausea, vomiting, diarrhoea and bronze pigmentation.

(e) Hypersecretion of sexcorticoids

- Virilism is due to excessive secretion of sex corticoids caused by adrenal tumour results in appearance of male secondary characters in females like male voice, beard moustaches, stoppage of menstruation and growth of clitoris.
- Hirsutism is presence of facial and excess body hair in females due to adrenal virilism.

12. Kidney

The kidneys produce hormones that affect the function of other organs. For example, a hormone produced by the kidneys stimulates red blood cell production. Other hormones produced by the kidneys help regulate blood pressure and control calcium metabolism.

- The kidneys secrete three hormones: rennin, erythropoietin and calcitriol
- Whenever the rate of ultrafiltration falls, the cells of their juxtaglomerular complex secrete and release into blood a compound named renin. It acts upon a plasma protein angiotensinogen, speparating a compound called angiotensin – II from it.
- Angiotensin –II accelerates heart beat and constricts arterioles, thereby increasing blood pressure. This enhances the rate of ultrafiltration.
- Simultaneously, the angiotensin-II stimulates adrenal corten to secrete aldosterone and enhances water and sodium reabsorption from nephrons. These factors also elevate blood pressure.
- The oxygen shortage stimulates the kidney cells to secrete a hormone named erythropoietin (a circulating glycoprotein) into the blood.
- Erythropoietin stimulates the bone marrow to increase the production of RBCs.
- Vitamin D exists in two forms: Calciferol or D_2 and cholecalciferol or D_3

- Calcitriol is the active form of vitamin cholecalciferol(D_3). It promotes absorption of Ca^{+2} and phosphrous in the small intestine and accelerates bone formation.

13.0 Pancreas

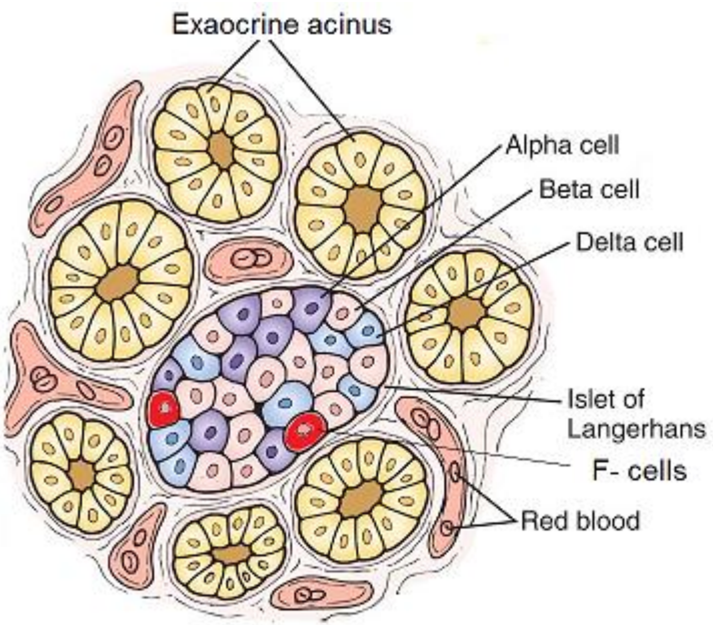
- The pancreas lies inferior to the stomach in a bend of the duodenum. It is both an exocrine and an endocrine gland.
- Pancreas has group of cells called islets of Langerhans. These produce endocrine secretions. Four kinds of cells have been identified in the islets

- Alpha cells (about 15%) produce glucagon.
- Beta cells (about 65%) produce insulin.
- Delta cells or D-cells (about 5%) produce somastostatin.
- F cells: Pancreatic polypeptide cells (15%) produce pancreatic polypeptide.

- Glucagon stimulates the liver to convert stored glycogen into glucose in the blood. Glucagon is controlled by feedback in accordance with the level of glucose in the blood. When the blood sugar rises, the secretion of glucagon is suppressed and when it drops the secretion of glucagon is stimulated. Glucagon is also called an 'anti-insulin' hormone.
- Insulin is antagonistic to glucagon. Insulin decreases the level of glucose in the blood. It acts by increasing the rate at which glucose out of the blood and into the cells and by stimulating muscle cells to take up sugar from the blood and convert it to glycogen.
- Like glucagon, insulin is primarily regulated by feedback from the blood glucose concentration.

- When the blood sugar level drops, the secretion of insulin is suppressed. When the blood sugar level increases, the secretion of insulin is stimulated.
- It promotes protein synthesis in tissue from amino acids and reduces catabolism of proteins. It is an anabolic hormone. It increases the synthesis of fat in the adipose tissue from fatty acids and reduces the breakdown and oxidation of fat.
- Somatostatin seems to suppress the release of hormones from the pancreas and digestive tract.
- Pancreatic polypeptide inhibits the release of digestive secretion of the pancreas.
- The most common endocrine disorder of the pancreas is the diabetes mellitus (hyperglycemia), now recognized to exist in two forms – insulin dependent and non insulin dependent.
- The insulin dependent diabetes mellitus (IDDM) is caused by a failure of the Beta cells to produce adequate amounts of insulin while the non-insulin dependent diabetes mellitus (NIDDM) appears to involve failure of insulin to facilitate the movement of glucose into the cells.
- In both disorders the blood glucose concentration is elevated above the normal range.
- Some of the glucose is excreted in the urine and water follows the glucose, causing excessive urination and dehydration of body tissues. The causes excessive thirst (polydipsia). The cells are unable to utilize their proteins for it. The person becomes very weak. Degradation of fats increases, producing ketone bodies (ketosis). Blood cholesterol level rises.

- Hypoglycemia occurs when the blood glucose level falls below normally. Symptoms of hypoglycemia include weakness, profuse sweating irritability, confusion, unconsciousness and convulsions.



14.0 Gonads

- Gonads are the sex glands, the ovaries and the testis. They produce ova and sperm respectively but also secrete hormones.

14.01Male sex hormones

- Male sex hormones or androgens are produced by testis. They are secreted by Leydig cells or interstitial cells found in the connective tissue around seminiferous tubules. Androgens are steroid hormones produced under control of ICSH (LH) of pituitary gland with maximum activity at puberty. Two common androgens are testosterone and androsterone. Dihydrosterone is the active form of testosterone.

- Testosterone is first produced during foetal growth under the influence of chorionic gonadotropin of placenta. There is a spurt of testosterone production at the age of 10-13 years when puberty begins. Testosterone production declines after the age of 50 years. At the time of puberty testosterone causes development of male secondary sex organs external / accessory male sex characters, growth of body tissue, broadening of shoulders, growth of muscles, higher metabolism, increased sebaceous gland activity, normal skin and formation of sperms through spermatogenesis is mainly due to FSH. Development of external genitalia in the male foetus is under the control of testosterone produced by testes. Deficient androgen secretion causes eunuchoidism

14.01.01 Eunuchoidism

- Eunuchoidism is a hormonal disorder due to non-secretion of testosterone in a genetically male individual. The secondary male sex organs are under developed and non-functional. The accessory male character fails to develop. Spermatozoa are not formed. Castration is artificial removal of testes. Secondary male characters do not differentiate. Castrated human males are called eunuchs.

15.0 *Female sex hormones*

- They belong to both steroid and protein categories. The hormones are secreted by growing graafian/ ovarian, corpus luteum and placenta.

1. **Estrogens**

   They are steroid hormones secreted by growing ovarian follicles under instructions from anterior pituitary through FSH. Estrogens include estradiol, estriol and estrone. Estradiol is the principal estrogen. Its maximum concentration is found at the time of puberty. Later it shows cyclic rise and fall during menstrual cycle. During pregnancy estradiol is secreted by placenta. At puberty the hormone is required for development of female secondary sex organs, external / accessory female sex characters, body contour and onset of menstrual cycle. Later on the hormone helps in maintaining the traits and organs in reproductive tract. During menstrual cycle, estrogen released from growth ovarian follicle inhibits FSH secretion and stimulates LH secretion from pituitary increasing blood supply to uterine epithelium.

2. **Progesterone**

   It is a steroid hormone secreted by corpus luteum under the influence of LH of anterior pituitary in the second half of menstrual cycle and hCG of placenta during pregnancy. The placenta also secretes the hormone. Routinely progesterone causes temporary changes in endometrial lining of uterus for receiving egg. During pregnancy it helps in attaching embryo to uterine wall development of placenta, maintenance of pregnancy and growth of secretory alveoli in mammary glands. Progesterone checks ovulation. Hyposecretion results in abortion and misconception.

3. **Relaxin**

   The proteinaceous hormone is secreted by corpus luteum towards the close of gestation period for loosening of pelvic ligaments. Softening dilating and relaxing of uterus for decreasing discomfort of carriage and easy child birth.

4. **Human Chorionic Gonadotropin (hCG)**

   The proteinaceous hormone is secreted by placenta for maintaining corpus lutoum,hCG is urine is an indication of pregnancy.

5. **Human placental Lactogenic hormone (HPL)**

   The hormone produced by placenta prepares the mammary glands to secrete milk.

6. **Inhibin / Actin**

   Hormones produced by corpus luteum, placenta and testes that inhibits or activates gonadotrophic activity of pituitary gland and hypophysis.

16.0 Puberty related endocrine abnormalities

16.1Hypogonadism

- Defect or injury to hypothalamus, pituitary testes or ovaries. In male hypogonadism, there is deficient production of testosterone due to hypofunction of Leyding cells or deficient formation of sperms on account of hypofunction of sertoli cells. Both the defects may be present. Male musculature and male secondary sexual characteristics do not develop. In female hypogonadism there is deficient secretion of estrogen, little development of secondary sexual characters of females and non-development of reproductive cycles.

16.2Precocious puberty

- It is early maturation of primary sex organs. Ovary before the age of 11 years and testes before the age of 12 years. Sexual pseudoprecosity in boys occurs due to excess formation of testosterone as there is tumour growth in testes or adrenals. It results in early enlargement of pensis, development of pubic and axillary hair, faster body growth, masculinisation and then stunting . Similarly, sexual pseudoprecosity in girls results from excessive production of estrogen due to tumours in ovaries / adrenals. Breast and pubic hair develop early but ovarian cycle does not occur.

16.3Gynaecomastia

Normally-developing pubertal males may be at risk for gynecomastia that is part of the normal developmental process. Normal male infants also may have gynecomastia. Gynecomastia results from an imbalance in hormone levels in which levels of estrogen (female hormones) are increased relative to levels of androgens (male hormones).

- It is the development of breast tissue in males due to
  (i) Perturbation of estrogen to androgens ratio.
  (ii) Temporary increase in circulating estrogen during neonatal period and during puberty.
  (iii) Decreased testosterone in later life

17.0 other organs which secrete hormones

17.1Heart

- It produces a peptide hormone atrial natriuretic factor (ANF) in case of hypertension. The hormone inhibits renin (in kidneys) and ADH secretion (in pituitary)

17.2 Salivary glands

- The glands produce proteinaceous hormone parotine required for calcification of teeth.

17.3 Gastrointestinal mucosa

1. Gastrin
   It is produced by pyloric mucosa and duodenum (small quantity by γ-cells in pancreas) in response to presence of food in stomach. Stimulus is provided by vagus nerve. Gastrin stimulates secretion of gastric juices and churning movements of stomach. Hypersecretion produces gastric ulcers and other gastric problems.
2. Motilin
   It is secreted by duodenum in response to food and acidity. Motilin controls motility of stomach and intestine
3. 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. Secretion was the first hormone to be isolated.

4. Enterogastrone

   It is believed to be produced by duodenum in response to chyme. Enterogastrone stops digestive activity in stomach.

5. Cholecystokinin

   It is produced by duodenum and jejunum in response to presence of food. Cholecystokinin stimulates the flow of pancreatic enzymes and contraction of gall bladder.

6. Pancreazymin

   The hormone is believed to be secreted by duodenal mucosa and required for the flow of pancreatic juice. Both cholecystokinin and pancreazymin are now believed to be one structure.

7. Enterocrinin

   The hormone secreted by duodenal mucosa stimulates crypts of Lieberkuhan for secretion of succus or intestinal juice.

8. Duocrinin

   Intestinal hormone that stimulates secretion of mucus and HCO_3 from Brunner's gland

9. Villikinin

   Intestinal hormone that stimulates movements of intestinal villi

10. Gastric Inhibitory Peptide (GIP)

    It is secreted by mucosa in the upper part of small intestine in response to fat and protein in chyme,monosaccharides also have a stimulating effect. GIP inhibits gastric mobility and secretion for slowing down of passage of food. It stimulates insulin secretion.

18.0 Hormones which always remains in tissue fluid

Never reach blood stream but remain in ECF

1. Neurohormones : Secreted by nodesof axons of nerve cells, Acetylcholine and Norephrine are the main neurohormone. Acetylcholine causes muscles to contract, activates pain responses and regulates endocrine and REM sleep functions.
2. Prostaglandin: Called local hormones. They are fatty acid, Many types, Kidney, gonads, seminal vesicle, thymus, brain organ and cells secrete these hormone in EC. Function in the contraction and relaxation of smooth muscle, the dilation and constriction of blood vessels, control of blood pressure, and modulation of inflammation.
3. Kinins : Called as "First aid hormone", reducesblood pressure by expanding blood vessels. Secreted at the time of chemical change in ECF
4. Pheromones or Ectohormones: effect the other animal's behavior and mode of life of same species. , are volatile andtravel through air from place to place

   Three tyeps

   1. Sex-Pheromone : These attact male and female animal for reproduction Examples Muskone, Civetone

   2. Aggregation pheromone: Sendingmessage to othermember of the socity of insect, to help in aggregation Example Geradial in honeybee

   3. Alarm pheromones: Alarm other member of same species of insect. Example Formic acid in ants.

18.0 Distinguish

18.1 EnzymeVs Hormone

	Enzyme	Hormone
1	Always proteinaceous	May be proteinaceous or amine or steriod
2	High molecular weight	Low molecular weight
3	They may act at site where they are produced or carried to another site by some duct	They are produced at one site and are passed by blood to another site for action
4	Acts slowly, but increases rate of reaction	Accelerate or retard the specific reaction. May act slowly or quick
5	Catalyze reversible reaction	Hormone controlled reactions are not reversible
6	Are not used up in reactions	Are used up in reaction

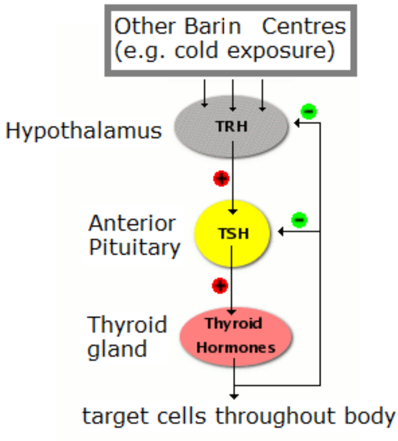
18.2 Vitamins Vs Hormone

	Vitamins	Hormone
1	Taken along with food from outside. Rarely synthesized in	Synthesized in endocrine glands and some by

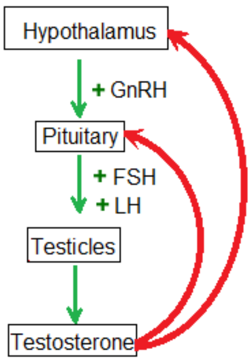
	the body	neurosecretory cells.
2	Simple organic compounds like amines, esters, organic acids etc.	These are steroids or proteinous or amino acid derivatives.
3	These are generally acts as coenzymes or constituents of coenzymes for enzyme action.	These are excitatory or inhibitory in action. They never act as coenzymes
4	Vitamins have catalytic action.	Hormones directly influence gene expressions.
5	Their deficiency (avitaminosis) causes specific deficiency diseases.	Their deficiency and overproduction cause metabolic disorders

19.0 Important feedback mechanism

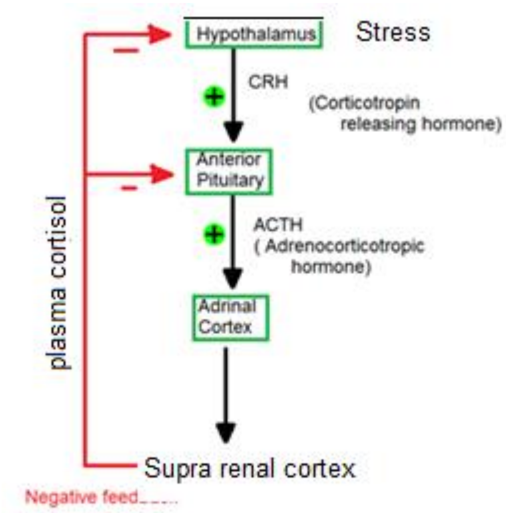
19.01 (TSH) feedback mechanism



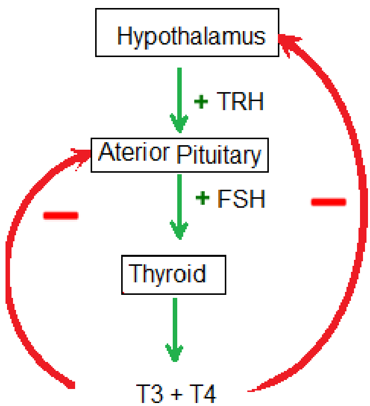
19.2 feedback loop of the male reproductive system



19.03Corticotropin releasing hormone or CRH feedback mechanism



19.04 Corticotropin releasing hormone or TRH feedback mechanism



www.instamojo.com/gneet/chemical-coordination-and-regulation/

"gneet.com" is very thankful to Nishigandha for compiling contents of notes,

THAT'S ALL FOLKS!

सर्वे भवन्तु सुखिनः सर्वे सन्तु निरामयाः। सर्वे भद्राणि पश्यन्तु मा कश्चिद्दुःखभाग्भवेत्॥

All should/must be happy, be healthy, see good; may no one have a share in sorrow.

DIGESTON AND ABSORPTION

NOTES

for

NEET AND AIIMS

Examinations

TOPIC INDEX

Nutrition

Nutrition is a process by which animals obtain essential and nonessential substances called nutrients and utilize these produce to energy required for various life process such as growth, repair, development, reproduction and other activities from the surrounding as food.

1.0 Modes of nutrition

1.1 Autotrophic nutrition

- Preparation of organic food from the inorganic materials is called autotrophic nutrition
- It is of two types : Photoautotrophic and chemoautotrophic

a) Photoautotrophic nutrition

- All green plants, certain protists (Euglena viridis) and some bacterial (green sulphur bacterium, chlorobium) take carbon dioxide and water from the environment and transform these into glucose and oxygen with the help of Sun's energy trapped by chlorophyll.

$$6CO_2 + 12H_2O \xrightarrow[\text{sunlight}]{\text{chlorophyll,}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

b) Chemoautotrophic nutrition

- Some bacteria utilize light as source of energy during the synthesis of food, utilize the energy obtained in the form of A.T.P
- Examples of chemoautotrophic bacteria
  i) Sulphur bacteria – *Beggiatoa, thiothrix* and *Thiobacillus thiooxidans*

ii) *Iron bacteria*

iii) Nitrifying bacteria – *Nitrosomonas, Nitrosococcus, Nitrobacter* and *Nitrocystis*

1.2 Hetrotrophic nutrition

- Animals, fungi etc cannot manufacture their food. They depends upon autotrophs directly or indirectly

i) Holotrophic (Holozoic) nutrition

- Most vertebrates and invertebrates take solid or liquid food through their mouth is called holozoic nutrition

ii) Saprozoic nutrition

- It consists of obtaining food from dead and decaying organic food by first pouring digestive juices over the same and then sucking the digested food. Example – Spider, housefly

iii) Parasitic nutrition

- In this type of nutrition, food is obtained in liquid form from the body of another killing him
- Example – *Plasmodium, Trypanosoma, Taenia, ascaris*

2.0 Digestive system of human

- It is a system of alimentary canal and digestive glands that takes part in ingestion of food, its crushing, digestion, absorption of digested nutrients and egestion of undigested materials.

2.1 Mouth

- The mouth is a transverse slit. It is bounded by two soft movable lips
- The lips are covered with skin and mucous membrane on the inner side
- In mammals, the upper lip has a well defined cleft called median cleft, which provides exposure to the teeth
- In human, the median cleft not seen but only a depression can be seen which is called phlitrum

2.2 Vestibule

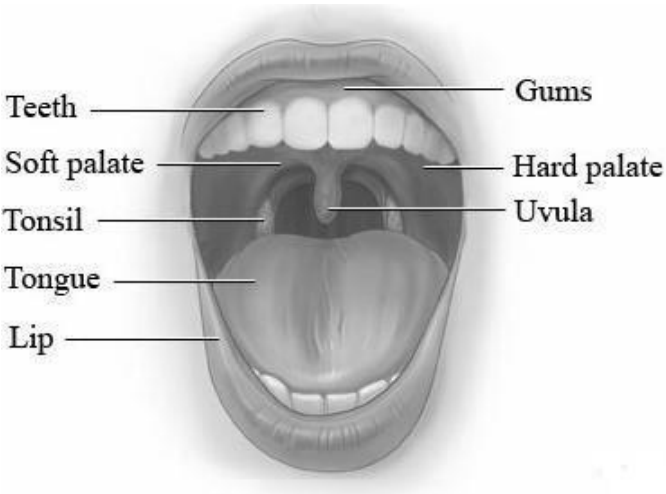
- It is a narrow space enclosed between the lips and checks externally and the gums and teeth internally
- In the vestibule, a small median fold of mucous membrane, the superior labial frenulum, connects the middle of the upper lips to the gum.
- A smaller inferior labial frenulum connects the middle of lower lip to the gum.

2.3 Oral (Buccal) cavity

- It is a space bounded above by the palate, below by the throat and on the sides by the jaws.
- The buccal cavity is lined by stratified squamous epithelium.

2.4 Palates

- The anterior part of palate is arched and strong. It is called hard palate. This part is well supported by maxilla bone.
- It bears transverse ridges called palatine rugae. The rugae help in keeping the food in place during mastication.
- The posterior part of the palate is smooth and fleshy. It is termed soft palate. Its smooth surface makes swallowing easy.
- The soft palate contains hanging small, conical flap called uvula.
- The ulva is movable and capable of coming in contact with the posterior pharyngeal walls so as to cut off the upper nasal part of the pharynx, called nasopharynx from the lower oral part of the pharynx, termed oropharynx during swallowing.

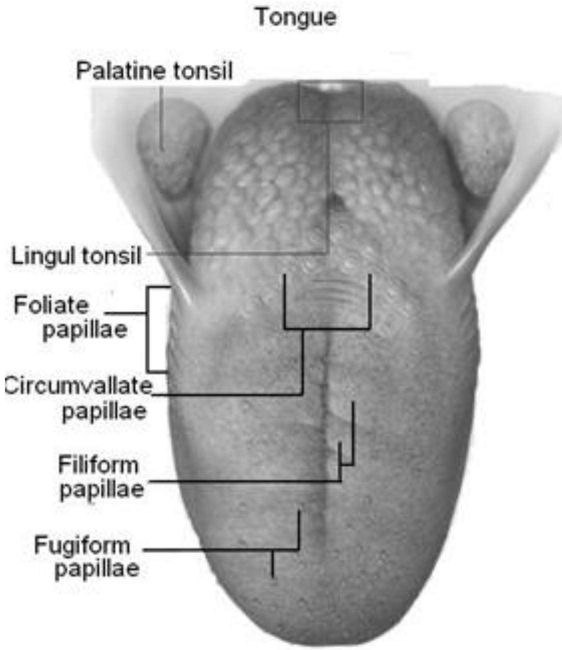


2.5 Tongue

- The tongue is a voluntary musculo-sensory and glandular structure which occupies the floor of the mouth.
- It is attached to the floor of the mouth by a fold called frenulum.
- An inverted V-shaped furrow termed the sulcus termanalis divided into the upper surface of the tongue into the anterior oral part and posterior pharyngeal part.
- Upper surface of the oral part of the tongue has a slight median groove
- The upper surface of tongue has four types of papillae , small projection which bear taste buds
  i) Vallate (surrounded by wall)
  ii) Fungiform (mushroom shaped)
  iii) Foliate (leaf –shaped)
  iv) Filiform (filament-shaped)

2.5.01 Function of the tongue

i) It helps in chewing the food.
ii) It plays a role in speech.
iii) It aids in swallowing the food and mixing the food and saliva.
iv) It acts as brush to clear the teeth by cleaning small food particles.
v) It is an organ of taste and can recognize four tastes, i.e. salty, sweet, bitter and sour.



2.6 Teeth

- Teeth are hard structures which are meant for holding and crushing the food.
- Most of the mammals have diphydont (two sets of teeth-milk or deciduous and permanent), theocodont (teeth are embedded in the socket of jaw bone) and heterodont teeth (different types of teeth).

2.6.01 Types of teeth

- There are four kinds of teeth incisors, canines, premolars and molars present in the human

- Incisors: These are chisel shaped and possess sharp cutting edges
- They are usually specialized for cutting
- Canines: They lie immediately behind the incisors

Canines are well developed in carnivores and may be absent in herbivores leaving a gap called diastema (which is used to separate the chewed and unchewed food in the mouth cavity)

They have long, sharp pointed end for piercing, killing and tearing off flesh

- Premolars and molars: these are called cheek teeth which are broad, strong crushing teeth.

Last molars in human beings are called wisdom teeth.

2.6.02 Structure of teeth

- Teeth are embedded in the jaws man has fixed upper jaw and movable lower jaws. Each tooth consists of three parts: crown, root, neck.

a) Crown: It is the exposed portion of tooth above the gums (gingiva)

- The gingiva is a specialized region of the oral mucosa surrounding the neck of the teeth
- Crown is covered with the hardest substances called enamel that protects the crown
- Beneath the enamel is dentine which is made up of hard substances but are not tough as enamel and they can decay

- Dentine forms the bulk of the tooth. There is a pulp cavity inside the dentine. It is jelly like substance and carries the nerves fibres, blood vessels and sensory cells.
- The nerves supply to the upper teeth is by the branches of maxillary nerves and to the lower teeth by the branches of mandibular nerves. These both are branches of 5^{th} cranial nerve called trigeminal nerve.

b) Neck: It is a narrow portion at the gumline.

c) Root: It is embedded in the jaw bone and holds the tooth securely in place.

- The root is fixed in alveolus of the jaw bone by periodontal membrane and cementum. Cement holds a tooth in its socket and periodontal membrane covers the cement.

2.6.03 Number of teeth

- The milk or deciduous teeth are 20 in number, 10 in upper and 10 in lower jaw
- The deciduous teeth begin to erupt when the child is about 6 months old and should all be present by the end should all be present by the end of 24 months.
- The permanent teeth begin to replace the milk teeth in the 6^{th} year of age. These teeth are 32 and usually complete by the 20^{th} year

2.6.04 Dental formulae

- The number and kinds of teeth in mammals are represented by an equation called dental formula. This equation looks like

- $$\frac{ICP_mM}{ICP_mM}$$

  I = Incisors, C = Canines P_m = Premolars

- Total number of teeth = Number of teeth in dental formula × 2

  Dental formula of some animals

  Pig

  $$\frac{3143}{3143} \times 2 = 44$$

  Dog

  $$\frac{3142}{3143} \times 2 = 42$$

  Kangaroo

  $$\frac{3124}{3124} \times 2 = 34$$

  Man

  $$\frac{2123}{2123} \times 2 = 32$$

  Elephant

  $$\frac{1003}{0003} \times 2 = 14$$

  Cat

  $$\frac{3131}{3121} \times 2 = 30$$

  Rat

  $$\frac{1003}{1003} \times 2 = 16$$

  Cow, sheep, goat

  $$\frac{0033}{3133} \times 2 = 32$$

2.6.05 Dentition of animals

1. Aerodont

   Part of bone, not embedded in sockets eg. Reptiles, except crocodiles
2. Theocodont

   Embedded in deep socket of some jaw bones e.g. mammals, crocodiles
3. Monophycodont

   Teeth grow only once in life e.g. platypus, toothed whale.
4. Diphyodont

   All teeth, except molar, grow twice in life. Eg. Mammals
5. Polyphyodont

   Fallen or wornout teeth can be replaced many times throughout life. Eg. Frog
6. Isodont

   All teeth are similar Eg. Tooth whale
7. Heterodont

   More than one type of teeth E.g mammals, crocodiles

3.1 Pharynx

The mouth leads to funnel shaped pharynx. The pharynx is about 12cm long vertical canal beyond the soft palate. The food and air passages cross here. The pharynx may be divided into three parts

i) Nasopharynx: Upper part of Pharynx Have internal nares in the root, oval opening of Eustachion tubes

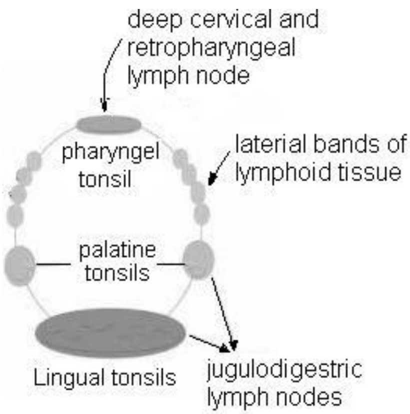
ii) Oropharynx Middle part of pharynx Has palatine tonsils

iii) Laryngopharynx

- Lower part of pharynx
- Leads to oesophagus and to pharynx through glottis (opening to larynx) and epiglottis (leaf like cartilageous flap)
- The function of the pharynx as a part of digestive tract is merely to serve as passage way for the food from oral cavity to oesophagus
- The lymphatic tissues of pharynx and oral cavity are arranged in a ring which are collectively called Waldeyer's ring. All these lymphoid tissue are active in production of immunoglobin A which forms an important part of our immune system

3.1.01 Waldeyer's ring

All lymphoid tissues are active in production of immunoglobulin



The ring mainly consists offollowing

(i) Nasopharyngeal tonsils

- In children nasopharyngeal tonsil become enlarged and is then referred to as adenoids
- The resulting swelling causes obstruction to normal breathing

(ii) Tubal tonsils

Lymphoid tissue found around the opening of each Eustachian tube

(iii) Palatine tonsils

- Located in the lateral wall of oropharynx
- The palatine tonsils is often infected leading to sore throat and surgical removal of such enlarged tonsils become necessary

(iv) Lingual tonsils

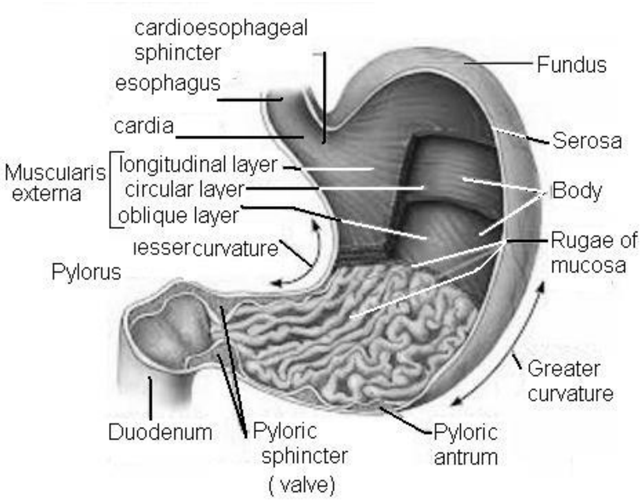
- Lymphoid tissue present at the base of tongue

3.2 Oesophagus

- The oesophagus is 25 cm long, narrow muscular straight tube lined by stratified squamous epithelium containing mucous glands
- The opening of oesophagus is called gullet
- It runs downward through the neck behind the trachea and through behind the heart and passes through diaphragm into abdomen. Here it sharply bends to open into the stomach. This bend is one of the device to check the backflow of the stomach content into the oesophagus
- Longitudinal folds keep its cavity almost closed, except during swallowing of food.
- The oesophagus serves to convey the food by peristalsis (a series of waves of contraction that passes through ends and is meant for pushing food) from pharynx to stomach

- The nerve supply to oesophagus includes parasympathetic and sympathetic branches seen in the form of myeteric and messner's plexus namely

3.3 Stomach



- Stomach is the widest organ about 30 cm long and 15cm wide of alimentary canal.
- It is a hollow, J- shaped organ lying between the oesophagus and the small intestine. The exact positioning of the stomach is in the upper $(5/6)^{th}$ part and right $(1/6)^{th}$ part of abdominal cavity
- The lesser curvature is short and lies on the posterior surface of stomach. The greater curvature is on anterior surface of stomach.

- The fold of peritoneum which attaches the stomach to the posterior abdominal wall extends beyond the greater curvature. This is called the greater omentum which stores fat
- Inner surface of the stomach has numerous folds, the gastric rugae. These folds, by unfolding let the stomach expand to accommodate a large meal
- Unlike other parts of the digestive tract, the stomach wall contains there smooth muscle layers, outer of longitudinal, middle of circular and inner of oblique fibres, to churn the food and to mix it with the gastric secretion
- The stomach has four parts: cardiac part, fundus, body and pyloric part
    - (i) Cardiac part: It is so called because it is present near the heart. The cardic sphincter lies in the opening between oesophagus and stomach. It is a functional valve. Cardiac gland secrete mucus
    - (ii) Fundus: It extends superiorly from the cardiac part. The fundus is commonly filled with gas or air. Fundic glands secretes HCl and intrinsic factor
    - (iii) Body :It is main part stomach
    - (iv) Pyloric part : It is the distal part of stomach. The pyloric region is divided into the pyloric antrum and pyloric canal. The pyloric sphincter guards the opening between the stomach and duodenum and periodically permits partially digested food to leave the stomach and ether duodenum. Pyloric glands secrete gastrin produced by their G-cells

3.3.01 Functions

(i) Storage: the stomach allows a meal to be consumed and the material to be consumed and the materials released incrementally into the duodenum from digestion
(ii) Chemical digestion: Pepsin begins the process of protein digestion cleaving large polypeptides into shorter chains
(iii) Mechanical digestion: The churning action of muscularis causes liquifaction and mixing of the contents to produce acid chyme
(iv) Some absorption: Water, electrolyte monosaccharides and fat soluble molecules including alcohol are all absorbed in stomach to some degrees.

3.4 Ruminant Stomach

In ruminants, the stomach is differentiated into chambers

(i) Large rumen for churning, breaking of food by cornified surface of villi, fermentation of cellulose by symbiotic microorganism
(ii) Recticulum
(iii) Omasum for mechanical churning and breaking of food, absorption of fluid
(iv) Abomasum for mixing gastric juice, ruminates the chew cud. This is done by breaking small part of food present in rumen and sending it to buccal cavity for chewing. Omasum is absent in camel. Here rumen and reticulum have water pockets for temporary storage of food. Abomasum functions as true stomach.

3.5 Small intestine

- The small intestine is a narrow tube , about 6 metres long in a living adult. It is longest part of alimentary canal. It comprises of alimentary canal. It comprises of three parts: duodenum, jejunum and ileum

(i) Duodenum: It is a C-shaped structure and about 25 cm long. It receives the hepatopancreatic duct formed by union of bile duct (from liver) and pancreatic duct (from pancreas) and whose opening is guarded by sphincter of oddi. Small nodules of lymphoid tissue are seen along the entire length of small intestine. These nodules are call Payer's patches

(ii) Jejunum: It is slightly coiled moderately wide (3.5 – 4 cm) middle part of small intestine. Its wall is thicker and more vascular than that of illum. Jejunum is rich in digestive glands villi are rounded. Its length is about 0.8 – 1.5m

(iii) Ileum: the ileum forms the lower part of small intestine. It is about 3.5 m long, and opens into large intestine. It is characterized by club-shaped villi and Peyer's patches. Villi increases internal surface of ileum by about 10 times. Peye's patches contain higher concentration of white blood cells that helps protect the body from infection and disease

3.5.01 Functions

(i) The small intestine completes digestion of proteins, carbohydrate, nucleic acids and fats.

(ii) It absorbs nutrient materials into the blood and lymph and also lubrication of food.

(iii) It secretes certain hormones such as cholecystokinin, secretin, enterogastrone, duocrinin, enterocrinin and villikinin.

Most nutrient absorption occurs in the small intestine including minerals, vitamins, proteins, and fats. Iron, calcium, magnesium, and zinc are absorbed almost immediately after leaving the stomach – ie, in the 8 feet of the duodenum and the jejunum. Sugars and vitamin C, as well as thiamin, riboflavin, pyridoxine, and folic acid, are absorbed in the upper third of the small intestine. Protein is absorbed approximately midway through the ileum.

Water and lipids are absorbed by passive diffusion throughout the small intestine.

Sodium bicarbonate is absorbed by active ransport and glucose and amino acid co-transport.Vitamins A, D, E, and K, fats, and cholesterol are absorbed in the lower third of the ileum. Vitamin B_{12} is absorbed just before the small intestine joins the large intestine. Bile salts are reabsorbed in the distal ileum and the ascending colon.

3.6 Large intestine

- Its diameter varies from one region to another but it is always larger than that of small intestine. It is about 1.5 metres long and is divisible into there parts caecum, colon and rectum

(i) Caecum and vermiform appendix:

The caecum is a pouch – like structure which is about 6cm. the caecum is called ileocoecal junction guarded by ileocaecal valve which prevent back flow. The vermiform appendix is an outgrowth of the caecum. It is a slightly about 8 cm long. Its wall contains prominent lymphoid tissue. Appendix is thought to be vestigial. The inflammation of vermiform appendix due to decay of food or warm infection is called appendicitis and rupture of appendix leads to spilling of faecal matter onto the peritoneum leading to infection and inflammation known as peritonitis.

The caecum is well developed in herbivorous mammals like, horse, rabbit, etc.

(ii) Colon: The caecum leads into the colon, which is divided into four region, the ascending, transverse, descending and sigmoid colon. The sigmoid colon is S-shaped and enters the pelvis and joins the rectum. Ascending colon is shortest part of the colon

The right colic flexure marks the boundary between the ascending and transverse colon; the left flexure (splenic flexure) marks the boundary between the transverse and descending colon

(iii) Rectum: the sigmoid colon opens into the rectum. The rectum comprises the last 20cm of the digestive tract and terminates 2cm long anal canal. The mucosa of anal canal is folded into several vertical folds, called anal columns, supplied with arteries and veins

- The opening of anal canal is called anus. The anus has internal anal sphincter composed of smooth muscle fibres and external anal sphincter comprised of striped muscle fibres
- Structures formed due to enlargement of venis of anal columns in anal canal as well as anus are called haemorrhoids or piles

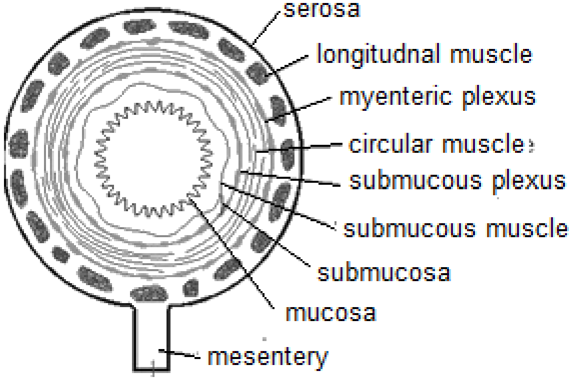
3.6.01 Functions

(i) The large intestine does not secrete enzymes. It plays a minor role in the absorption of nutrients. It stores unabsorbed food remnants temporarily, concentrates the contents by absorbing water to form faeces and the movement of the colon helps to avoid faecus through anus

(ii) It also play role in digestion and excretion

(iii) The colon bacteria (E. Coli) produce vitamins B and K which are absorbed

4.0 Histology of human gut



It is a hollow tube having a central cavity or lumen surrounded by a distensible wall, wall of gut is differentiated into four regions which starting from outside to inside are serosa, muscuaris, externa, submucosa and mucosa

(i) Serosa: It is fibrous outer coat or covering layer of gut. Serous consists of two parts, visceral peritoneum and a sheet of loose connective tissue called subserosa

(ii) Muscularis externa(muscular coat): It is quite thick in the region of stomach and proximal part of intestine muscularis externa has an outer layer of longitudinal smooth fibres followed by a thick layer of circular smooth muscles. Another layer of oblique muscle fibres occurs in stomach inner to circular muscle fibres. On contraction, circular muscular muscle fibres bring about narrowing of gut while longitudinal muscle fibres cause shortening of gut

(iii) Submucosa. It is a layer of connective tissues that lies below the muscularis externa. Submucosa contains nerves, blood vessels and lymph vessels. The tissue has a lot of collagen and elastin fibres for permitting changes in transverse and longitudinal dimensions

(iv) Mucosa: It is the innermost which is thrown into circular folds or plical circulars (valves of kerking or valvulae conniventes) in the region of intestine. Longitudinal folds or rugal occur in case of empty stomach. Circular folds slow down the movement of food through the intestine. The intestinal wall also bears millions of microscopic figure like projections called villi. Mucosa is differentiated into three layer, namely epithelium, lamina propria and muscularis mucosae

(a) Epithelium

These are columnar cell and possess upto 3000 microvilli on their free surface.

Goblet or mucous cells are columnar shaped glandular cells which secrete mucus. Mucus functions as lubricant. It protects the wall of gut from action of proteolytic enzymes. Mucus further provides protection to the epithelium against abrasion or excoriation

Epithelium bears a number of pits. The pits bears deep tubular glands in stomach and upper duodenum. They are called crypts of Lieberkuhn in the region of intestine

(b) Lamina propria

It is a layer of aerolar reticular connective tissue which contains some scattered smooth muscles cells, blood, capillaries, lymph vessels and non-medullated nerve fibres. It posses Peyer's patches

(c) Mucularis mucosae: It forms the outer boundary of mucosa that possesses smooth longitudinal muscle fibres externally and smooth circular muscle fibres internally.

5.0 Digestive glands

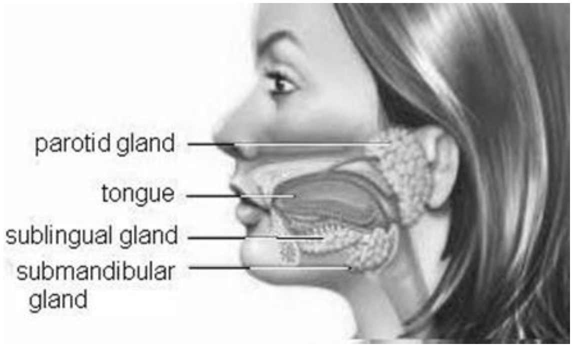
5.1 Salivary glands:

There are three pairs of salivary glands : parotid, sublingual and submaxillary or submandibular.

(i) Parotid glands: These are the largest salivary glands. They lie on the sides of the face, just below and in front of ears. Viral infection of parotid glands causing swelling and pain, is the disease called mumps.

(ii) Sublingual glands: These lie under the front part of the tongue

(iii) Submaxillary glands: These lie at the angles of the lower jaw. The submaxillary ducts, also known as wharton's ducts open under the tongue



5.1.01 Saliva

- The salivary gland secrete a viscous fluid called saliva. It contains water, salts, an enzyme salivary amylase or ptyalin
- Its pH is neutral, being 6.7
- About 1.0 – 1.5 litres of saliva is produced daily
- The salivary gland secretion is very rich in salivary amylase. The secretion from sublingual and submaxillary glands are rich in mucin. Saliva contains two important enzyme, amylase and lysozyme.
- Amylase is a starching digesting enzyme, breaking starch into maltose and triose. Lysozyme causes lysis of several common bacteria that may be present in mouth. Mucin in saliva helps to lubricate the food for swallowing

  Function

  (i) It moistens and lubricates the buccal cavity, tongue and lips, thus making speech possible.

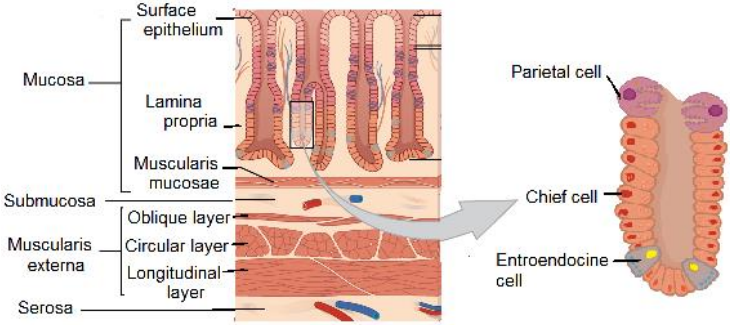
  (ii) It also moistens food and changes it to semi-solid mass for easy swallowing

  (iii) Saliva washes mouth and tongue clear of food debris

(iv) Its enzyme help in digestion

5.2 Gastric glands

- Fundic glands (oxyntic glands): They secrete HCl, pepsinogen and soluble mucin
- Pyloric glands: Secretion is rich in mucin and does not contain HCl
- Cardiac glands : Secrete mucin and very little pepsinogen
- Types of cells present in the epithelium of gastric glands are –
  (i) Peptic cells are usually basal in location and secrete gastric digestive enzymes as proenzymes, pepsinogen and prorenin. The chief cells (zymogenic or peptic cell) also produce small amount of gastric amylase and gastric lipase, pepsinogen and chymosin
  (ii) Oxyntic cells are large and are most numerous on the side walls of the gastric glands. They secrete hydrochloric acid (HCl) and castle's intrinsic factor
  (iii) Mucous cells are present between other and types of cells and secrete mucus. It protects stomach wall against HCl action and produce protein digestive enzyme
  (iv) Endocrine glands are usually present in the basal parts of the gastric glands. They secrete serotonin, somatostatin and histamine, gastrin
- Serotonin is a vasoconstrictor and stimulates the smooth muscles
- Somatostatin suppresses the release of hormones from the digestive tract
- Histamine dilates the walls of blood vessels
- Gastrin stimulate the gastric glands to release gastric juice



5.2.01 Gastric juice

The secretion of the cells of gastric glands from gastric juice with pH 2 – 3.7. About 2,000 to 3,000 ml of gastric juice is secreted per day

5.3 Liver

- It is the largest internal gland of the body which is reddish brown in colour.
- The liver lies in upper right side of the abdominal cavity just below the diaphragm.
- It is heavier in males than females. In males it is generally 1.4 -1.8 kg and in females 1.2 – 1.4kg
- It has both endocrine and exocrine parts
- Liver is differentiable into small left lobe and large right lobe. The right lobe is further made of right lobe proper, quadrate lobe and caudate lobe. A pyriform yellow green muscular sac or gall bladder lie on inferior surface of right lobe. It is 8cm long and 2cm wide

- The two lobes of liver produce right and left hepatic ducts. They join to form common hepatic duct. A cystic duct comes from gall bladder. The two join to form bile duct that attaches with pancreatic duct before opening in duodenum.
- The opening of bile duct into pancreatic duct is controlled by sphincter of Boyden
- Amount of bile produced per day is 600 ml. Bile from gall bladder is 5-10 times more concentrated. Its pH is 7.6 compared to 8.6pH of hepatic bile
- Bile is yellowish green alkaline solution with 89-98% water, no digestive enzymes but four types of chemicals and some nondigestive enzymes

(a) Inorganic salts: Bicarbonates, chlorides, carbonates and phosphates of sodium, potassium and calcium

(b) Bile salts: Sodium taurocholate and sodium glycocholate,. They are partly water soluble and partly fat soluble

(c) Fatty substances: Cholesterol, lecithin and other phospholipids

(d) Bile pigments: Bilirubin (yellowish) and biliverdin (greenish). Other minor bile pigment are bilicyanin, bilipresin, bilifusun, bilihumin and bilifulvin

5.3.01 Functions of liver

(i) Secretion of bile

(ii) Deamination – It is a process by which the amino group ($-NH_2$) is removed from amino acids resulting the production of ammonia which is converted into urea

(iii) Excretion

- Liver synthesis urea with the help of ammonia and carbon doxide urea is passed out through excretory system

- The bile contains bile pigments (bilirubin and biliverdin) are excretory products
- The liver cells also eliminate certain other waste products like cholesterol, metal ions and waste products of haemoglobin

(iv) Glycogenesis : It is the conversion of the excess of glucose into glycogen by liver cells with the help of insulin secreted by pancreas

(v) Glycogenolysis: It is the conversion of glycogen into glucose by the liver cells with the help of glucagon secreted by pancreas

(vi) Lipogenesis: It is the conversion of glucose and amino acids into fats which takes place in liver

(vii) Gluconeogenesis: It is the formation of glucose or glycogen from non-carbohydrate sources like amino acids, fatty acids etc.

(viii) Detoxification: Liver converts toxic substances into harmless substances

(ix) Haemopoiesis: The process of formation of blood corpuscles is called haemopoiesis. The liver produces red blood corpuscles in the embryo

(x) Synthesis of blood protein: The liver produces blood protein such as prothrombin and fibrinogen that help in the clotting of blood

(xi) Secretion of heparin- Liver secretes heparin (anticoagulant)

(xii) Lymph formation: Liver is important for lymph formation

(xiii) Synthesis of vitamin-A from B-carotene

(xiv) Destruction of R.B.C. : The old worn out red blood corpuscles are broken down in the liver cells. Their haemoglobin is changed into bile pigments

(xv) Phagocytosis: the Kupffer's cells of the liver engulf the disease causing microorganisms, dead cells and foreign matter

(xvi) Osmoregulation: Liver produces angiotensinogen which helps kidneys in maintaining body fluid osmoregulation through the action of renin on angiotensin.

5.4 Pancreas

The pancreas is soft, lobulated grayish – pink gland which weighs about 60 grams. It is about 2.5cm wide and 12-15 cm long, located posterior to the stomach in the abdominal cavity

5.4.01 External structure of pancreas

- The main pancreatic duct (duct of Wirsung) is formed from smaller ducts within the pancreas. The main pancreatic duct opens into hepatopancreatic ampulla.
- An accessory pancreatic duct (duct of Santorini) is also present in pancreas and open directly into the duodenum

5.4.02 Internal Structure of Pancreas

(i) Exocrine part: the exocrine part of the pancreas consists of rounded lobules (acini) that secretes with pH 8.4. About 500-800 ml of pancreatic juice is secreted out per day. The pancreatic juice is carried by the main pancreatic duct into the abdomen through hepatopancreatic ampulla.

The pancreatic juice contains sodium bicarbonate, three proenzymes; trypsinogen, chynao-trypsinogen, chymotrypsinogen anad procarboxy peptidase and some enzymes such as pancreatic amylase DNAase, RNAase pancreatic lipase. The pancreatic juice helps in the digestion of starch, protein, nucleic acids and fats, therefore pancreatic juice is also called complete digestive juice

(ii) Endocrine part: the endocrine part of pancreas consists of groups of islets of Langerhans

Each islet is separated from the surrounding alveoli by a thin layer of reticular tissue. The islets are richly supplied with blood through a dense capillary plexus. The following three types of cells occur in pancreatic islets.

a) The alpha cells (α) – Secreting hormone glucagon
b) The beta cells (β) – Secreting hormone insulin
c) The delta cells (δ) – Producing hormone gastrin

In the islets of pancreas the alpha cells are arranged towards the periphery of the islets, the beta cells near the centre and the delta cells are placed peripherally

5.5 Intestinal glands

- The intestinal glands are numerous and microscopic. These are 2 types; crypts of Lieberkuhn and Brunner's gland

(i) The crypts of lieberkuhn are simple tubular glands and occur throughout the small intestine between the villi. They have two types of cells

(a) Paneth cells are found particularly in the duodenum. These cells are rich in zinc and contain acidophilic granules. They secrete lysozyme (antibacterial substance)

(b) Argentaffin cells is located among epithelial cells and is common in duodenum. It secretes serotonin. Serotonin is a powerful stimulant of smooth muscle, resulting in contraction and play a role in stimulating peristaltic activity of the intestine

(ii) The Brunner's gland are branched tubular glands and are confined to the duodenum. They secrete alkaline watery fluid, little enzyme and mucus. The mixture of secretions is called intestinal juice or success entericus

About 2 to 3 litres of succus entericus is secreted every day.

It is alkalin (ph = 8.3) and contains many enzyme amino peptideases, dipeptidases, intestinal amylases, maltase, isomaltase, nucleo-sidases

6.0 Process of digestion

- Digestion is the breakdown of large complex insoluble organic food molecules into small, simpler soluble and diffusible particles by the action of digestive enzymes

6.1 Digestion in mouth

- The tongue helps in tasting the food, mixes it well along with saliva. The saliva is continuously released and secreted into the buccal cavity by salivary glands under the influence of autonomic nervous system
- Mucus in saliva helps in lubricating and adhering the masticated food particles into a bolus. The bolus is then conveyed into pharynx and then into oesophagus by swallowing or deglutition.
- Saliva contains about 99% water along with K^+ and HCO_3. It contains a carbohydrate splitting enzyme called salivary amylase. About 30% of starch is hydrolysed into a disaccharide – maltose

$$\text{starch} \xrightarrow[\text{(pH =6.8)}]{\text{salivary amylase}} \text{maltose}$$

6.2 Digestion by Stomach

- The bolus of food remains in the stomach for 3-4 hours and gradually converted into semifluid mixture called chyme
- The proenzyme pepsinogen, on exposure to hydrochloric acid gets converted into active enzyme pepsin. Pepsin converts proteins into protesoses and peptones (peptides).
- The mucus and bicarbonates play important role in lubrication and protection of mucosal epithelium
- Renin is proteeolytic enzyme found in gastric juice of infants which helps in the digestion of milk proteins

6.3 Digestion by intestine

- Trypsinogen is activated by an enzyme, enterokinase, secreted by intestinal mucosa into active trypsin, which in turn activates the other enzymes. Proteins, proteases and peptones in chyme reaching the intestine are converted into dipeptides

$$\left.\begin{array}{l}\text{proteins}\\ \text{peptones}\\ \text{proteoses}\end{array}\right] \xrightarrow[\text{carboxypeptidase}]{\text{– trypsin}} \text{dipeptides}$$

- Bile helps in emulsification of fats i.e. breaking down of fats into very small micelles. Bile also activates lipases. Fats are broken down by lipases with the help of bile into di- and monoglycerides.

$$\text{Fats} \xrightarrow{\text{lipases}} \text{diglycerides} \longrightarrow \text{monoglycerides}$$

- Carbohydrates in the chime are hydrolysed by pancreatic amylase into disaccharides

$$\text{polysaccharides (starch)} \xrightarrow{\text{amylase}} \text{disaccharides}$$

- Nucleases in the pancreatic juice acts on nucleic acids to form nucleotides and nucleosides

$$\text{nucleic acid} \xrightarrow{\text{nucleases}} \text{nucleotides} \longrightarrow \text{nucleosides}$$

- The enzymes in the succus entericus acts on the end products to form respective simple absorbable forms

$$\text{dipeptides} \xrightarrow{\text{dipeptidases}} \text{amino acids}$$

$$\text{maltose} \xrightarrow{\text{maltase}} \text{glucose + glucose}$$

$$\text{lactose} \xrightarrow{\text{lactase}} \text{glucose + galactose}$$

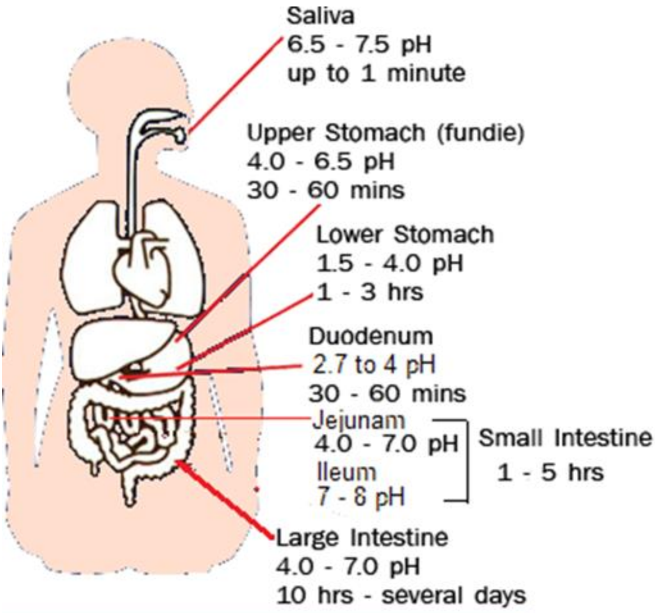
$$\text{sucrose} \xrightarrow{\text{sucrase}} \text{glucose + fructose}$$

$$\text{nucleotides} \xrightarrow{\text{nucleotidases}} \text{nucleosides} \longrightarrow \text{sugars + base}$$

$$\text{di- and monoglycerides} \xrightarrow{\text{lipases}} \text{fatty acids + glycerol}$$

7.0 Neural control of digestion

- The gastro intestinal tract innervated, by intrinsic nerves as well as extrinsic nerves
- The intrinsic nerves controls gastrointestinal functions like secretion
- The extrinsic nerves which can modify the activity of intrinsic neural system
- The sight, smell and presence of food in the gastrointestinal tract act as a stimuli for secretion of saliva. This happens by stimulation of vagus nerve



This diagram illustrates the average time food spends in each part of the digestive system along with the average pH.

7.1 Digestive hormones in gastrointestinal tract-Summary

1) Hormone Gastrin

Produced by Gastric antrum, duodenum (Gcells)

It stimulatesecretion of gastricacid and intrinsic factor from parietal cells, stimulate secretion of pepsinogen from chief cells also promotesgastric and intestinal motility , mucosal growth

2. Cholecystokinin (CCK)

Produced by Duodenum, jejunum (I cells)

It stimulates gall bladder contraction, stimulates release of pancreatetic enzyme, relaxes sphincter of Oddi for release of bile and enzymes, role is inducing satiety

3. Secretin

Produced by Duodenum, jejunum (S cells)

It stimulates secretion of HCO3 frompancrease, inhibits gastrin and gastric acid secretion

4. Vasoactive intestinal peptide (VIP)

Produced by Enteric nerves

It increases water and electrolyte secretion from pancreas and gut, relaxes smooth muscles (via nitric oxide)of gut

5.Gastric inhibitory polypeptide (GIP)

Produced by Duodenum, jejunum (K cells),

Reduces gastric acid secretion and intestinal motility, stimulates insulin release

6. Somatostatin

Produced by Stomach, small intestine and pancreas (D cells)

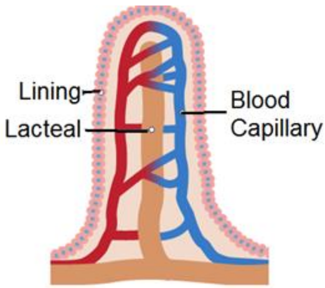
It inhibits secretion and action of many hormones, including all of the above

8.0 Absorption of digested food

- Only some drugs are absorbed in mucosal lining of sublingual area
- Water, alcohol, some drugs and sugar are absorbed in stomach
- In large intestine absorption of Na^+, Cl^- and vitamins (vit K, B_{12}, thiamine, riboflavin) produced by intestinal bacteria is undertaken. Solidification of indigestible matter also occurs here due to withdrawal of water
- Simple diffusion helps in passage of alcohol, fatty acids, monoglycerides, cholesterol and fat soluble substances.

Osmosis is involved in passage of water from lumen to epithelial lining

- Fructose and few amino acids are absorbed through facilitated diffusion Na^+ is main ion absorbed actively. Others involved in active transport are Ca^{2+}, Fe^{2+}, K^+, Mg^{2+}
- Co-transport occurs in case of glucose and most amino acids. Most of the absorbed materials are passed into para cellular spaces
- Most monoglycerides and fatty acids are converted into triglycerides which along with cholesterol, phospholipids and some protein forms chylomicrons inside Golgi apparatus. Chylomicrons are passed into lymph vessels or central lacteals.



9.0 Nutritional requirement

9.1 Carbohydrates, proteins and fat

1. Carbohydrates
   - The sources of carbohydrates in our diet are cereals (rice, wheat, maize), potato, grams, fruits (banana, mango, melon), sugar, honey, sugarcane, beet, jam and milk
   - An adult man of average weight and doing moderate work needs about 350-500gms of carbohydrates daily

2. Proteins
   - The sources of proteins in our diet are cereals, pulses, oil, seeds and nuts, fish, egg, milk, soyabean, cheese, leafy vegetable.
   - About 70 – 100 gms of protein are needed daily
3. Fats
   - The sources of fats in our diet are vegetable cooking oil, ghee, butter, chese, eggs.
   - About 50gms of fat is needed daily

9.2 Minerals

1. Sodium
   - The sources are table salt, beef, spinach
   - It maintains electric potential across the membrane. It maintains pH balance of our body
   - Deficiency of sodium causes cramps, diarrhea and dehydration, low blood pressure
2. Potassium
   - The sources are banana, orange, milk, spinach
   - It helps to retain water in cells. Maintains osmotic pressure
   - Deficiency causes muscle disorder low BP
3. Chlorine
   - The sources are table salt, cabbage, cheese
   - It helps in regulation of osmotic pressure. It helps in formation of HCl in stomach
   - Deficiency of loss of appetite, causes cramps
4. Calcium
   - The sources are milk, green leafy vegetables, cheese, cereals

- Helps in clotting of blood. It helps in building of bones and teeth
- Deficiency causes rickets, muscle spasms, retarded body growth

5. Phosphorous
   - The sources are cereal grains, milk, meat, peas, cheese
   - It required for tooth and bone formation. It helps regulation of heart beat
   - Deficiency causes metabolic disorders
6. Iron
   - Sources: Oatmeal, honey, dates, eggs, spinach, pulses
   - Importance : Formation of haemoglobin
   - Deficiency causes: Weakness and weak immunity
7. Iodine:
   - Sources: Onion, table salt
   - Causes goiter (Deficiency)
8. Sulphur
   - Sources : Meats, daily products
   - Importance: It helps to keep hair skin and nails healthy
   - Deficiency causes unhealthy growth of skin and hair
9. Magnesium
   - Sources: Dairy products, green leafy vegetable, chocolate
   - It helps in muscle relaxation
   - Deficiency causes hallucinations, irregularities of metabolism
10. Copper
    - Sources: Peanuts, beet, barley, soyabean, onion
    - It helps in development of blood vessels and connective tissue
    - Deficiency causes anemia

11. Chromium
    - Sources : Black gram, soyabean, carrot
    - It promotes insulin action in the metabolism of sugar
    - Deficiency of nitrogenous waste products
12. Fluorine
    - Sources: tea, city water supply
    - It maintains normal enamel and check dental caries
    - Deficiency causes weak teeth which are prone to decay
13. Zinc
    - Sources: Barley, soyabean, groundnut, egg, almond
    - It hastens healing of wounds. It is needed for healthy skin and hair
    - Deficiency causes retarded growth rough skin and weak immunity
14. Cobalt
    - Sources: Milk
    - Deficiency causes anemia
15. Manganese
    - Sources: Nuts, legumes
    - It is important for reproduction and synthesis of haemoglobin
    - Deficiency causes infertility, menstrual problems
16. Molybdenum
    - Sources: Onion, potato, bajra
    - It is important for synthesis of haemoglobin and absorption of iron
    - Deficiency causes irregular excretion of nitrogenous waste products
17. Selenium
    - Sources: Barley, garlic, orange juice

- It acts with vitamin E for slowing down ageing process
- Deficiency causes higher risk of cancer, cardiovascular disease

9.3 Fat soluble vitamins

(1) Vitamin – A

- Sources: Milk, butter, maize, carrot, papaya, spinach
- Deficiency causes night blindness drying of eyeball etc

(2) Vitamin – D

- Sources: Sunlight, cod liver oil, eggs
- Deficiency causes rickets
- Increases intestinal absorption of calcium and phosphorous

(3) Vitamin – E

- Sources : green vegetables, vegetable oil
- Deficiency causes reproduction failure, slow growth, anemia

(4) Vitamin – K

- Sources: Leafy vegetables
- Deficiency causes profuse and prolonged delay in blood clotting

9.4 Water soluble vitamins

(1) Vitamin B_1

- Sources : yeast, sprouted beans, nuts, pulses, cereal
- Deficiency causes beriberi, loss of appetite, accumulation of keto acids in blood

(2) Vitamin B_2

- Sources: yogurt, milk, green vegetables
- Deficiency causes skin disorder, headache, cheilosis (sores at corner of mouth)

(3) VitaminB_3

- sources: pulses, liver, fish

- Deficiency causes pellagra, gum diseases, skin problems

(4) Vitamin B_5

- Sources: eggs, milk, ground nut and tomatoes
- Deficiency causes fatigue, muscle cramp, poor motor coordination

(5) Vitamin B_6

- Sources: All plant and animal tissues
- Deficiency cause anemia, diarrhea, nausea and vomiting

(6) Vitamin B_{12}

- Sources: Meat, fish, egg, milk
- Deficiency causes nervous disorder

(7) Vitamin C

- Sources: All citrus fruit
- Deficiency causes scurvy, bleeding from small vessels

10.0 Disorders of digestive system

1. Jaundice: The liver is affected , skin and eyes turn yellow due to deposit of bile pigment
2. Vomiting: It is the ejection of stomach contents through the mouth. This reflex action is controlled by vomit centre in the medulla
3. Diarrhoea: the abnormal frequency of bowel movement and increased liquidity of faecal discharge is known as diarrhea
4. Constipation: in constipation, the faeces are retained within the rectum
5. Indigestion: in this condition, the food is not properly digested leading to a feeling of fullness

11.0 Distinguish

10.1 Digestion Vs Absorption

	Digestion	Absorption
1	Digestion is a mechanical and chemical break down of large food contents in to smaller particles that are easy to be absorbed	Absorption is transferring the digested molecules across the gastrointestinal tract to the blood stream.
2	Digestion starts from the mouth.	Absorption starts from the stomach.
3.	Digestion needs enzymes	absorption does not need enzymes.
4.	Most of the digestion takes place at duodenum	absorption occurs mainly at ileum and jejunum
5.	digestion functions upon large and complex digestive matter only.	Absorption operates on both simple molecules of digestive and non-digestive matter
6	Digestion is always an active process and needs energy	some of the absorption mechanisms do not need energy

10.2 Glycogenesis Vs Glycogenolysis

	Glycogenesis	Glycogenolysis
1	Produce glycogen from glucose	Breakdown of glycogen back to glucose

2	Can occur in all cells, but is an especially important function of liver and muscle cell	Occurs in liver, kidney and intestine but not in muscle tissue because an essential enzyme is lacing

10.3 Intracellular Digestion Vs Extracellular Digestion

	Intracellular Digestion	Extracellular Digestion
1	break down of materials into small components takes place inside the cell.	break down of materials into smaller components takes place outside the cell.
2	Intracellular digestion occurs inside food vacuoles within the cell.	Extracellular digestion occurs outside the cell in the lumen of the alimentary canal or on the decaying organic materials.
3	Ingestion occurs through a phagocytic vesicle in intracellular digestion.	Ingestion occurs through the mouth in extracellular digestion.
4	The digestive enzymes in the lysosomes are secreted into the food vacuole in intracellular digestion	The glands of the alimentary canal secrete digestive enzymes into the lumen in extracellular digestion. Fungi secrete digestive enzymes on the decaying organic materials.
5	Only the chemical digestion	mechanical digestion and

	of food occurs during intracellular digestion.	chemical digestion occur in extracellular digestion in animals
6	The nutrients diffuse into the cytoplasm through the membrane of the vacuole	The nutrients are absorbed into the blood through the gut epithelia in extracellular digestion in animals. In fungi, nutrients are absorbed through the cell wall.
7	The indigestible materials are excreted through exocytosis in intracellular digestion.	The indigestible materials are excreted through the anus in extracellular digestion

10.4 Gluconeogenesis Vs Glycogenolysis

	Gluconeogenesis	Glycogenolysis
1	It results in the formation of glucose molecules from non-carbohydrate sources.	It results in the formation of glucose by breaking down glycogen molecules stored in the liver.
	Amino acids, lactic acids are converted into glucose.	Glycogen is broken down to form Glucose- 6-phosphate
	It is anabolic process.	It is hydrolytic process.
	6 molecules of ATP are consumed per 1 glucose molecule synthesised.	Less amount of ATP is consumed.

11.0 Enzyme summary

Mouth

Enzymes & Function

Salivary Amylase - break down starches convert to maltose sugar- pH neutral

Lingual lipase - starts the digestion of the lipids/fats.

Stomach

Enzymes & Function:

Pepsin- Breaks protein into small peptides

Gastric amylase- Degradation of starch

Gelatinase- Degradation of gelatin and collagen

Rennin- Conversion of liquid milk to solid particles

Gastric lipase- Degradation of butter fat

Pancreas

Enzymes & Function:

Pancreatic lipase- Degrades triglycerides into fatty acids and glycerol

Phospholipase- Hydrolyzes phospholipids into fatty acids

Trypsin- Converts proteins to basic amino acids

Steapsin- Breakdown of triglycerides to glycerol and fatty acids

Chymotrypsin- Converts proteins to aromatic amino acids

Carboxypeptidase- Degradation of proteins to amino acids

Pancreatic amylase- Degradation of carbohydrates to simple sugars

Elastases- Degrade the protein elastin

Nucleases- Conversion of nucleic acids to nucleotides and nucleosides

Small Intestine

Enzymes & Function:

Sucrase- Converts sucrose to disaccharides and monosaccharides

Maltase- Converts maltose to glucose

Lactase- Converts lactose to glucose and galactose

Isomaltase- Converts maltose to isomaltoses

That’s all folks!

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All should/must be happy, be healthy, see good; may no one have a share in sorrow.

"gneet.com" is very thankful to Nishigandha for compiling contents of notes,

Environmental Issues

Notes

For

NEET and AIIMS

Examinations

"Environmental problems are really social problems anyway. They begin with people as the cause and end with people as the victims"

Edmund Hillary

INDEX

1.0 Pollution

Pollution is any change in physical, chemical or biological characteristics of the environment that has the potentiality to harm human life, other species, natural resources

Contamination is the presence of harmful organisms or their toxins that cause discomfort or disease

1.01 Causes of pollution

i) The major cause of pollution is

- Automobile exhaust
- Increasing use of pesticides, insecticides, and herbicides
- Waste chemical production from factories
- The rise in atmospheric CO_2
- Radioactive substances

ii) Natural pollution is pollution caused by natural sources. Example: Volcanic eruption, the release of methane by paddy fields and cattle, the release of carbon monoxide of plants and animals, emission of natural gas, ozone, nitrogen oxide, soil erosion, dust storms, ultra-violet rays etc. 99.95% of pollution is natural

iii) Man-made or anthropogenic pollution is pollution resulting from human activities like the burning of fossil fuels, deforestation, mining, sewage, industrial effluents, pesticides, fertilizers etc. Amount of man-made pollution is hardly 0.05% of total but more dangerous than natural pollution

iv) On the basis of emission, pollution may be :

- Point source pollution: It is from a single point. Example municipal sewage and chimney

- Line source pollution: It is passed along a narrow belt.
Example Road due to automobile exhaust.
- Area source pollution: It is over a large area. Example.
Sprayed fertilizers or pesticides through runoff

1.02 Classification of pollutants

On the basis of their existence in nature pollutants are of two types:

- Quantitative pollutants: These normally occurs in nature but are also added in large quantities by man. Examples: CO, CO_2 and nitrogen oxide
- Qualitative pollutants: They do not occur in an environment normally but are added by man. Example: D.D.T, insecticides

On the basis of form, pollutants are of two types

i) Primary pollutants: These persist in the form in which they are added to the environment. Example DDT, plastics, CO

ii) Secondary pollutants: These are formed by reacting amongst the primary pollutants. Example nitrogen oxide and hydrocarbons react in presence of sunlight to form two secondary pollutants such as PAN (peroxy acyl nitrate). Secondary pollutants are more toxic than the primary pollutants. The phenomenon of increase in toxicity by reaction among the pollutants is called synergism

On the basis of their nature of disposal the pollutants are of two types:

i) Non-degradablepollutants: Pollutants which cannot be broken down by a micro-organism. Example: DDT, phenolic compounds, ABS, hydrocarbons

ii) Biodegradable pollutants: Pollutants which can be broken down by a micro-organism. Example Sewage

1.03 effect of pollution

Pollution has an adverse effect like:

i) Crop production change

ii) Causes different diseases

iii) Soiling of building and textiles

iv) Loss of resources

v) Metal corrosion

vi) Money, funds, manpower involved in pollution control

2.0 Air pollution

According to WHO (World Health Organization), air pollution may be defined as " the presence of materials in the air in such concentration which is harmful to man and his environment"

- Major sources of atmospheric pollution are

  i) Combustion of fissile fuels in homes, factories, thermal plants, automobiles, railways, etc

  ii) Mining and processing

  iii) Chemical industries

  iv) Cosmetic industries

  v) Welding, stone crushing.

  vi) Construction and demolition

- 52% of air pollution is caused by CO, 18% by SO_2, 12% by hydrocarbon, 10% by particulates, 6% by nitrogen oxides, 2% by remaining.

2.1 air pollutants and their effects

- Carbon dioxide (CO_2) – A major pollutant in the atmosphere comes from burning of fossil fuels.
- Carbon monoxide (CO) – It is produced due to incomplete combustion, metallurgical operations and naturally by plants and

animal. Normally CO has a brief residence in the atmosphere and gets oxidized to CO_2. CO combines with haemoglobin, produces carboxyhaemoglobin which impairs oxygen transport resulting in headaches, decreased vision, cardiovascular disease, asphyxia.

• Particulate matter (PM) – It consists of soot, flyash, the dust of various types, fur, hair, spores, pollen grain etc. Particulate matter is differentiated into settleable (larger than 10 μm,) remaining in the air for less than one day, and suspended (lesser than 10 μm) remains in the air for more than one day to several weeks. SPM (suspended particulate matter) is maximum in Kolkata. SPM is differentiated in aerosol (less than1 μm), dust (more than 1 μm) and mist (liquid, more than 1 μm)

According to Central Pollution Control Board, particles most harmful to human health are of 2.5 μm diameter. Dust and smoke produce smog. Smoke is similar to dust but consists of a visible suspension of carbon and another particle suspension of carbon and other particles given off by burning or smouldering organic matter. PM causes respiratory disease, tuberculosis, byssinois (due to cotton dust), allergy.

• Nitrogen oxide (NO_X) – They are produced naturally through biological and non-biological activities from nitrates, nitrites etc. They cause fading and deterioration of textiles, produce lesions, necrosis, defoliation. They also cause eye irritation, respiratory troubles, lung edema, blood congestion, dilation of arteries and cancer.

• Sulfur dioxide (SO_2) – It is produced during combustion of fossil fuels, refining of petroleum and melting of sulfur-containing ores. Sulfur dioxide produces smog. Maximum SO_2 pollution is formed in Kolkata. It causes membrane damage, destruction of chlorophylls.

Lichens are most sensitive to SO_2 pollution. SO_2 corrodes metal, impairs sensitive equipment, damages building, marble, paper, and textiles. It produces eye irritation, damages respiratory tract, produces asthma, bronchitis. SO_2 produces acid rain which destroys vegetation and degrades articles.

• Fluorides – They are produced during the refining of minerals. Fluorides cause fluorosis. It causes chlorosis, necrosis of leaf tips and margins. It causes abnormal calcification of bones and teeth, frequent diarrhea, neuromuscular disorders.

• Hydrocarbons – These are produced naturally as well as due to incomplete combustion. Hydrocarbons are carcinogenic, cause irritation of eyes and mucous membrane. There is increased mucus secretion and tearing of alveoli. Methane is naturally occurring hydrocarbon produced due to decomposition of organic matter, paddy fields and incomplete combustion in automobiles, industries.

• Chlorofluorocarbon / Freons (CFC) – This chemicalare used in the refrigerator, propellants CFC reacts with ozone and depleted it.

• Other atmospheric pollutants – Mercury (burning of coal, smelting), methyl isocyanate (pesticide manufacturer), phosgene (pesticide manufacture, dye industries) and lead (automobile exhausts) are pollutants added to the atmosphere. Bhopal gas tragedy was due to the releaseof phosgene and methyl isocyanate.

• Smog (Des Voeux, 1905) – Smog is opaque dark fog having condensed water vapors, dust, smoke and gases.

Smog is of two types

i) contains sulfur gases, smoke and dust particles. Classical smog has the reducing environment. It is dark brown and opaque. The smog is formed by condensation of water vapour with H_2S and SO_2 over dust and smoke particles. Classical smog occurred in

London during December 1952 when it affected 50% population and killed over 4000 persons.

ii) Photochemical (Los Angeles) smog – It was first reported over Los Angeles in 1940's. Photochemical smog is produced at high temperature over cities and town due to still air, emission of nitrogen oxides. Nitrogen dioxide splits into nitric oxide and nascent oxygen. Nascent oxygen combines with oxygen to form ozone. Ozone reacts with a hydrocarbon to form aldehydes and ketone. Nitrogen oxides, oxygen, ketones combine to form peroxyacyl nitrates (PAN)

• Peroxyacyl nitrate(PAN) – It is produced due to the reaction between NO_X and hydrocarbons under the effect of UV – radiation of sunlight. It causes eye irritation, respiratory tract disease in human. Several enzymes are deactivated by PAN

2.2 Prevention and control of air pollution

2.2.01 Source Correction

This is the easiest solution to air pollution, where we control the emissions by changing the quality process. Example : Elimination of lead in gasoline to minimize the level of lead in the air

2.2.02 Treatment

According to size, range, and types of air pollutant, suitable devices are effective. These are

• Settling chamber: To remove large particulates

• Cyclone separators: The dirt air is blasted into a conical cylinder. This creates a violent swirl within the cone, the heavy materials migrate to wall and exits from the bottom of the cone. The clean air exits out from the top.

• Bag filters: Fabric bags are used to collect dust like a commonvacuum cleaner

• Wet collector: It promotes contact between air and water. Water is introduced through a narrow throat section.
• Electrostatic precipitators: In power plants charged particulate matters are separated and collected through the pipe.
• Gas scrubbers: It is used for dissolving gases
• Absorption: Activated carbon is used to capture pollutants
• Incineration: For removing gaseous pollutants CO_2, H_2O and inerts are used.
• Catalytic combustion: Use of catalyst to remove pollutants.
• Dispersion: It is a process of spreading out emission over a large area and thus reducing the concentration of the specific pollutants
• Vegetation – A broad strip of vegetation along the road and around industrial area reduces particulate pollution

2.2.03 Control of vehicular air pollution

The Supreme court directed the government to take appropriate measures for reducing pollution caused by automobiles through:

i) Switch over of public transport from petrol/diesel to CNG
ii) Phasing out of old vehicles
iii) Compulsory use of unleaded petrol and reduced sulfur content of diesel
iv) Compulsory regular check-up of pollution emission of vehicles
v) Fitting the vehicle with catalytic converters

2.3 Acid rain

• The term was coined by Robert August
• Acid rain is rainfall and other forms of precipitation with pH less than5. pH of normal rain is 5.6 – 6.5.
• Acid form atmosphere is deposited over the earth in two forms

i) Wet deposition occurs through rain, snow, and fog

ii) Dry deposition is settling down of windblown acidic gasesand particles over trees, articles, and soil. About 50% of acidity is passed to earth as dry deposition

- Acid rain is caused by the large-scale emission of acidic gases into the atmosphere from thermal power plants, industries, and automobiles. The common ones are sulfur dioxide, nitrogen oxide (NO_X), volatile organic carbon. NO_X is also produced in the atmosphereby lightning. Sulfur dioxide and nitrogen oxides are changed in the atmosphere into sulphuric acid and nitric acid by combining with oxygen and water.

$$2SO_2 + O_2 \rightarrow 2SO_3 \ ; \quad SO_3 + H_2O \rightarrow H_2SO_4$$

$$2NO + [\ O\ ] \rightarrow N_2O_5 \ ; \ N_2O_5 + H_2O \rightarrow 2HNO_3$$

- Acid rain damages plants by a direct effect on foliage and growing plants – chlorosis, necrosis, defoliation. It causes leaching of essential mineral soil. Due to acid rain, many lakes in Germany and other European countries have a pH of less than 5, an acidity level considered lethal for many aquatic species. Acidity dissolves toxic metals like Hg, Pb, Zn, Al. Both acidity and toxic metals kill all type of aquatic life except some algae and fungi. Acid rain corrodes metals, marble, painted surface, slates, stone etc. The phenomenon is called stone leprosy.

3. Water pollution

- The water pollution may be defined as the presence of foreign organic, biological, radiological or physical substance in water that tends to lower its quality and either constitutes a health hazard or decrease the utility of water.
- The various categories of water pollution are:

  i) Biological pollutants: Pathogens such as viruses, bacteria, protozoans, algae.

ii) Chemical pollutants: Organic chemicals like biocides, polychlorinated biphenyls, inorganic chemicals like cadmium, mercury, lead.

iii) Physical pollutants: Hot water from industries, oil spills from oil carriers etc. These pollutants are generated by different sources and activities:

3.1 sources of water pollution

Domestic sewage

- Liquid waste from domestic activities such as kitchen, toilet and households, wastewater.
- Domestic effluents carry organic wastes which are biodegradable.

Industrial wastewater

- The major sources of water pollution come from wastes from industries such as paper mills, leather tanneries, textile and jute mills, chemical and petroleum industries.
- Most of the coastal water is threatened by pollution from the effluents of coastal prawn cultures farm and fish processing industries
- Power plants and nuclear power stations are the mainsources of thermal pollution of water. In these plants, water is used for cooling and it becomes hot. The release of hot wastewater, having 8 to 10°C higher temperature than intake water, causes thermal pollution in the water body.

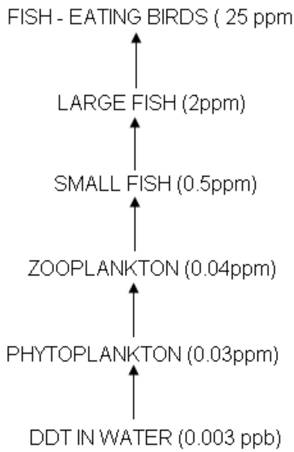
Agricultural sources

- Modern agricultural techniques require the use of millions of tones of artificial fertilizers, pesticides, insecticide for obtaining better yield. These get mixed with groundwater, lakes etc and produce several health hazards.

Oil Spills

- Oil spills are the accidental discharge of petroleum in oceans or estuaries.
- Offshore oil mining, capsized oil tankers add to oil pollution of the marine ecosystem.
- It forms a thick layer called slick, which floats on the surface of the sea and affect oceanic ecosystem as they are extremely harmful to coral reefs.

4.0 biological magnification



- The phenomenon, through which certain pollutants gets accumulated in tissues in increasing concentrations along the food chains and produce a fatal effect is called biomagnifications. The example of biological magnification is that of DDT, which is an insecticide that is sprayed on water bodies to check the growth of mosquitoes.
- The concentration of DDT increases as it passes from water to plant body. Its concentration increases 800 times in the

phytoplankton relative to the concentration in water. Zooplankton contained about 5 times greater DDT than phytoplankton.

5.0 biological oxygen demands (BOD)

• Biological oxygen demand is the oxygen in milligrams required for five days in one liter of water at 20^{O} C for micro-organisms to metabolize organic wastes.

• BOD is a measure of oxygen required by the aerobic material. Higher the BOD lower would be dissolved oxygen (DO). Usually, a high BOD in water means a high level of nutrients is present, along with a high number of microorganism feeding the nutrients.

• Some major industries effluent BOD levels

BOD of Distillery is above 90,000mg/L

BOD of sugar mill is above 2200mL/lt

BOD of sewage is above 600mL/lit

BOD of Papermill is above 170mL/lit

6.0 Eutrophication

• It is the excessive growth of algae, plants, and animals in water bodies due to nutrient enrichment, particularly with nitrogen and phosphorus. Eutrophication is both natural and accelerated.

• Natural eutrophication occurs slowly at a rate which may not be detectable in a humanlifetime. Accelerated or cultural eutrophication occurs due to the passage of sewage and runoff from fertilized fields into ponds, lakes and other water bodies.

• Nutrients present in sewage and fertilizers cause the dense growth of plants and planktonic algae. The algae use oxygen at night and may deoxygenate the water enough to kill fish and other animals. However, soon planktonic coloration to water depending upon the pigments present in them. The excess growth of planktonic algae that causes coloration of water is called algal bloom.

- In many cases, the bloomis formed by blue-green algae. They are toxic to animals and humans. In some cases, eutrophic water bodies support the excessive growth of water hyacinth that chocks pond, lakes, and rivers. Algal bloom and floating plants cut off light from submerged pants. They die and a drastic decrease in oxygen causes organic loading of water and thus lakes turn into the land.

7.0 Effects of water pollution on human begins

- Domestic sewage contains pathogens like viruses, bacteria, protozoans, and worms. Contaminated water causes diseases like cholera, typhoid, amoebiasis, jaundice etc. Such contamination makes the water unsuitable for drinking, bathing etc.
- Heavy metal contamination causes serious health problems. Mercury poisoning (Minamata disease) happens when mercury is converted into extremely toxic methylmercury, which can cause numbness of limbs, lips and tongue, deafness, blurring of vision and mental retardation.
- Excess of nitrate in drinking water is unsafe for human health and fatal for infants. It reacts with hemoglobin and forms non-functional methaemoglobin that impairs oxygen transport. This is called methaemoglobin or blue baby syndrome
- Overexploitation of groundwater perhaps initiates leaching of arsenic from soil and rock sources and contaminates groundwater chronic exposure of arsenic causes black foot disease. Arsenic causes diarrhea, neuritis, lungs and skin cancer.

• Excess fluoride in drinking water causes teeth deformity, hardened bones, and stiff painful joints or knock-knee disease.

• Copper causes hypertension, uremia, fever.

• Lead interferes with oxygen and glucose metabolism. Harmful effects include anemia, vomiting, loss of appetite, damage to liver, kidneys, and brain.

• Zinc causes vomiting, cramps, renal damage.

• The harmful effect of cobalt includes diarrhea, hypertension, damage to liver and kidney, diarrhea and skeletal deformities call itai-itai.

7.1 Different types of filters and coagulants used for purifying potable water

(i) Enzymatic filters are used to remove hydrocarbon impurity

(ii) Activated carbon filters and Aluminium-based coagulants are used to remove Heavy metals

(iii) UV Filters is used to remove the pathogen

(iv) Activated Carbon Filters used to remove chlorine, volatile organic compounds (VOCs), taste and odor from water. They are not effective at removing minerals, salts, and dissolved inorganic compounds (DOCs)

8.0 Control of water pollution

• Improved methods for handling and disposal of sewage garbage should be introduced.

• To control the epidemic and other diseases proper methods of sterilization of water drawn from shallow wells should be developed.

• The effluents from industries should be neutralized and treated before discharges into streams. Suspended mater should be removed by settling filtration and specific poisons should be removed by chemical methods

- The industrial and municipal wastewaters are treated in effluent treatment plant (ETP) prior to disposal in water bodies. Sewage treatment system often involves three stages:

  i) Primary treatment: This is a physical process that involves the separation of large debris followed by sedimentation in tanks.

  ii) Secondary treatment: This is a biological process and is carried out by the microorganism. In this treatment, wastewater is pumped in shallow stabilization, where the microbes oxidize the organic matter. The process results in the release of CO_2 and formation of sludge. The sludge is continually aerated for further oxidation. Algae are grown in the upper lighted zone of the wastewater supply aeration by generating O_2.

  iii) Tertiary treatment: This is physic- chemical process that removes turbidity in wastewater caused by the presence of nutrients (nitrogen phosphorus, etc) dissolved organic matter, metals, and pathogens. This stage involves chemical oxidation of wastewater by strong oxidizing agents, such as chlorine gas, perchlorate salts, UV-radiation and ozone gas.

  iv) It contains a lot of salts and other solids. Alum, ferric chloride and lime are used for their precipitation. They precipitate 90% of suspended solids and 90% of phosphates. It should be normalized and treated further with activated carbon for removal of dissolved organics and coloring agents. Water is now treated for removal of salts and nitrate. Ideally, such a water should be recycled to irrigation.

9.0 Soil pollution

- It is an alternation in soil caused by removal or addition of substance and factors which decreases its productivity, quality of plants and groundwater. Negative soil pollution is a reduction in soil productivity due to erosion and over-use. Positive soil pollution is a reduction in soil productivity due to the addition of undesirable products (industrial wastes, air pollution wash down by rain). Landscape pollution is converting the fertile land into barren one by dumping wastes (ash, sludge, garbage, industrial wastes).

9.01 Sources of soil pollution

1. Pesticides: They include insecticides, fungicides, algaecides, weedicides, and rodenticides.

(i) Organochlorine – These include DDT, BHC etc. They are persistent, fat-soluble and show biomagnifications.

(ii) Organo-pesticides- Deradeble but toxic to workers eg, malathion, parathion, carbamates.

(iii) Inorganic pesticides – They contain arsenic and sulfur and is persistent.

(iv) Weedicides – Often persistent and harmful.

2. Fertilizers: Excessive use causes natural microflora. Leaching down causes pollution of underground water salts entering crop plants in excess may prove harmful. For example, nitrate-rich leaves, fruits, and water produce nitrate in the alimentary canal that enters the blood combines with haemoglobin which forms methaemoglobin and reducing oxygen transport. It may prove fatal for infants.

3. Industrial effluents/ wastes: They include scrap, effluents, sludge, flyash and radioactive wastes. Industrial solid wastes and

sludge add a lot of toxic chemicals into the soil. Fly-ash is fall-out from industrial emissions especially thermal plants. Radioactive wastes from testing laboratories and other sources also pollute the soil.

4. Municipal wastes: they include domestic wastes market wastes, sweepings, wastes from commercial complex, plastic can etc.

5. E-wastes: Electronic wastes are irreparable computers, mobile, and other electronic goods

9.02 Control of solid wastes

1. Recovering and recycling

It is carried out with the help of rag pickers. The articles which can recover and recycled are tins, cans, other metal wastes, glass, plastic, polyethylene, rags, paper, and cardboard. Metal waste can be melted and purified.

2. Source reduction

Garbage and other organic wastes are taken out of the urban area and used for formation of compost, biogas, and manure.

Three R's-Reduce, Reuse and Recycle of wastes

3. Burning

Burning is combustion of solid wastes having organic materials in open space. It produces offensive odour and air pollution. Better methods are incineration and pyrolysis.

- Incineration: It is controlled aerobic combustion of wastes inside chambers of temperature 900 -1300^{o}C. Incinerators are fitted with scrubbers and electrostatic precipitators to prevent the release of smoke and toxic chemicals.
- Pyrolysis: It is combustion inside chambers in the absence of oxygen at a temperature of 1650^{O}C. It does not yield pollutants but industrial gas and other substances are produced.

4. Construction material

Flyash is being converted into bricks for construction work. Flyash, industrial effluents containing toxic chemicals and hazardous metals can be used as bedding material or road construction

5. Dumping

Dumping is piling of waste on selected low lying land. It is of two types, open and sanitary.

- Open dumping: It is accumulating waste on uncovered low lying area. The waste is piled up as high as the equipment can easily do. The waste is periodically burnt or compressed at intervals to reduce its bulk.
- Sanitary dumping: The waste is compacted and covered over by a layer of earth.

10 Noise pollution

- Noise can be defined as unwanted sound.
- Noise is measured in decibel (dB). The decibel measures the loudness of noise to the ear. The range of hearing in human beings is upto 120dB. We can hear ordinary 50dB but any sound above 120dB is harmful. Prolonged noise at 95dB will produce deafness, nervous tension, and rise in blood pressure.

Sound becomes hazardous noise pollution at the level of 80dB

10.1 Sources of noise pollution

- Main sources of noise pollution are:
- Various industries such as textile mills, printing press, engineering establishment.
- Agricultural machines like tractors, harvesters
- Defense equipment such as tanks, artillery, rocket launching, explosions

- Entertaining equipment like radio, record players, and television sets.
- Domestic gadgets such as fans, vacuum cleaners, pressure cookers.
- Public address system like loudspeakers.
- Transport vehicles like buses, trains, cars, scooters, jet planes.
- Dynamite blasting.
- Crackers used at occasions like marriage and festivals.
- Bulldozing, stone crushing, construction work.

10.2 Effects of noise pollution

- Noise brings about
- Damage to eardrum and impairment of hearing.
- Interference in conversation and hearing.
- Emotional disturbance, development of anxiety and stress.
- Damage to eyesight, color perception, night vision etc.
- Hypertension, changes in peripheral circulation and breathing problems, decreased heart output and gastric problems.
- Startle reaction.
- A headache, sleeplessness, annoyance, and irritability.
- Reduced productive performance.

10.03 Control of noise pollution

- Delimiting of acoustic zoning. A silent zone for 100m around hospitals and educational institutes will provide comfort for ailing patients and help students to concentrate on their studies.
- Use of cotton plugs or ear muffs in occupational exposure.
- Development of quieter machines.

- Soundproof insulating jackets or filters for reducing noises from machines
- Restricted use of loudspeakers.
- Acoustic furnishing and low voice radio / TV.
- Regulation of noise on road.
- Green muffler.

11.0 Radioactive pollution

It is degradation of environment due to the release of radioactivity. Radioactivity is measured in units called roentgens or 'r'.

1. Background radiation

   It is radiation level found naturally in biosphere due to cosmic rays reaching earth and radio-nuclides found in earth's crust. The naturally occurring radioactive elements are Uranium-232, Uranium-235, Thorium-232, Radium-224, Radon-222, Potassium-40 and Carbon-14.
2. Man-made radiation

   They are due to mining and refining of radioactive elements like plutonium, uranium, and Thorium, nuclear power plants and fuels, preparation of radioactive isotopes, production and explosion of nuclear weapons

11.1 Nuclear weapons

They use Uranium-235, Plutonium-239 for fission and hydrogen or lithium as fusion material.

A nuclear explosion produces:

i) Uncontrolled chain reaction

ii) Tremendous heat.

iii) Neutron flux that changes another element to radioactive state.

iv) Unused explosive and activation products.

v) A lot of radioactive and other gases forming mushroom type cloud.

11.2 Radioactive elements and its effects

- Iodine-131 forms thyroxine and damages spleen, lymph nodes, leucocytes, bone marrow, produces a lungtumour, skin cancer as well as sterility.
- Strontium-90 causes bone cancer, blood cancer, and tissue regeneration.
- Cesium-137 brings about nervous, muscular and genetic changes.

11.3 Atomic reactors

They employ controlled radioactive fission, fusion for the liberation of energy.

i) The coolant water causes thermal pollutions.

ii) A small amount of radioactivity enters coolant water which undergoes magnification to some 75,000 times in birds.

iii) They release halogen and inert gases.

iv) A mishap can be dangerous as an atomic explosion.

v) Radioactive waste is highly pollutant and its dumping requires several precautions – first cooling in small ponds for 50 -100 years and then packing in special containers, which are buried some 500 meters deep in rocks or at the bottom of the ocean.

11.4 Harmful effects of radioactive radiations

They were first recorded in 1909 in uranium miners as skin burns and cancer. Young and recently divided cells become easily damaged. Short range effects are a loss of nails and hair, bleeding, the changed proportion of blood cells changed metabolism. Long range effects are tumours, cancer, mutations, genetic deformities.

12.0 Thermal pollution

The rise in temperature of air and water due to waste heat from various sources such as thermal power plants, nuclear power plants, industries, and automobiles causing undesirable changes in the natural environment is called thermal pollution.

12.1 Effects of thermal pollution

- Heat causes deoxygenation in water.
- The rise in temperature of water speeds up metabolic activities of aquatic organisms. As a result, they require more oxygen.
- Increase in microbial activity in hot water also contributes to the death of fishes.
- Migration of aquatic animals is affected due to the formation of different thermal zones in water.

12.2 Control of thermal pollution

- Cooling ponds: In this method, water from the condensers is stored in ponds where natural evaporation causes its cooling. This water is discharged is nearby water body.
- Spray towers: In this method, water from the condensers is received in spray ponds. Thereafter it is sprayed through nozzles in the form of fine jets. Water drops dissipate the heat to the atmosphere.
- Cooling towers: In this method, hot water is sprayed over baffles. The cool air entering from sides takes away the heat and results in cooling of water.

12.3 Global environmental changes

12.3.01 Ozone layer depletion

- Ozone layer or shield is present in the stratosphere. It is also called ozonosphere. The thickness of ozone is measured in Dobson unit (DU).
- Ozonosphere functions as a shield against strong UV radiations.
- Depletion in the concentration of ozone over a restricted area as over Antartica is called ozone hole.
- Ozone-depleting substances (ODS) are substances which react with ozone present in the stratosphere and destroy the same. The major ODS are chlorofluorocarbons (14% of total depletion), sulfur dioxide, halogen, carbon tetrachloride, methyl chloroform etc. A single chlorine atom converts 1 lakh molecules of ozone into oxygen

$$CFCl_3 \rightarrow CFCl_2 + Cl$$

$$CFCl_2 \rightarrow CFCl + Cl$$

$$Cl + O_3 \rightarrow ClO + O_2$$

$$ClO + O_3 \rightarrow Cl + 2O_2$$

- UV-B is harmful as well as capable of deep penetration. Thinning of ozone layer increases the amount of UV-B radiations reaching the earth.
- The various effects of ozone depletion are:
- Cornea absorbs UV-B radiations and becomes inflamed. The disorder is called "snow blindness" cataract. It leads to a diminishing of eyesight, photoburning and later permanent damage to the cornea that results in actual cataract.

- UV-B radiation damage to skin cells causesaging of skin and skin cancer.
- Damage of nuclei acids increases resulting in higher number of mutations.
- UV radiations inhibit photosynthesis by affecting photosynthetic machinery.
- Decreased photosynthetic activity will increase the CO_2 concentration of the atmosphere resulting in global warming.

12.3.02 Greenhouse effect

- It is warming effect found in the greenhouse by allowing solar radiations to pass in but preventing loss wave heat radiations to pass out due to glass panels, water vapours, and carbon dioxide. Because of its greenhouses are used for growing tropical plants in temperate areas.
- The whole sunlight does not reach the earth. About one-fourth of incoming solar radiations are reflected back by clouds and gases another one-fourth of radiation is absorbed by atmospheric gases. The gases which are transparent to solar radiation but retain and partially reflect back long-wave heat radiation are called greenhouse gases.
- Greenhouse gases are essential for keeping the earth warm and hospitable. They prevent a substantial part of the longwave radiation emitted by earth to escape into space. Rather greenhouse gases radiate a part of it back to earth. This phenomenon is called greenhouse flux. Because of greenhouse flux, the mean annual temperature is $15^{O}C$.
- The various greenhouse gases are CO_2 (60%). CH_4(20%), chlorofluorocarbon (14%)and nitrous oxide (6%), other of minor significance are water vapor and ozone.

- Global warming – It is believed that increase in the concentration of greenhouse gas has resulted in the rise of atmospheric temperature. The rise in temperature will be slight in tropics, moderate in middle latitudes and maximum in polar regions.

12.4 The effects of global warming

- Warming of the atmosphere will significantly increase its moisture carrying capacity while the troposphere warms up, the stratosphere will cool down hence increasing the size of the ozone hole. This would also cause extensive changes in precipitations due to changed pattern of air mass movements.
- The global warming may contribute a sea level rise due to the thermal expansion of the ocean as it warms and melts the glaciers and Greenland ice sheets. A rise of even half a meter in sea level would profoundly affect human population, one-third of which lives within 60km of coastline. Numerous low lying islands may be submerged.
- Each plant or animals species occur within a specific range of temperature. The global warming is likely to shift the temperature ranges and as a result, would affect altitudinal and latitudinal distribution pattern of an organism with increasing global warming. Many species are expected to shift polewards or towards high elevation in mountain areas. Since trees are sensitive to temperature stress, a rapid rise in temperature may cause the extensive death of trees and their vegetation by scrub

vegetation. Many species may not able to migrate fast enough to track temperature changes and may disappear.

- Small temperature increase may slightly improve crop productivity in the temperate region, but larger temperature changes will reduce crop productivity. This will have disturbing consequences on world food supply.

13.0 Environmental laws for controlling pollution

1. Environment (Protection) Act, 1986
   - It is the most comprehensive law meant for prevention, control of environmental pollution by laying down emission norms and setting up of central and state pollution control boards
   - The boards check the emissions and effluents by various institutes and industries, their treatment and disposal. The act encompasses air, water, soil, and noise. Rules have been framed under this law from time to time such as

i) Hazardous wastes (management and handling) Rule 1989.
ii) Noise Pollution (Regulation of control) Rules 2000.
iii) Biomedical waste (management and handling) Rules, 1998.
iv) Recycled plastic manufacture and usage Rule 1999.
v) Ozone-depleting substances (Regulation and control) Rule 2000.
vi) Municipal Solid Wastes (Management and handling) Rule 2000.

2. Insecticide Act 1968
   - It regulates the manufacture, import, sale, transport, distribution, and use of insecticides laying down various rules to reduce risk to human health and health of other organisms.

3. Water (prevention and control of pollution) Act 1974.
   - It specifies the quality of water for various purposes, way,and means to control water pollution and prevention of detrimental pollution and prevention of detrimental effects on human health and health of other biological entities.

4. Air (Prevention and control of pollution) Act 1981
   - This act is meant for preserving the quality of air, controlling air pollution and preventing detrimental effects of air pollutants and human health and health of other biological entities. By an amendment in 1987, the noise was also recognized as air pollutants.

14.0 International initiative for mitigating global change

1. Montreal Protocol (16 September 1987): 27 industrialized countries agreed to limit production of chlorofluorocarbons to half the level of 1986.

2. Helsinki Declaration (May 1989): Montreal Protection was ratified by 82 nations at Helsinki. They pledge to phase out CFC by the year 2000.

3. In June 1990, 93 nations amended Montreal Protocol and Helsinki Declaration. They agreed to phase out CFC's till date 175 nations have signed it.

4. Intergovernmental Panel on climatic change (IPCC, 1988) Prepared world climatic programme (wcp)
5. Convention on climate change (CCC) : Under UN framework in 1991.
6. Earth Summit (United Nation Conference on Environment and Development, 1992).
It was held in Rio-de-Janeiro (Brazil) and adopted the recommendations of CC for reducing greenhouse gases. The recommendations were signed by 154 nations. They pledged to maintain emission of greenhouse gases at 1990 level.
7. Kyoto Protocol (Dec 1997)
An international conference held in Kyoto, Japan obtained commitments from different countries for reducing overall greenhouse gas emissions at a level of 5% below 1990 level by 2008 – 2012.
8. World Summit for sustainable development (2002)
The Summit was held in Johannesburg, South Africa, for discussing ways and means to sustain development without depletion of biodiversity.
9. U.N. Convention on climatic change (CCC, 2004)
The meeting was held in Buenos Aires, Argentina, for preparing a strategy to reduce global warming.
10. Bali conference (2007) : It has concentrated on ways and means to check global warming.
11. Copenhagen conference (2009): Participating countries have agreed to voluntarily reduce CO_2 emissions.
12. UN climate change conference (CCC, 2011): It was held in Durban, South Africa.

15.0 Degradation natural resources by improper resource utilization and maintenance.

Degradation of natural resources not only occurs due to over-exploitation and action of pollutants but also due to too improper utilization practices.

(i) Soil erosion

It is the removal of topsoil occurs when the plant cover is removed. The agencies that cause soil erosion are water and wind. Plants cover is removed due to deforestation, overgrazing, leaving tilled loose soil for a few days un-irrigated and unseeded. Since the onlytopsoil is fertile soil erosion reduces the productivity of the land. The water eroded soil passes into rivers and reservoirs.

It raises river bed causing flood and storage capacity of reservoirs also reduces. Water becomes muddy killing all types of aquatic life.

(ii) Desertification

It occurs in the plain where excessive grazing and trees fallingleave the land barren. In the dry season, such exposed is eroded by wind. As fine soil particles are taken away by wind, heavy sand particles are left. They also show creepy. The area becomes arid and sandy.

(iii) Waterlogging

It is the presence of water more than field capacity of the soil. waterlogging occurs due to

(a) Seepage from irrigation channels.

(b) Excessive irrigation.

(c) The absence of underground drainage. Waterlogging drives out soil air. Anaerobic conditions produce toxins, prevent root growth and kill the plants.

(iv) Soil salinity

Poorly drained soil in semi-arid areas and soil irrigated by brackish water turn saline. Evaporation of water from the surface draws more and more water from below. As soil water contains salts. Salts are left over the surface while the water evaporates.

16.0 Deforestation

It is removal, decreases or deterioration of forest cover of an area.

16.1 Causes of deforestation

1. Jhuming

In India about 5 lakh hectares of land is cleared every year through lopping, burning the remainder, mixing the ash with soil and sowing the cleared land with crop seeds. The land is used for 2-3 years without manuring. This results in nutrient depletion reduced moisture retention and increased soil erosion

2. Hydroelectric projects

Dams, reservoirs and hydroelectric projects submerge forest killing all plants and animals.

3. Forest fires

Huge forest fires engulfing areas of 40,000 km^2 have occurred in Indonesia in 1983 and 1997.

4. Human establishment

5. Mountain and Forest Road

Construction of roads and railways in hilly forested areas bring about a lot of deforestation, landslides and soil erosion large sections are dynamited. This weakens the already fragile mountain system. The fragments pass into valleys. They increase soil erosion.

6. Overgrazing

India with 2.4% geographical area has some 500 million livestock population. Grazing area is only 13 million hectors where one hectare of land supports only 6 livestock heads. The remaining livestock naturally grazes in forests trampling seedlings and compaction of soil. Compaction of soil reduces water storing capacity.

7. Requirement of wood

It is rising, some 300 million m^3 for fuel and 40 million m^3 for the industry, mostly timber and paper industry.

8. Quarrying and mining.

16.2 Effects of deforestation

1. Shrinking fuelwood

In India, availability of fuelwood in 58 million m^3 / year against the requirement of 300 million m^3/year.

2. Reduced timber

3. Change in climate

Deforestation results in reduced rainfall, increased drought, hotter summers and cold winters.

4. Soil erosion

The soil is exposed in insolation, dries up and get eroded by wind and water

5. Flash floods

They occur during rainy season due to non-retention of water in the soil, increased runoff water flowing into streams and rivers during rains.

6. Siltation

Rainy season rivulets bring eroded soil and bring the deposits on a bed of reservoirs reducing storage capacity.

7. Drought loss of biodiversity, rainfall

8. Global warming

Deforestation increases atmospheric CO_2 content by releasing carbon stored in organic matter and reduced primary productivity.

16.3 Conservation and management of forests.

1. Sustained yield block cutting : Cutting is allowed only in the non-vulnerable forest at a rate which is equal to their regeneration capacity.

2. Control of weeds, pesticides, and controlled grazing.

3. Chipko movement: It is movement initially meant for protecting trees but now meant for preservation of environment including habitat and wildlife. Chipko movement was born in March 1973 in Gopeshwar in Chamoli district, when trees were not allowed to be cut by village folk by hugging them first near village Mandal, then Rampur Phata in 1974 near village Reni (led by Gaura Devi). The movement has two leaders, Chandi Prasad Bhatt of Gopeshwar and Sunder Lal Bahuguna of silyara in Jehri region. A similar moment was undertaken by Paudurang Hegde in the south. It is known as an appiko movement.

16.4 Other forms of forestry

(i) Social forestry – Raising quick growing multipurpose plants in common village lands for meeting requirement of fodder, firewood, and small timber.

(ii) Urban forestry – It is a plantation of fruit, flower, and shade-bearing plants in urban areas to reduce pollution and ultimate yield of wood

(iii) Agroforestry – It is a plantation of multipurpose trees, shrubs along with crops for stabilizing soil, meeting the needs of fodder, fruit, and timber.

(iv) Production plantation – It is growing of industry required trees on specific, free grazing lands. Production plantation decrease pressure from real forests.

Reserve forest – These forests are grown over the ecologically fragile area where our water regimes are also located.

16.5 Efforts for the conservation of forest

16.5 01 Joint Forest Management (JFM)

Despite best efforts by the forest department, the degraded sal forest of Arabari in Midnapore district could not be regenerated. The forest officer A.K.Banerjee was allowed to seek the participation of villagers in regeneration on employment cum share basis. Within few years, by 1983, Arabari forest has been revived. Buoyed by this success, the government of India introduced the concept of Joint Forest Management of forest for which the communities get benefits from forests like fruits, gum, rubber, medicine etc.

16.5.02 Bishnoi

Forest conservation is an old practice in India. In 15century, Guru Jambheshwar Maharaja enunciated 29 principles for protecting the environment, on account of this principles, his followers are known as Bishnoi. Bishnoi does not allow falling of trees and killing of animals. In 1731, a king of Jodhpur asked one of his ministers to arrange wood for his new palace. The minister alongwith personnel of royal force came to a forest near village Khejrali. A Bishnoi woman Amrita Devi hugged the tree and challenged King's men to cut her down before cutting the trees. She sacrificed her life. Her three daughters and 360 other Bishnois lost their lives saving trees. This perhaps a singular example where humans laid down their lives in order to save trees. The government of India has instituted

Amrita Devi Bishnoi wildlife protection Award for rural individuals and communities who show exemplary courage and dedication for protecting wildlife.

17.0 Forest and wildlife laws

1. Forest acts, 1927

(i) Establishment and management of three types of forests – village forest, reserved forest, and protected forests

(ii) Protection of non-governmental forests and forest land against over-exploitation

(iii) Control of movement of forest products

(iv) Control of grazing.

2. Forest (Conservation) Act, 1980, Amended 1988.

No forest land can be de-reserved and diverted to non-forest purposes without the approval of central government. A diversion when permitted would be accompanied by compensatory afforestation, in some cases, twice the forest area lost. Six regional offices have been set up to monitor enforcement of Act – Bangalore, Bhopal, Bhubhaneshwar, Lucknow, Shillong and Chandigarh.

3. Wildlife (Protection) Act, 1972, Amended 1991

i) The act restricts and prohibits hunting of the animal

ii) Protection of certain plants from excessive exploitation

iii) Setting up and managing national parks and sanctuaries

iv) Creation of zoo authority for controlling of zoos and captive breeding.

v) Control trade in wildlife, wildlife products

vi) Encouraging and assisting the formation of wildlife societies.

4. National Forest policy (1988)

It aims at increasing cover of forest in plains and hills so that optimum of 33% forest cover is achieved in plains and 67% in hills. Other aims are:

i) Maintenance of environmental stability through preservation and restoration of ecological balance.

ii) Check on soil erosion and denudation of catchment areas

iii) Checking on the spread of sand dunes.

iv) Increase in forest tree cover through massive afforestation and social forestry programmes.

v) Steps to create massive people's movement of afforestation, management, and protection of forests. Already about 17.33 million hectares of degraded and protected by 84632 Joint Forest Management Committees

18.0 Important dates

1. Wetland Day : 2nd Feb
2. World Forest Day:21st March
3. World Water Day : 22nd March
4. Earth Day: 22nd April
5. World Environment Day : 5th June
6. Hiroshima Day : 6th August
7. Nagasaki Day: 9th August
8. World Ozone Day : 16th September
9. World Animal Welfare day : 4thOctober
10. National Pollution Prevention Day : 2nd December

That's all folks!

सर्वेभवन्तुसुखिनःसर्वेसन्तुनिरामयाः।सर्वेभद्राणिपश्यन्तुमाकश्चिद्दुःखभाग्भवेत्॥

All should/must be happy, be healthy, see good; may no one have a share of sorrow.

Evolution

NOTES

For

NEET and AIIMS

Examinations

By PLoS Biology Journal

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INDEX

11. A brief account of the evolution
12. Distinguish (i) convergent and divergent evolution (ii) Adaptive radiation and divergent evolution (iii) Darwinism and Lamarckism (iv) Humans and Apes

- Evolution is unrolling or unfolding of nature that brings about an orderly change from one form or condition to another resulting in descendants becoming different from ancestors. Evolution is rather a law of nature
- Evolutionary biology is the study of the history of the development of newer forms of life from the pre-existing ones in various periods of time on earth

1.0 Origin of the universe

- Universe or cosmos is the whole existing space and matter which is differentiated into several galaxies with each galaxy having several stars and cloud of gas and dust
- Most accepted theory to explain the origin of the universe is the Big Bang theory which was proposed by Abbe Lemaitre in 1931. According to this theory, the universe has an explosive beginning. The universe expanded and hence temperature came down

1.1 Origin of the solar system

- According to Nebular Hypothesis of Kent, our solar system was probably created about 4.5 to 5 billion years ago when gaseous cloud called solar nebula was formed

- Our earth was supposed to have been formed about 4.5 billion years back. There was on the atmosphere on the early earth

1.2 Origin of life (biopoiesis)

- As far as we know life occurs only on earth though there is the possibility of its presence elsewhere as well. Methane which has helped develop life on earth occurs on Jupiter, Saturn and interstellar space. Water has been detected on our moon, on mars

1.2.01 Theory of special creation

Life was created by God

(i) The genesis of Bible has proposed that God created the world in six days

Day 1: Heaven and earth

Day 2: Sky and water

Day 3: Land and land plants

Day 4: Sun, moon and stars

Day 5: Birds and fishes

Day 6: Land animals and human

The first man was Adam. He was created from clay. The first woman was Eve who developed from 12^{th} rib of Adam

(ii) Hindu mythology – Hindu believed that the world was created by Brahma. The humans were formed from his head, birds from the chest, goats from mouth and plants from hair. The first man was Manu and the first woman was Shradha

- Theory of eternity

Different living beings, plants, stars etc. existed as such from the beginning and would continue

1.2.02 Theory of catastrophism

This theory was supported by Cuvier (1826), a French paleontologist, who believed that the world has passed through many ages. A catastrophe occurred at the end of each age, which killed most of the living beings and at the beginning of next new age, a new creation evolved

1.2.03 Theory of the cosmozoic origin

Both living and non-living matters were formed simultaneously. Early living objects were resistant spores call cosmozoa. Cosmozoa gave rise to different types of living beings on earth

This theory was given by Richter in 1865.

1.2.04 Theory of Panspermia

Arrhenius (1908) proposed the theory of directed panspermia. The salient features are

(i) They assumed the presence of advanced civilization on other planets in our galaxy.

(ii) Life on earth and many other planets were infected from these advanced civilized planets

(iii) Directed panspermia theory was supported by genetic code

1.2.05 Theory of spontaneous generation

It originated in Egyptian civilization. Greek philosophers believed in it. Anaximander thought life to arise from much warmed by the sun. Aristotle believed plants to developed from the soil while worms and snails to be products of putrefaction. Frog was believed to arise from moist soil

Van Helmont had claimed the origin of mice of both sexes from human sweat and wheat bran kept in dark for 21 days

1.2.06 Biogenesis

- Theory of spontaneous generation was disapproved through the finding that life comes from pre-existing life

• Francesco Redi (1668) placed thoroughly cooked meat in three jars (i) Uncovered (ii) covered with parchment (iii) covered with muslin.

Maggots developed only in an uncovered jar. No maggot developed in a jar covered with parchment. Flies visited the third jar and laid an egg on muslin. Egg fallen in jar produced maggots.

• Spallanzani (1765) boiled nutrition in glass flasks, sealed the flasks and kept them. The broth remained clear indefinitely with no signs of living beings

• Pasteurs (1862) took broth in flasks straight and swan (bent S-shaped) necks, boiled and allowed the broth to cool. No germ developed in the broth it was connected with the atmosphere through the curved neck of the flask. The dirt particles could not reach the broth because they got trapped in the bend of the neck. When swan neck was broken, broth developed colonies of microorganisms showing that the same have come from the air. The same happened in straight necked flasks

1.2.07 Modern hypothesis of the origin of life

Chemical origin of life (chemogeny)

• Oparin suggested that from the simple compound like nitrides, oxides, ammonia, methane complex organic compounds were formed gradually under the influence of electric charges, ultra-violet rays

• First , were the formation of hydrocarbons, like acetylene, ethylene etc. these then form oxy and hydroxyl derivatives forming aldehydes, ketones and acids, sugar and starch were the main products.

• Miller’s experiment – Stanley Miller (1953)a graduate student of Harold C Urey designed an apparatus for stimulating condition prevalent on earth at the time of abiogenic evolution of organic substances. The apparatus has a spark chamber with two electrodes, a flask for boiling and a condenser. A control apparatus was also prepared but without electrodes in the spark chamber

- Miller used a mixture of methane-ammonia, hydrogen and water. The mixture was exposed to electric discharges, following by condensation and then boiling. It was continued for 18 days.
- Miller was able to identify 15 amino acids, organic acid, ribose sugar and purine, adenine.
- The formation of a protein molecule is considered a landmark in the origin of life

2.0 Biological evolution

- Formation of proteinoids: Proteinoids are molecules which are obtained by synthesizing polypeptides by heating a mixture of amino acids at 160 – 210°C for several hours.
- Formation of coacervates

When macromolecules were formed they undergo aggregation and precipitation in the sea, which led to the formation of organized structures were distinct bodies, which did not mix with the surrounding seawater. They contained proteins, nucleoproteins and other organic and inorganic molecules in various reactions. The surface layer of the coacervates had the ability for selective absorption of substances from the medium. Oparin considered the coacervates as the sole living molecules which gave rise to cells

- Formation of precells or protocells.: The protocells were spherical in shape and a double-layered membrane was present around them. They exhibited reproduction by binary fission. The protocells were heterotrophs; they obtained the energy formed by the fermentation of organic molecules which gave rise to cells

• Formation of precells to cells: When DNA – RNA system developed within protocells, they looked like a bacteria or virus. The DNA acquired the ability for self-duplication and protein synthesis. Thus life originated after a long process of molecular evolution. The protocells in course of time differentiated into cells

cells
↑
precells or protocells
↑
coacervates
↑
macromolecules
↑
micromolecules
↑
H_2O, H_2, NH_3, CH_4
↑
C, H, N, O
↑
primitive earth

3.0 Evidence of evolution

• The convincing evidence for the occurrence of descent with modification come from

(i) Paleontology

(ii) Morphology and comparative anatomy

(iii) Embryology

(iv) Geographical distribution

(v) Taxonomy

(vi) Connecting links

(vii) Cytology

(viii) Biochemistry

(ix) Genetics

3.1 Evidence from paleontology

- Paleontology is the study of past life based on fossil records. Their study reveals the existence of life in past and illustrates the course of evolution of plants and animal
- Leonardo da Vinci is considered the father of paleontology while George Cuvier is called the father of modern paleontology

3.1.01 Types of fossils

(i) Body fossils: These are hard parts of an organism, which provide details of shape and function of an actual organism such as bone, tooth, skull etc.

(ii) Subfossils: These are the remains of plant and animals which were formed during Holocene period after the last ice age and found preserved in rocks formed after 10,000 years.

(iii) Microfossils : Microscopic fossil remains of animals and plants usually less than 0.5 mm in size are known as microfossils.

(iv) Macrofossils: Fossils of larger than one cm size such as corals, skeleton

(v) Pseudofossils: these are inorganic origin objects, which show close resemblance with the forms of organic origin and are found in sedimentary rocks.

(vi) Unusual fossils: Fossils formed as a result of a combination of events and condition which results in all or most of the organism getting preserved in rock.

(vii) Trace fossils: these are fossils of footprints and trail left in mud by past living organisms such as dinosaur’s footprint

(viii) Coprolites : These are trace fossils of dropping of animals or faecal matter, either very small like faecal pellets of sea snail or large coprolites of dinosaurs, crocodiles and mammals

3.1.02 Determination of age of fossils

Carbon dating – radioactive C-14 occurs naturally. It enters the food chain and is therefore found in all living beings and their remains. Half-life of C-14 is 5730 years. Carbon dating can measure articles up to 25,000 years old

3.2 Evidence from morphology and comparative anatomy

(a) Homology (Divergent evolution)

Homology is the similarity between organs of different animals based on common ancestry and built on the same fundamental pattern, but perform the varied function

Examples

(1) The flipper of a seal, a wing of bat front leg of horse and arm of man shows homology

(2) Thorns of Bougainvillea and tendrils of Passiflora are modified branched but thorns of Bougainvillea are for protection while tendrils of Passiflora are for climbing

Presence of homologous organ in different group confirms

- Common ancestry and relationship between different groups
- The difference in appearance due to divergent evolution

(b) Analogy (Convergent evolution)

The analogy is the difference in basic structure and origin but is adapted to perform similar functions Examples:

1. Fines of fishes and flippers of a whale. Similar appearance and function but their structural designs are different
2. Wings of butterfly and bat serve the same purpose i.e. flight, but wings of insect are formed of a thin flap of chitin and stiffened by series of veins. Whereas in bat wing is formed of a

fold of integument, supported by the elongated and outspread phalanges.

(c) Adaptive radiation

- The process of evolution of different species in a given geographical area starting from a point and literally radiating to other areas of geography is called an adaptive radiation.

Example: Australian marsupials. A number of marsupials, each different from other evolved from an ancestral stock, but all within the Australian island continent

3.3 Embryology

Embryology is the study of formation and early development of an individual from zygote to young ones

(1) Similar early development early embryo development is similar in animals passing through morula (solid ball), blastula (two layered) stages showing their common origin

(2) Resemblance amongst vertebrate embryos. Embryos of all vertebrates pass through fish like state having somites, gill clefts / slits behind neck, tail, notochord

(3) Development of vertebrate organs . Heart of a mammal or bird is initially two chambered (as in fishes), three-chambered (as in amphibians) and then four-chambered

(4) In seventh month of pregnancy human foetus resembles a baby ape

(5) Recapitulation theory / Biogenetic law

Meckel (1810) proposed that developing animal embryo passes through stages resembling adult forms of its ancestors

3.4 Evidences from Geographical distribution

• The degree and period of separation of an area from another correspond to species diversity

• Double coconut occurs only in Seychelles island. Kangaroo and Koala are marsupials found in Australia

• Darwin observed that the finches on mainland of America were all of one type, possessing short straight beaks for seed crushing. These birds from Galapagos island differed in size and shape due to different food types available. Some were vegetarian finches, warbler finches while others were insectivorous finches

Evidences from taxonomy

Depending upon their resemblances and differences, living organisms are divided into groups i.e. monera, protista, fungi, plantal and Animalia. The common characters present in a species, genus, family, class or phylum indicate common ancestry while the difference indicate evolution.

3.5 Evidences from connecting links

While classifying animals one comes across certain animals or small animal groups which exhibit characteristics of more than one group. Such animals or animal group are called connecting links between those two groups

Example: Euglena

A connecting link between animal and plant. Some animal character of Euglena are

(1) Body is covered by a pellicle

(2) Reproduction is an animal like some plants character of Euglena are

(a) It is having chlorophyll and chloroplasts
(b) Nutrition is autotrophic
(c) It synthesis their food through photosynthesis

3.6 Evidence from cytology

(1) The protoplasm of all the organisms have carbon, hydrogen, oxygen and nitrogen
(2) DNA and rarely RNA is the genetic material in all the organisms, which show common ancestry and origin of all organisms.
(3) The same genetic code have triplet codons is found from the viruses to man and all living beings have same amino acids for the same codon.

3.6 Evidence from biochemistry

- Living being possess similar types of biochemicals, biochemical reaction and body functions, Trypsin digest protein from amoeba to man, Amylase digest starch from Porifera to mammalian
- Example, aerobic organisms perform Krebs cycle having similar types of enzymes from Chlamydomonas and amoeba to human being and peepal tree
- A - B blood grouping is present in apes as well as humans but not in monkeys indicating a closer relationship between the former
- The chemical composition of Protoplasm is same in protozoa and mammalia
- Hereditary material is DNA in all organism and its basic structure is same in all animals
- Respiratory protein Cytochrome C are identical in all organism.

3.7 Evidence from genetics

Accumulation of mutation produces new verities and races, e.g. red sunflower, dwarf wheat etc. Hybridisation and induction of polyploidy has given rise to new plants

4.0 Modern theories for the evolution

Four modern theories have been put forward to explain the mode of evolution. These are

(i) Lamarck's theory of inheritance of acquired characters or Lamarckism

(ii) Darwin's theory of natural selection or Darwinism

(iii) De Vries mutation theory

(iv) The modern concept of evolution

4.1 Lamarckism or Inheritance of acquired characters

- Jean Baptiste de Lamarck was a French naturalist, well known for his theory of evolution
- The central idea of Lamarckism is that the characteristics acquired by an organism during a lifetime in response to environmental conditions are passed on to their offspring. The main points include

(i) Organisms and their organs have a natural tendency to continuously increase in size, generation after generation

(ii) Continuous changes in the environmental conditions directly influence the natural habits, a way of living or organism and their structural organism and their structural organization

(iii) The growth of less used parts decline, while that of better-used parts progresses

(iv) The growth of organs either better or poor acquired during the lifetime of an organism is heredity

- Examples of Lamarckism

(1) Giraffe – the ancestors of giraffe were bearing a small neck and forelimbs and were like horses, but as they were living in places with no surface vegetation, they have to stretch their necks and forelimbs in order to eat leaves from trees

(2) Flightless birds : The development of flightless birds like an ostrich from flying ancestors is considered due to continued disuse of wings as they were found in well-protected areas with plenty of food

(3) Snakes: The present-day limbless snakes with long slender neck were developed from the limbed ancestors. It is due to continued disuse of limbs and stretching of their body to suit their creeping mode of locomotion and fossorial mode of living

• Evidence in favour of the law of inheritance of acquired characters are-

(1) During vegetative propagation of plants and regeneration in animals somatic cells can produce the germ cells

(2) Sudden heritable variations or mutations were obtained by Auerbach et. Al on exposure of Drosophila to high energy radiations like UV – rays, X-ray, γ-ray and mustard gas etc.

• Lamarckism or theory of inheritance of acquired characters was discarded due to following reasons

(1) Blind, deaf and lame parents do not produce abnormal offspring

(2) Despite use of iron shoes to keep their feet short by Chinese women, their young ones at birth have normal feet size

4.1.01 Neo-Lamarckism

• These criticism lead to the foundation of Neo-Lamarckism

The postulates of Neo-Lamarckism are

(1) According to Neo-Lamarckism, there is a causal relationship between the structure, function and environment

(2) Some of the variations acquired by an individual can be transmitted to its offspring

(3) The role of internal vital forces in evolution has been discarded

(4) Only those variations are inherited, which are associated with the germ cells or where the somatic cells give rise to germ cells
(5) It has been realized now that the body character of organisms are related to result of the interaction of genes and the environmental conditions

4.2 Darwin's theory of natural selection or Darwinism

- Charles Darwin was born in 1809. In 1831, he accepted an unpaid post of naturalist on the survey ship, i.e. HMS Beagle, in which he spent five years in sea charting the East coast of South America
- Features of the theory of natural selection are

(1) Overproduction: Organisms have a very high reproductive potential and capacity , multiply in geometric ratio.
(2) Limitations of food and space: The resources of the earth are limited. Therefore, populations of different species cannot increase beyond a certain limit.
(3) Struggle for existence: A struggle or competition occurs amongst organisms to obtain the available resources. It is of three types-

(a) Intra-specific struggle: This is the acutest type of struggle, which occurs amongst individuals of the same species for similar basic necessities like food, shelter, breeding place, light, water etc
(b) Inter-specific struggle: the struggle occurs amongst individuals of different species for similar requirements like food, shelter
(c) Environmental struggle: The struggle is between organism and restricting environmental factors like carrying capacity,

drought, heavy rains, floods, famine, earthquake, volcano, lightning, meteorite, etc.

4.2.01 Variations

- They are small morphological and behaviouristic differences amongst the individuals. Variation can be continuous discontinuous, harmful.
- Darwin believed that continuous and useful variation constitute the raw material of evolution. Neutral and occasionally harmful variations may also prove helpful with the change of environment.

Natural selection and survival of the fittest:

In the struggle of existence, only those individuals survive which possess the most useful variations. This has been called natural selection by Darwin and survival of the fittest by Spencer

- This theory was criticized because

(1) Darwin did not explain the mechanism of origin of variations

(2) He did not know the mode of transmission of variations to the next generation.

(3) Continuous variation cannot go beyond the limit of species. Mutation is actually the source of evolution

(4) Darwinism does not explain the origin of variation, new characters

(5) It is unable to explain the persistence of degenerate organ and over-specialization (e.g. tusk of an elephant)

(6) There are certain organisms which have remained unchanged for the past several million years

4.2.02 Evidence in support of Darwinism

(1) Evident facts: High rate of reproduction, limitation of resources, an abundance of variation are quite evident

(2) Entomophily: Many pollinating insects have proboscis length exactly matching the position of nectary in flower. This may develop due to natural selection.
(3) Mimicry: It is the resemblance of an organism to another or a natural object so as to conceal itself for protection or some other advantage like catching of prey. E.g. praying mantis, stick insect
(4) Extinct forms: Extinction of past plants and animals can be explained only by the development of better organisms through natural selection
(5) Adaptations: Variations present in the population help the individuals in adapting themselves to changed environmental conditions. Adaptations produce new ecotypes from which new forms can develop
(6) Artificial selection : It is a selective breeding of plants and animals so as to obtain varieties with desired traits.

(a) Agriculture perhaps originated with a selection of nonbrittle ear in Triticum monococcum (Einkorn wheat) This was later replaced by naked and high yielding wheat
(b) Through artificial selection, wild cabbage has given rise to several vegetables like Kale, kohlrabi, cabbage, Cauliflower, Broccoli etc
(c) High milk yielding varieties of Buffalo have developed by monitoring of animals producing more milk and breeding them with bulls of high milk yielding lineage

4.2.03 Neo-Darwinism

- The theory of evolution as proposed by Darwin and Wallace has been modified in the light of modern evidence from genetics, molecular biology, paleontology, ecology and is known as neo-Darwinism

- Neo-Darwinism distinguishes the germplasm and somatoplasm
- It explained that adaptations result from the multiple forces and natural selection is one of them
- As per Darwinism, characters are not inherited as such, instead there are character determiners which control the development.
- The characters are the result of genes of organisms and the environment during its development

4.3 De Vries mutation theory

- The term mutation was introduced by Hugo de Vries, a Dutch botanist who independently rediscovered Mendel's law of heredity
- Mutation theory was put forward by him in 1908
- Salient features of mutation theory are as follows

  (a) Mutation acts as a raw material for evolution.

  (b) Mutation is large heritable and subjected to natural selection

  (c) Mutation is large heritable changes in contrast to small, a directional fluctuating variation of Darwin

  (d) The mutation may occur in any direction and may be useful or harm

  (e) Sometimes, new species are produced by a single mutation

4.3.01 De Vries mutation theory criticism

1) D.M. Davis claimed that the Oenothera lamarckiana (evening primrose) was a hybrid plant, which could be obtained by the hybridization of two wild species and is not a normal plant
2) Natural mutation are not the common phenomenon
3) Most of the mutation is recessive
4) Development of mimicry cannot be explained satisfactorily

5) Theory failed to explain the role of nature

5.0 Modern concept of evolution

- The present concept of evolution is a modified form of Darwin's and Hugo de Vries theories. This is also called the synthetic theory of evolution
- The main postulates of this theory are

(1) This theory recognizes four basic types of process. These are

(a) Migration of individuals from one population to another, hybridization between races or closely related species both increase the genetic variability

(b) Mutation, genetic recombination and natural selection are equally important

(c) The effect of the change, acting on the small population may alter the way in which natural selection guides the course of evolution.

(2) All sexually reproducing organisms contain a large gene pool of genetic variability, which maintain a dynamic equilibrium between inflow and outflow of genes

(3) Genes may be added to the gene pool by immigration from other gene pool and mutation.

(4) Genes are removed from the gene pool by natural selection and chance elimination of alleles, which take place in small population or during reduction of population size

(5) Genetic recombination following the principles of Mendelian heredity is constantly reshuffling the genes in the gene pool.

(6) Natural selection, which results from the interaction between populations and their environment, may either stabilize gene composition by eliminating most immigrants and mutants or change in a various way

(7) Evolution takes place through alternations of the frequency of genes and gene combination in the population brought about by natural selection

(8) Reproductive isolation, includes all the barriers to gene exchange between the populations has a canalizing effect

(9) The populations that are reproductively isolated from each other are almost certain to evolve in different directions while those that are not so isolated because of gene exchange will evolve in the same direction

6.0 Mechanism of evolution

6.1 Hardy – Weinberg Law

• Hardy-Weinberg Law was proposed in 1908 by the independent contributions of two scientists, Hardy (England) and Weinberg (Germany)

• Gene Pool

Gene pool is defined as "the sum total of genes present in a population "or "A gene pool comprises a diverse form of a gene combination and recombination by the process of sexual reproduction."

• Gene frequency

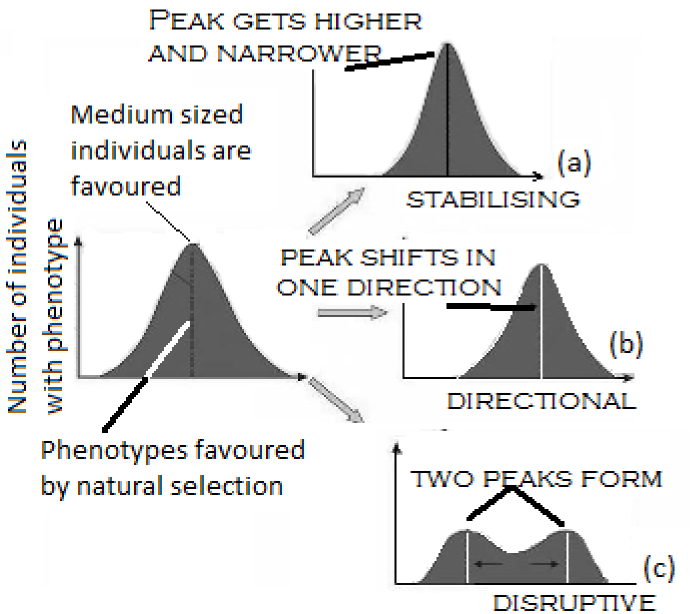
The ratio of the gene in a gene pool or in a population is called gene frequency

When the gene frequency of another allele in the population can be calculated by applying a simple formula. If the gene frequency of A – allele is p and a-allele is q, the $p+q=1$

The frequency of AA individual in the population is p^2, of aa is q^2 , of Aa is 2pq. Hence $p^2+q^2+2pq = 1$

6.2 Significance

- This law states that the gene frequencies in the large population remain constant generation after generation where there is no selection and mutation. In a small population, this equilibrium cannot be maintained
- When the population is large and in equilibrium rate of evolution is zero as there is no possibility of evolutionary change



• Gene flow

Animals are not static. They have a tendency to migrate and mate with an inmate of the population. Thus the genes of one population are transferred to another population. This is called gene flow and are an important source of genetic variation

• Genetic drift

Genetic drift is an evolutionary force operating in a small population
The change in the frequency of gene purely by chance is called genetic drift

7 Human evolutionary trends

The gradual evolution of man from ape is fully supported by available fossils

1. Propliopithecus: It was an ape-like a primate, but in the possession of short arms, it resembled a man. It lived, about 30 million years ago
2. Aegyptopithecus: It is similar to propliopithecus. It is believed that it was ancestral of Dryopithecus
3. Dryopithecus: It is a group of apes that lived about 20 million years ago. Their forelimbs were shorter than hindlimbs. It is also an ancestor of modern apes like Chimpanzee and Gorilla
4. Oreopithecus : In the structure of teeth and erect walking, it resembles a man, but having long forelimbs, it resembles apes. Straus and Simpson suggest that man and oreopithecus have parallel evolution and hence are not ancestral to man.
5. Ramapithecus: It lived 12 to 12 million years ago. The dentition is more identical to the dentition of man and their fossil was collected from Africa and India
6. Kenyapithecus: It is closely related to Ramapithecus. Its fossil is collected from East Africa.
7. Australopithecus: It is connecting link ape and man. It lived 2 to 5 million years ago. The characters of Australopithecus like man and ape are as below
   - A man like characters: Erect posture, bipedal locomotion and dentition is like that of man

- Ape-like characters: Teeth were larger than modern man, the absence of chin, eyebrow ridges projected over the eyes

8. Homo habilis : It is first human being like, It is an erect ape-man,chin absent, dental formula same as human,jaw 'U' shaped, cranial capacity -650-800cc. the first man who made tools of stone for protection

9. Homo erectus: It is an erect ape man. They are commonly called Java man because their fossils were collected from Java. They lived about 5,00,000 years ago. The main characters of Homo erectus are

- They have upright bipedal locomotion
- They were slightly taller than Australopithecus.
- The face is chinless
- They used fire and variety of tools
- cranial capacity -800-1000cc

10. Peking man: Complete erect posture, Lived in caves, cranial capacity -850-1300cc, jaws prognathous, used fire for protection and cooking, Omnivorous, use sharp tools of stones and bones for cutting and killing animals

11. Homo sapiens

(1) Neanderthal man: They existed about 75,000 years ago. The main character is

- Their eyebrow ridges were heavy and protruding
- Their teeth were large
- They had no chin
- Their cranial capacity was about 1400 cc

(2) Rhodesian man: The fossils were collected from Rhodesia. The cranial capacity was about 1300 cc

(3) Cro-magnon man: These were the men who lived in Europe during the last 30,000 years. They possessed all characteristics of modern man

(4) Modern man: They were originated 8000 years ago. The cranial capacity of modern man is 1450cc

The main human races are:

(a) Caucasoid race
(b) Negroid race
(c) Mongoloid race
(d) American race
(e) Australian race
(f) Indian race

8 Different types of evolution

a) Parallel evolution

An evolutionary process by which two or more separate species in the same environment develop similar adaptation or characteristic for survival.

Parallel evolution is similar to convergent evolution in a way that two unrelated species evolved similar traits. However, in parallel evolution, the two species evolved same traits while living in the same type of environment whereas in convergent evolution the two species evolved same traits in different types of environment.

Examples

1. North American cactus and the African euphorbia that developed similar adaptation, which is their thick stems and sharp quills to survive the hot, arid climates.

2. Internal fertilization has evolved independently in sharks, some amphibians and amniotes.

3. two groups of organisms living in similar habitats such as a marsupial mammals distinctive characteristic of these species are that most of the young are carried in a pouch in Australia and placental mammals on another continent.
4. Colouration that serves as a warning to predators and for mating displays has evolved in many different species.
5.The eye of the octopus has the same complicated structure as the human eye.

b) Divergent evolution (Homologous organs)

Also called as Adaptive Radiation
The process by which an interbreeding population or species diverges into two or more descendant species, resulting in different species developing new characteristics to enable them to survive to their new habitats.
Homologous organs are examples of divergent evolution similar structures but dissimilar function is in the state of homology and such structures are referred to as homologous structures. Examples The arm of a human, the wing of a bird. The leg of a dog and the flipper of a dolphin or whale are homologous structures.

c) Convergent evolution (Analogous organs)

A kind of evolution wherein organisms evolve structures that have similar (analogous) structures or functions in spite of their evolutionary ancestors being very dissimilar or unrelated.
convergent evolution is the process whereby organisms not closely related (not monophyletic), independently evolve similar traits as a result of having to adapt to similar environments or ecological niches
example of convergent evolution is the similar nature of the flight/wings of insects, birds, pterosaurs, and bats. All four serve

the same function and are similar in structure, but each evolved independently.

d) Retrogressive evolution

This is the process in which complex forms of organisms develop towards the simpler structural and physiological organizations.

For eg - Monocot plants are considered as more advanced groups of plants with a simple structure and herbaceous habit.
Several species of cave-dwelling animals, including fish, crabs, and salamanders, have evolved blindness and deteriorated eye structure.

e) Progressive Evolution : This is the type of evolution in which simple forms of organisms develops towards the complex forms and physiological organizations. For eg - evolution of multicellular organisms from unicellular organisms.

9. Speciation

Speciation is a process of evolution that leads to the formation of new, distinct species that are reproductively isolated from one another.

a) Allopatric speciation

When a species split into two group or more geographically isolated population, natural selection to cause genetic drift as mutations arise within populations. Over time, the separate populations may develop morphologically distinct features due to adaption to their new environment. It is a divergent speciation
Examples are Finches of Darwin

b) Sympatric Speciation

Sympatric speciation is the evolutionary process whereby species are formed from a single ancestral species while inhabiting the same geographic area or without geographical isolation. sympatry occurs when members of one population make use of a new niche. Mainly present in plants due to polyploidy. It is a divergent speciation

c) Phyletic evolution

a type of evolution characterized by the gradual change, without divergence, of an entire group of organisms. Phyletic evolution is usually characterized by moderate or low evolution rates and is detected when one studies the evolution of The evolution of the horse over 50 million years of its evolution

Eohippus → Orohippus→ Mesohippus → Miohippus→ Merychippus→ Hipparion→ Pliohippus→ Dinohippus→ Equus

d) Quantum evolution

the comparatively rapid transition from one stable type of biological adaptation to another distinctly different type under the influence of some strong selection pressure. It is caused by a major mutation

10. Isolations

The field of biology describes "isolation" as a process by which two species that could otherwise produce hybrid offspring are prevented from doing so. There are five isolation processes that prevent two species from interbreeding: ecological, temporal, behavioral, mechanical/chemical and geographical.

a) Ecological Isolation

Ecological isolation occurs when two species live in different habitats and will not encounter one another, each is isolated from the other species. For example line and tiger

b) Temporal Isolation

Temporal isolation is when species that could interbreed do not because the different species breed at different times.. For example, the field crickets Gryllus pennsylvanicus and Gveleti becomes sexually mature at different seasons, one in the spring and the other in the autumn.

c) Behavioral Isolation

Behavioral isolation refers to the fact that many species perform different mating rituals. This is a common barrier between animals. For example, certain species of crickets will only mate with males that produce a particular mating song. Other species of rituals may include a mating dance or emitting a scent. These clues are ignored by species not accustomed to the ritual.

d) Mechanical or Chemical Isolation

Mechanical isolation is caused by structures or chemical barriers that keep species isolated from one another. These chemical barriers will only allow sperm from the correct species to fertilize the egg.

e) Geographical Isolation

Geographical isolation refers to the physical barriers that exist that keep two species from mating. For example, a species of monkey that is located on an island cannot breed with another species of monkey on the mainland. The water and distance between the two species keep them isolated from one another and make it impossible for them to breed.

11. A brief account of the evolution

It is believed that first life form came into existence on earth around 2000 million years ago (mya). The vast expanse of geological time has been separated into eras

The vast expanse of geological time has been separated into eras,

Era	Plant and Animal Development
Cenozoic 66 million years ago	Extinction of dinosaurs and many other species. → "Age of mammals" → Humans develop
Mesozoic 252 to 66 million years ago	"Age of Reptiles" First flowering plants , First birds, Dinosaurs dominant
Paleozoic 541 to 251.902 million years ago	"Age of Amphibians", Extinction of trilobites and many other marine animals, First reptiles, Large coal swamps Large Amphibians abundant
	"Age of Fishes" First insect fossils , Fishes dominant ,First land plants
	"Age of Invertebrates" First fishes, Trilobites dominant, First organisms with shells
Precambrian 4,600 million years ago	Origin of Earth , First one-celled organisms , First multicelled organisms

12. Distinguish

i) Difference between convergent and divergent evolution

Convergent evolution	divergent evolution
Different ancestor species are genetically different	Common ancestor, shares genetic homology
Convergent evolution is a process by which distantly related species develop similar structures as adaptations to the environment	Divergent evolution is a process by which an interbreeding species diverges into two or more descendant species.
Both species live in the same environment.	The divergence of two different species results in two species becoming less like the common ancestor.
developing analogous structures.	developing homologous structures.
Ostriches, rheas, and emus are examples of convergent evolution. Wings of insects birds and bats	Dinosaurs, Darwin's finches, and forelimb structures of vertebrates are examples of divergent evolution.

ii) Difference between Adaptive radiation and divergent evolution

Adaptive radiation	divergent evolution
adaptive radiation is a process in which organisms diversify rapidly from an	The process by which an interbreeding population or species diverges into two or

ancestral species into a multitude of new forms,	more descendant species, resulting in once similar or related species to become more and more dissimilar
Adaptive radiation is a type of microevolution.	Divergent evolution is a type of macroevolution.
The outcome of the adaptive radiation is different morphological, physiological and ecological changes in a particular population.	A new generation of species is formed which are unable to interbreed with the original species.
Examples of adaptive radiation include Darwin’s finches and Australian marsupials.	Penta-dactyl limb structure of mammals is an example of divergent evolution.

iii) Difference between Darwinism and Lamarckism

Darwinism	Lamarckism
It does not believe in the internal vital force	This theory states that there is an internal vital force in all organisms.
They do not form part of Darwin’s natural selection theory.	It considers new needs or desire produce new structures and change habits of the organism

An organ can develop further or degenerate only due to continuous variations.	According to this theory if an organ is constantly used it would be better developed whereas disuse of organ results in its degeneration.
Struggle for existence is very important in this theory	It does not consider struggle for existence.
Only useful variations are transferred to the next generation	All the acquired characters are inherited to the next generation.
Darwin's natural selection theory is based on survival of the fittest.	Lamarckism does not believe in survival of the fittest.

iv) Difference between Humans and Apes

Humans	Apes
Walks fully erect after infancy on the soles of the feet.	Walks semi-erect on outer edges of feet and knuckles of hands.
Head erect and balanced on the neck	Head balanced on heavy shoulders and is buried
Cranium rounded with a cranial capacity of about 1450cm3	Cranium flattened with a cranial capacity under 650cm3
Jaw small with a prominent chin	Jaw strong without well-marked chin.
Anterior premolar in the	Anterior premolar in the

lower jaw is small and bicuspid.	lower jaw is strong and pointed.
Canines are not projecting	Canines are projecting.
Body covered with short and sparse hair.	Body covered with long and coarse hair.

That’s all folks

सर्वे भवन्तु सुखिनः सर्वे सन्तु निरामयाः । सर्वे भद्राणि पश्यन्तु मा कश्चिद्दुःखभाग्भवेत्

॥

All should/must be happy, be healthy, see good; may no one have a share of sorrow.