The Living World

1 Chapter

1 WHAT IS LIVING?

When we try to define living we simply understand that what living is as opposed to the non-living

- There are some unique features of living organisms such as growth, reproduction, ability to sense environment, metabolism, ability to self replicate, self organise and interact.

FEATURES	DEFINING OR CHARACTERISTICS	SEEN IN
GROWTH Increase in mass and increase in number	Characteristic	Both living (Intrinsic) and non living objects (Extrinsic)
REPRODUCTION Production of progeny of same kind	Characteristic	Living organisms but some exceptions are seen such as infertile human couples, mules and sterile worker bees
METABOLISM Sum total of all the chemical reactions occuring in body.	Defining	Seen in all unicellular as well as multicellular organisms.
CONSCIOUSNESS Ability to respond to external stimulus	Defining	Seen in all unicellular as well as multicellular organisms. Only human is self-conscious
CELLULAR ORGANISATION	Defining	Seen in all unicellular and multicellular organisms

- Reproduction is synonymous with growth in unicellular organisms but not in multicellular organisms.
- A reaction in test tube is neither living nor non-living.
- Photoperiod affects reproduction in seasonal breeders, both plants and animals.
- In *Planaria* (flat-worms), we observe true regeneration.
- Properties of tissues are not present in constituent cells similarly properties of cell organelles are not present in the molecular constituents of the organelles but arise due to interactions.
- The patient lying in coma has no self-consciousness.
- All living organisms – Present, past and future are linked to one another by the sharing of the common genetic material but to varying degrees.
- Living organisms are self-replicating, evolving and self regulating interactive system capable of responding to external stimuli.

2 DIVERSITY IN THE LIVING WORLD

- Biodiversity is number and types of organisms present on earth.
- The number of species that are known and described range between 1.7-1.8 million.
- As local names vary from place to place, there is need to standardise the naming of living organisms. This process is NOMENCLATURE.
- Before nomenclature identification should be done.
- Scientific names are based on agreed principles and criteria which are provided in ICBN (International Code of Botanical Nomenclature) - for plants and ICZN (International Code for Zoological Nomenclature) - for animals.
- The most accepted system for naming of organisms is binomial nomenclature, given by **Carolus Linnaeus**
- According to this, each scientific name has two names, the generic name and specific epithet and are generally in Latin.
  Ex. Mango → *Mangifera indica* Linn.
  Genus Species
- Genus starts with capital letter and species starts with small letter.
- Scientific name should be printed in italics, if handwritten should be underlined separately.
- Name of the author should be at the end of the biological name in abbreviated form.

CLASSIFICATION :

- Classification is process by which anything is grouped into convenient categories. The scientific terms for these categories is taxa. (Dogs, cats, mammals, plants etc.)
- Hence, based on characteristics, all living organisms can be classified into different taxa. This process is called taxonomy.
- Taxa can indicate categories at very different levels. e.g. animals , mammals and dogs represent taxa at different levels.
- Taxonomy and evolutionary relationships = systematics.
- Morphology, anatomy, cell structure, development process and ecological informations are basis of modern taxonomic studies.
- Characterisation, identification, classification and nomenclature are basics of taxonomy.

3 TAXONOMIC CATEGORIES

- Each step in classification is called **category or rank**.
- As it is a part of taxonomy hence called taxonomic category and all categories constitute **taxonomic hierarchy**.
- There are seven obligate categories.
- Sub categories are also developed by scientists.
- The number of common characteristics goes on decreasing from species to kingdom.
- Each rank or taxon infact, represents a unit of classification.

4

ASCENDING ORDER

- Kingdom
- Phylum/division — For plants division is used, has related classes
- Class — Has assemblage of related orders
- Order — Has related families characterised mainly on floral characters
- Family — Comprises a group of related genera. Characterised on the basis of both vegetative and floral characters
- Genus — Comprises a group of related species
- Species (Basic and lowest category)

5

ANIMALS	CATEGORIES	PLANTS
leo, tigris, pardus	: Species :	***tuberosum, nigrum, melongena***
Felis + *Panthera*	: Genus :	*Solanum* + ***Datura, Petunia***
Canidae + Falidae	: Family :	Solanaceae + ***Convolvulaceae***
Primata + Carnivora	: Order :	Polymoniales + ***Sapindales***
Aves, Reptalia + Mammalia	: Class :	Dicotyledonae + ***Monocotyledonae***
Non chordata + Chordata	: Phylum/ division :	Angiospermae + ***Gymnospermae***
Animalia	: Kingdom	Plantae

- The word systematics is derived from Latin word 'systema' which means systematic arrangement of organisms.
- Higher the category, greater is the difficulty of determining the relationship to other taxa at the same level. Hence, the problem of classification becomes more complex.

6 ORGANISMS WITH THEIR TAXONOMIC CATEGORIES

Common Name	Biological Name	Genus	Family	Order	Class	Phylum/ Division
Man	*Homo sapiens*	*Homo*	Hominidae	Primata	Mammalia	Chordata
Housefly	*Musca domestica*	*Musca*	Muscidae	Diptera	Insecta	Arthropoda
Mango	*Mangifera indica*	*Mangifera*	Anacardiaceae	Sapindales	Dicotyledonae	Angiospermae
Wheat	*Triticum aestivum*	*Triticum*	Poaceae	Poales	Monocotyledonae	Angiospermae

7 TAXONOMICAL AIDS

- These aids are prime source of taxonomical studies.

Taxonomical aids

Herbarium
- Store house of dried, presses and preserved plant specimens pasted on sheets
- Each sheet carries a label which has information of specimen

Monograph
Monograph contains information of any one taxon

Museum
- Generally setup in schools and educational institutes
- Has preserved plant and animal specimens, large animals are usually stuffed
- Insects are preserved in insect boxes

Manual
- Are useful in providing information for identification of names of species found in an area.

Flora
- Provides the index to the plant species found in a particular area.

Botanical Gardens
- Have collection of living plants for reference
- Each plant is labelled
- Largest Botanical garden at Kew (England) Indian Botanical Garden in Howrah.

Keys
- Analytical in nature
- Based on contrasting characters generally in pair, couplet
- Based on similarities and dissimilarities
- Each statement is called a lead

Zoological parks
- Wild animals are kept in their natural environment

Sharpen Your Understanding

1. Which of the following is seen in all organisms without exception? [NCERT Pg. 5]
   (1) Growth
   (2) Metabolism
   (3) Reproduction
   (4) Self consciousness
2. In the scientific name of mango, the word *indica* indicates [NCERT Pg. 9]
   (1) Generic name
   (2) Specific epithet
   (3) Family to which it belongs
   (4) Class to which it belongs
3. Wheat belongs to [NCERT Pg.11]
   (1) Family Solanaceae
   (2) Order Poales
   (3) Class Poales
   (4) Family Anacardiaceae
4. Which of the following statements is **incorrect**? [NCERT Pg. 4]
   (1) Increase in mass and increase in number of individuals are twin characteristics of growth
   (2) Mountains and sand dunes do not grow
   (3) Living organisms show intrinsic growth
   (4) Unicellular organisms grow by cell divisions.

NCERT Based MCQs

5. Reproduction is synonymous with growth in [NCERT Pg. 4]
   (1) Bacteria
   (2) *Amoeba*
   (3) Multicellular organisms
   (4) Both (1) and (2)
6. All living organisms [NCERT Pg. 4-5]
   (1) Reproduce
   (2) Show growth but not consciousness
   (3) Sense their surroundings
   (4) Are not self replicating
7. ICBN stands for [NCERT Pg. 6]
   (1) International Code for Bacterial Nomenclature
   (2) International Code for Botanical Nomenclature
   (3) International Code for Bacteriophages Nomenclature
   (4) International Code for blue green algae
8. Which of the following is **incorrect** about binomial nomenclature? [NCERT Pg. 7]
   (1) Biological names are generally in Latin and printed in italics
   (2) First word is genus and second word denotes the specific epithet
   (3) Both the words are separately underlined when handwritten
   (4) Both the words start with capital letter
9. Select the **odd** one w.r.t. basics of taxonomy. [NCERT Pg. 8]
   (1) Identification
   (2) Classification
   (3) Evolutionary relationship between organisms
   (4) Nomenclature
10. Select the **incorrect** statement. [NCERT Pg. 8]
    (1) The word systematics is derived from the Latin word 'systema'
    (2) All taxonomic categories together constitute taxonomic hierarchy
    (3) Taxonomic categories are merely morphological aggregate
    (4) Each rank is a category
11. Select the **odd** one w.r.t. genus which contains many species? [NCERT Pg. 9]
    (1) *Panthera*
    (2) *Homo*
    (3) *Solanum*
    (4) Both (1) and (3)
12. Genus is a group of related [NCERT Pg. 9]
    (1) Families
    (2) Orders
    (3) Species
    (4) Classes

13. Mark the **odd** one w.r.t. taxonomic category. [NCERT Pg. 9-10]
    (1) Felidae
    (2) Solanaceae
    (3) Canidae
    (4) Carnivora

14. Which of the following taxonomic category comes after order in ascending order of hierarchy? [NCERT Pg. 10]
    (1) Family
    (2) Species
    (3) Class
    (4) Genus

15. Find the **incorrect** match. [NCERT Pg. 11]
    (1) Man – Hominidae
    (2) Housefly – Felidae
    (3) Mango – Anacardiaceae
    (4) Wheat – Poaceae

16. Read the following statements and select the **correct** option. [NCERT Pg. 11]
    Statement A : The collection of actual specimens of plants and animal species is essential and is prime source of taxonomic studies.
    Statement B : Taxonomic studies of various species of plants, animals and other organisms are useful in agriculture, forestry, industry.
    (1) Only statement A is correct
    (2) Only statement B is correct
    (3) Both statements A and B are correct
    (4) Both statements A and B are incorrect

17. Herbarium sheet carries a label which contains all given information, **except** [NCERT Pg. 12]
    (1) Date and place of collection of specimen
    (2) Botanical name of specimen
    (3) Name of the collector
    (4) Height of the specimen

18. Indian botanical garden is situated in [NCERT Pg. 12]
    (1) Lucknow (2) Howrah
    (3) Darjeeling (4) Delhi

19. Which of the following statement is **incorrect** for museums? [NCERT Pg. 12-13]
    (1) They have collection of preserved plant and animal specimens for study and reference
    (2) Insects are preserved in insect boxes.
    (3) Larger animals like birds and mammals are usually stuffed and preserved
    (4) Live wild animals are also kept to study their food habits and behaviour

20. Select the **correct** statement for keys. [NCERT Pg. 13]
    (1) Is analytical in nature
    (2) Is based on similarities only
    (3) Each statement in key is called couplet
    (4) Same taxonomic keys are required for each taxonomic category

Thinking in Context

1. A _____ grow by cell division. [NCERT Pg. 4]
2. _____ easily multiply by fragmentation. [NCERT Pg. 4]
3. _____ of the body is defining feature of life forms. [NCERT Pg. 5]
4. *Solanum*, *Petunia* and *Datura* are placed in the family _____ [NCERT Pg. 9]
5. All the three names, *indica*, *tuberosum* and *leo* represent the _____ [NCERT Pg. 9]
6. _____ includes related orders [NCERT Pg. 10]
7. As we go higher from species to kingdom, the number of common characteristics goes on _____ [NCERT Pg. 11]
8. Wheat belongs to the class _____. [NCERT Pg. 11]
9. _____ is the store house of collected plant specimens that are dried, pressed and preserved on sheets. [NCERT Pg. 11-12]
10. National Botanical Research institute is situated in _____ [NCERT Pg. 12]

11. Monographs contain information on any _____ taxon [NCERT Pg. 14]
12. _____ contains the actual account of habitat and distribution of plants of a given area [NCERT Pg. 14]
13. Scientific name of mango is _____ [NCERT Pg. 13]
14. Order primata is placed in class _____ [NCERT Pg. 10]
15. The word systematics is derived from the _____ word 'systema' [NCERT Pg. 8]
16. Lion, leopard and tiger with several common features are all species of the genus _____. [NCERT Pg. 9]
17. Plant families like convolvulaceae and solanaceae are included in the order _____ [NCERT Pg. 10]
18. The number of species that are known and described range between _____ million. [NCERT Pg. 6]
19. Isolated metabolic reactions *in vitro* are not living things but surely _____ [NCERT Pg. 5]
20. The most obvious and technically complicated feature of all living organisms is _____ [NCERT Pg. 5]

❑ ❑ ❑

Biological Classification

2 Chapter

1 INTRODUCTION

There have been many attempts to classify living organisms since the dawn of civilisation. Aristotle was the earliest to attempt a more scientific basis for classification. He used simple morphological characters to classify plants into trees, shrubs and herbs. He also divided animals into two gropus, with RBCs and without RBCs.

2 TWO KINGDOM CLASSIFICATION SYSTEM

- Given by Linnaeus.
- Organisms were divided into two kingdoms Plantae and Animalia.

Disadvantages: This system did not distinguish between eukaryotes and prokaryotes, unicellular and multicellular organism & photosynthetic & non photo-synthetic organisms.

3 FIVE KINGDOM CLASSIFICATION SYSTEM

- Given by R.H. Whittaker.
- All organisms were divided into five kingdoms Monera, Protista, Fungi, Plantae and Animalia.
- Fungi were placed in separate kingdom called kingdom fungi.

Characters	Five Kingdoms				
	Monera	Protista	Fungi	Plantae	Animalia
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell wall	Noncellulosic (Polysaccharide+ amino acid)	Present in some	Present with chitin	Present (cellulose)	Absent
Nuclear membrane	Absent	Present	Present	Present	Present
Body organisation	Cellular	Cellular	Multicellular/ loose tissue	Tissue/ organ	Tissue/organ/ organ system
Mode of nutrition	Autotrophic (chemosynthetic and photosynthetic) and Heterotrophic (saprophytic/parasitic)	Autotrophic (Photosynthetic) and Heterotrophic	Heterotrophic (Saprophytic/ Parasitic)	Autotrophic (Photosynthetic)	Heterotrophic (Holozoic/ Saprophytic etc.

- Earlier classification systems included bacteria, blue green algae, fungi, mosses, ferns, gymnosperms and angiosperms under plants due to presence of cell wall.
- *Chlamydomonas* and *Spirogyra* were placed under algae.
- Kingdom Protista put together *Chalamydomonas, Chlorella* with *Paramoecium* and *Amoeba.*
- Over time, an attempt has been made to evolve a classification system which reflects not only the morphological, physiological and reproductive similarities but also phylogenetic i.e. is based on evolutionary relationships.

4 KINGDOM MONERA

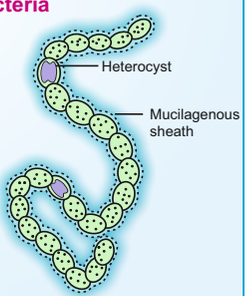
- Sole members of the kingdom are bacteria which occur almost everywhere.
- Many of them live in or on other organisms as parasites.
- They are grouped under four categories based on their shapes, spherical (*Coccus*), rod shaped (*Bacillus*), comma shaped (*Vibrio*) and spiral shaped (*Spirillum*).

ARCHAEBACTERIA

- Are special bacteria since they live in some of the harsh habitats such as extreme salty areas (halophiles) hot springs (thermoacidophiles) and marshy areas (methanogens).
- Have different cell wall structure than other bacteria. This feature is responsible for their survival in extreme conditions.
- Methanogens produce methane and found in gut of ruminant animals.

EUBACTERIA or True Bacteria

- **Cyanobacteria** (Blue green algae)
  - May be unicellular, colonial or filamentous, fresh water/marine or terrestrial.
  - Have chlorophyll a similar to green plants.
  - Are photosynthetic autotrophs.
- **Mycoplasma**
  - Smallest living known cells.
  - Can survive without oxygen.
  - Completely lack cell wall.
  - Are pathogenic to both plants and animals.



- Bacteria are simple in structure but very complex in behaviour.
- Show most extensive metabolic diversity.
- Majority of bacteria are heterotrophic but can be photo or chemoautotrophic.
- Chemosynthetic autotrophs oxidise various inorganic substances and play great role in recycling nutrients like nitrogen.
- **Heterotrophic bacteria:** Majority are decomposers and are helpful in making curd from milk, production of antibiotics, fixing nitrogen in legumes etc.
- Some are parasites, cause disease like cholera, typhoid, tetanus, citrus canker etc.

5 KINGDOM PROTISTA

- All single celled eukaryotes are placed in kingdom protista.
- Members are primarily aquatic.
- Boundaries of this kingdom are not well defined.
- Reproduce sexually and asexually both.

Chrysophytes

- Includes diatoms and golden algae (desmids).
- Microscopic and floats passively in water currents.
- Most of them are photosynthetic.
- Cell wall has silica and thus indestructible.
- Body look likes soap box.
- Form diatomaceous earth.
- Are chief producers in the oceans.

Dinoflagellates

- Mostly marine and photosynthetic.
- Appear in various colours depending on main pigments present in their walls.
- Biflagellated.
- Cell wall has stiff cellulosic plates on the outer surface.
- Responsible for red tides.
- Toxins released by organisms may kill other marine animals (fishes) *Gonyaulax*.

KINGDOM PROTISTA

Euglenoids

- Are fresh water forms found in stagnant water.
- Photosynthetic in presence of sunlight and predators in absence of sunlight.
- Biflagellated, has one short and one long flagella.
- Cell wall absent but proteinaceous pellicle present. Eg. *Euglena*.

Slime Moulds

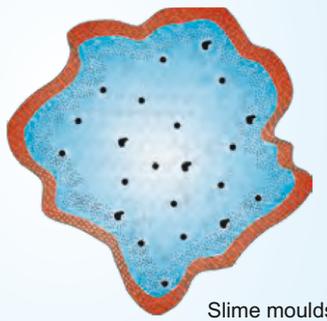
- Are saprophytic protists.
- Body moves along decaying twigs and leaves engulfing organic material.
- Under favourable conditions form plasmodium and under unfavourable conditions they form fruiting bodies.
- Spores have true walls, resistant to adverse conditions and dispersed by air currents.

Protozoans

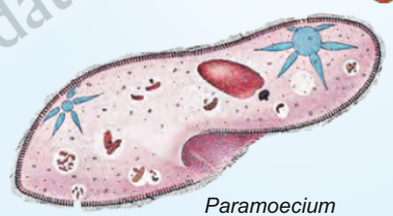
- Are heterotrophs and believed to be primitive relatives of animals.
- **Amoeboid:** have pseudopodia for capturing prey. Many have silica shells on their surface. Some are parasites Eg. *Entamoeba*, *Amoeba*.
- **Flagellated:** have flagella. Parasitic forms many cause disease as sleeping sickness. Eg. *Trypanosoma*.
- **Ciliated:** have cilia, gullet. Eg. *Paramoecium*.
- **Sporozoans:** have inflectious spore like stage in their life-cycle. Eg. *Plasmodium* (malarial parasite)

Dinoflagellates

Euglena



Slime moulds



Paramoecium

6 KINGDOM FUNGI

- Constitute a unique kingdom of heterotrophic organisms.
- Show great diversity in morphology and habitat.
- Unicellular forms such as yeast is used in bread and beer making.
- Most of them are saprophytes but they can be parasitic or symbionts such as lichens and mycorrhiza associations.
- Reproduction can take place by vegetative, asexual or sexual means.
- Vegetative reproduction by fragmentation, fission or budding.
- Asexual reproduction by spore formation such as conidia, sporangiospores or zoospores.
- Sexual reproduction involves oospores, ascospores and basidiospore formation.
- The sexual cycle involves three steps
  - Plasmogyamy – Fusion of protoplasm between two motile or non-motile gametes.
  - Karyogamy – Fusion of two nuclei.
  - Meiosis – In zygote results in haploid spores.
- The morphology of mycelium, mode of spore formation and fruiting bodies form the basis for the division of kingdom fungi into various classes.

- In some fungi (ascomycetes and basidiomycetes) an intervening dikaryotic stage (n + n) occurs. Such condition is called a dikaryon and the phase is called dikaryophase.

Comments	Phycomycetes	Ascomycetes (Sac fungi)	Basidiomycetes (Club fungi)	Deuteromycetes (Imperfect fungi)
Habitat	Aquatic habitats and on decaying wood or as obligate parasites on plant.	Coprophilous, saparophytic decomposers or parasitic.	Grow in soil, on logs and tree stumps or as parasites e.g. rust and smuts.	Saprophytes, parasites and some of them are decomposers and help in mineral recycling.
Mycelium	Aseptate and coenocytic.	Are multicellular, rarely uni-cellular, branched and septate.	Branched and septate	Branched and septate
Asexual Reproduction	By endogenously produced zoospores (motile) or aplanospores	Conidia, produced exogenously	Generally not found but vegetatively by fragmentation	Conidia
Sexual Reproduction	Zygospore is formed by fusion of two gametes.	Ascospores produced in asci, which is turn are arranged in fruiting bodies called ascocarp.	Sex organs are absent. Sexual spores are basidiospores formed on basidium inside basidiocarps	Absent
Examples	*Mucor, Rhizopus* (bread mould) and *Albugo* (the parasitic fungi on mustard)	*Aspergillus, Claviceps, Neurospora* (used in biochemical & genetic work), Morels and truffles (edible), *Penicillium* (source of antibiotics)	*Agaricus, Ustilago, Puccinia* (Parasitic), Bracket fungi & Puffballs.	*Alternaria*, *Colletotrichum*, *Trichoderma*

7 KINGDOM PLANTAE

- Includes all eukaryotic chlorophyll containing organisms called plants.
- Some are partially heterotrophic such as insectivorous plants *e.g. Cuscuta,* Bladderwort and Venus fly trap.
- Life cycle has two distinct phases - diploid sporophytic and haploid gametophytic, phenomenon called alternation of generation.

8 KINGDOM ANIMALIA

- Includes heterotrophic eukaryotic organisms called animals.
- These are multicellular and lack cell walls.
- Mode of nutrition is holozoic.
- Store food as glycogen or fat.
- Are capable of locomotion.
- Higher forms show elaborate sensory and neuromotor mechanism.

9 VIRUSES, VIROIDS, PRIONS AND LICHENS

- In R.H. Whittaker's system, there is no mention of lichens, viruses, viroids and prions.
- Viruses are non-cellular that are characterised by having an inert crystalline structure outside the living cell.
- Viruses contain either RNA or DNA.
- Bacterial viruses usually have dsDNA, viruses that infect plants generally have ss-RNA.
- Protein coat is called capsid made up of capsomeres, which protect the nucleic acid.
- Virus name given by Pasteur, recognized by D.J. Ivanowsky, demonstrated by M.W. Beijerinek.
- Viruses causes diseases in animals as well as plants. They cause mumps, small pox, herpes & influenza in animals.

VIROIDS

- Discovered by T.O Diener.
- Was found to be free RNA, devoid of protein coat, hence named viroid.
- Cause potato spindle tuber disease.

PRIONS

Is abnormally folded protein. Similar in size to viruses. Cause Bovine spongiform encephalopathy (BSE) commonly called mad cow disease in cattle and its analogous variant Cr-jacob disease CJD humans.

LICHENS

- Symbiotic association between algae & fungi.
- The algal component is phycobiont (autotrophic) and fungal component is mycobiont (heterotrophic)
- Lichens are good pollution indicators, they do not grow in polluted areas.

- In plants symptoms of viral diseases can be mosaic formation, leaf rolling and curling, yellowing and vein clearing, dwarfing and stunted growth.

Sharpen Your Understanding

1. Two kingdom system of classification did not distinguish between all of the given, **except** [NCERT Pg. 16]
   (1) Photosynthetic and non-photosynthetic
   (2) Eukaryotes and prokaryotes
   (3) Plants and animals
   (4) Unicellular and multicellular
2. In which kingdom, chemosynthetic organisms are seen out of five kingdoms proposed by Whittaker? [NCERT Pg. 17]
   (1) Protista (2) Monera
   (3) Fungi (4) Plantae
3. Select the **incorrect** statement. [NCERT Pg. 17]
   (1) In three domain system, all eukaryotes are placed in single domain
   (2) Plants have cellulosic cell wall
   (3) Cell type is prokaryotic in kingdom Monera
   (4) Mode of nutrition was not the criteria to classify organisms in five kingdom classification
4. The composition of fungal cell wall is [NCERT Pg. 17]
   (1) Cellulose
   (2) Non-cellulose (Polysaccharides + lipid)
   (3) Chitin
   (4) Lignin
5. Kingdom Protista has brought together *Chlamydomonas, Chlorella* with *Paramecium* and *Amoeba* as they all [NCERT Pg. 18]
   (1) Are heterotrophic
   (2) Have cell wall
   (3) Lack cell wall
   (4) Are unicellular and eukaryotic
6. Select the **incorrect** statement about kingdom Monera. [NCERT Pg. 18]
   (1) Bacteria are the sole members of kingdom Monera
   (2) They are most abundant micro-organisms
   (3) They can live in extreme habitats
   (4) They cannot be parasites
7. Find the **incorrect** match w.r.t. shapes of bacteria. [NCERT Pg. 18]
   (1) *Coccus* : Spherical shaped
   (2) *Bacillus* : Rod shaped
   (3) *Vibrium* : Circular shaped
   (4) *Spirillum* : Spiral shaped
8. Read the following statements and select the **correct** option. [NCERT Pg. 19]

   Statement-A: Bacteria as a group show most extensive metabolic diversity.

   Statement-B: Bacteria may be photo-synthetic autotropic or chemosynthetic autotrophic.
   (1) Only statement A is correct
   (2) Only statement B is correct
   (3) Both statements A and B are correct
   (4) Both statements A and B are incorrect

NCERT Based MCQs

9. Mark the **odd** one w.r.t. methanogens. [NCERT Pg. 19]
   (1) Found in the guts of ruminants
   (2) Responsible for production of methane
   (3) Live in some of the most harsh habitats
   (4) Have cell wall structure same as other bacteria
10. Cyanobacteria are also referred to as [NCERT Pg. 19]
   (1) Red algae
   (2) Green algae
   (3) Brown algae
   (4) Blue green algae
11. All of the following are functions of heterotrophic bacteria, **except**. [NCERT Pg. 19]
   (1) Making curd from milk
   (2) Fixing nitrogen in legumes
   (3) Production of antibiotics
   (4) Fixing atmospheric carbon

12. Select the **wrong** for mycoplasma. [NCERT Pg. 20]

(1) Can survive without oxygen

(2) Completely lack cell wall

(3) Pathogenic to plants and animals

(4) Are largest monerans

13. Select the **incorrect** one about Kingdom Protista. [NCERT Pg. 20]

(1) Being eukaryotes, the protistan cell body contains a well-defined nucleus and other membrane bound organelles

(2) They reproduce asexually only

(3) Boundaries of this kingdom are not well defined

(4) Members are primarily aquatic

14. Which statement is **wrong** about chrysophytes? [NCERT Pg. 20]

(1) They are microscopic

(2) Most of them are photosynthetic

(3) In diatoms the cell walls forms two thin overlapping shells, which fit together as in a soap box

(4) They are found in terrestrial habitats only

15. Which of the following is responsible for red tide? [NCERT Pg. 21]

(1) Diatoms (2) Desmids

(3) *Gonyaulax* (4) Slime moulds

16. Which of the following statements is **incorrect**? [NCERT Pg. 21]

(1) Dinoflagellates have two flagella

(2) Euglenoids are fresh water organisms

(3) Slime moulds are saprophytic protists

(4) The spores of slime moulds lack cell wall

17. The basis for division of the kingdom fungi into various classes is all, **except** [NCERT Pg. 23]

(1) Morphology of mycelium

(2) Mode of nutrition

(3) Mode of spore formation

(4) Type of fruiting bodies

18. Select the **incorrect** match [NCERT Pg. 23-24]

(1) *Rhizopus* : Sac fungi

(2) *Penicillium* : Multicellular

(3) Morels and truffles : Edible fungi

(4) *Ustilago* : Smut

19. Select the **incorrect** statement. [NCERT Pg. 25]

(1) Kingdom plantae includes all eukaryotic chlorophyll-containing organisms

(2) Life cycle of plants has two distinct phases

(3) Kingdom animalia includes multicellular organisms

(4) Animals store glycogen or starch

20. Mark the **wrong** statement. [NCERT Pg. 27]

(1) Viruses, viroids and prions are acellular

(2) Lichens are symbiotic associations between algae and fungi

(3) Viruses contain genetic material

(4) Prions are abnormally folded RNA molecules

Thinking in Context

1. _____ proposed five kingdom classification. [NCERT Pg. 17]

2. _____ are sole members of kingdom monera. [NCERT Pg. 18]

3. Bacterial ___A___ is very simple, but they are very complex in ___B___. [NCERT Pg. 19]

4. Archaebacteria found in salty areas are called _____. [NCERT Pg. 19]

5. Cyanobacteria have _____ similar to green plants. [NCERT Pg. 19]

6. _____ bacteria oxidise various inorganic substances such as nitrates, nitrites and ammonia and use the released energy for their ATP production. [NCERT Pg. 19]

7. Bacteria mainly reproduce by _____. [NCERT Pg. 20]

8. All single-celled eukaryotes are placed under _____. [NCERT Pg. ??]

9. Chrysophytes includes ___A___ and ___B___. [NCERT Pg. 20]

10. _____ are chief 'producers' in the ocean. [NCERT Pg. 20]

11. Euglenoids lack cell wall, they have _____ rich layer called pellicle. [NCERT Pg. 21]

12. During unfavourable conditions, the plasmodium of slime moulds differentiates and forms _____. [NCERT Pg. 21]

13. Protozoans are believed to be primitive relatives of _____. [NCERT Pg. 21]

14. Fungi that depend on living plants and animals are called _____. [NCERT Pg. 22]

15. Fusion of two nuclei is called _____. [NCERT Pg. 23]

16. In phycomycetes, asexual reproduction takes place by ___A___ or by ___B___. [NCERT Pg. 23]

17. Coprophilous fungi grow on _____ [NCERT Pg. 23]

18. The sex organs are generally absent in fungi called _____. [NCERT Pg. 24]

19. _____ is an example of insectivorous plant. [NCERT Pg. 25]

20. The viruses are _____ organisms that are characterized by having inert crystalline structure outside the living cell. [NCERT Pg. 25]

❑ ❑ ❑

Plant Kingdom

3 Chapter

1 INTRODUCTION

- Our understanding of the plant kingdom has changed overtime.
- Fungi and members of the Monera and Protista having cell walls have now been excluded from plantae. Cyanobacteria that are also referred to as blue green algae are not algae anymore.
- In plant kingdom, we describe algae, bryophytes, pteridophytes, gymnosperms and angiosperms.

2 CLASSIFICATION SYSTEMS

ARTIFICIAL

- Used only gross superficial morphological characters like habit, colour, number and shapes of leaves etc.
- Based mainly on vegetative characters or on the androecium structure (system given by Linnaeus).

LIMITATIONS

- Separated closely related species as they were based on a few characteristics.
- It gave equal weightage to vegetative and sexual characters. This is not acceptable because vegetative characters are more easily affected by environment.

NATURAL

- Based on natural affinities among organisms and consider both external and internal features, like
  - Ultrastructure
  - Anatomy
  - Embryology
  - Phytochemistry
- Such a classification for flowering plants was given by George Bentham and Joseph Dalton Hooker

PHYLOGENETIC

- Based on evolutionary relationship between the various organisms.
- This assumes that organisms belonging to the same taxa have a common ancestor.

3 BRANCHES OF TAXONOMY

NUMERICAL TAXONOMY

- Carried out using computers. Based on observable characteristics.
- Number and codes are assigned to all characters and then data are processed.
- Each character is given equal importance and at the same time hundreds of characters can be considered.

CYTOTAXONOMY

- Based on cytological information like chromosome number, structure and behaviour.

CHEMOTAXONOMY

- Uses chemical constituents of the plants to resolve confusions.

- (These become more important when there is no supporting fossil evidence)

4 ALGAE

- Algae are chlorophyll bearing, simple, thalloid, autotrophic and large aquatic (both fresh water and marine) organisms.
- They occur in variety of other habitats like moist stones, soil & wood.
- Some occur in association with fungi (lichen) & animals (e.g. on sloth bear).
- **Form and size** is highly variable, from colonial (*Volvox*) to filamentous (*Ulothrix* and *Spirogyra*) to massive plant bodies (**marine forms like Kelps**) to unicellular form (*Chlamydomonas*).
- Algae can reproduce by vegetative (**fragmentation**), asexual and sexual means.
- Asexual reproduction – by formation of different types of spores. Most common is zoospore.
- Sexual reproduction 1. ISOGAMOUS = Gametes are similar in size
  (I) Flagellated gametes e.g. *Ulothrix*
  (ii) Non -flagellated gametes e.g. *Spirogyra*
  2. ANISOGAMOUS = Gametes dissimilar in size e.g. *Eudorina*
  3. OOGAMOUS = Fusion between one large non-motile female gamete and a smaller male gamete. e.g. *Volvox, Fucus*

ECONOMIC IMPORTANCE

- At least a half of the total CO_2 fixation on earth is carried out by algae.
- Being photosynthetic they increase the level of dissolved oxygen in their immediate environment.
- They are primary producers of energy-rich compounds which form the basis of food cycles of all aquatic animals.
- Many species of *Porphyra*, *Laminaria* and *Sargassum* are among 70 species of marine algae used as food.
- HYDROCOLLOIDS like algin (brown algae) and carrageen (red algae) are used commercially.
- Agar obtained from *Gelidium* and *Gracilaria* are used to grow microbes and in preparations of ice-creams and jellies.
- *Chlorella* are rich in proteins and used as food supplement even by space travellers.

5 THE THREE MAIN CLASSES OF ALGAE

CHLOROPHYCEAE
- Usually grass-green due to dominance of Chl- a & b. Commonly called green algae.
- Pigments are localised in definite chloroplasts.
- Most members have one or more storage bodies in the chloroplasts called pyrenoids, which contain protein & starch.
- Have rigid cell-wall made of inner-cellulose and outer layer of pectose.
- Sexual reproduction may be isogamous, anisogamous or oogamous.
- Eg *Chlamydomonas, Volvox, Ulothrix, Spirogyra, Chara*. etc.

PHAEOPHYCEAE
- Found primarily in marine habitats.
- Commonly called brown algae.
- Possess chl- a, c; carotenoids and xanthophylls.
- Olive green to various shades of brown depending on amount of xanthophyll pigment fucoxanthin.
- Food storage as laminarin and mannitol
- Cellulosic cell wall covered by algin.
- Plant body usually has holdfast, stipe and frond.
- In most brown algae pear shaped biflagelled zoospores have two unequal laterally attached flagella.
- Sexual reproduction may be isogomous, anisogamous or oogamous.
- Gametes pyriform with two laterally attached flagella.
- *Eg. Ectocarpus*, *Dictyota, Laminaria, Sargassum, Fucus etc.*

RHODOPHYCEAE
- Red algae have predominance of red pigment r-phycoerythrin in their body.
- Possess chl-a and d.
- Majority are marine with greater concentrations found in warmer areas.
- Occur both in well-lighted regions close to water surface or at great depth in ocean where little light penetrates.
- Cell wall is made up of cellulose, pectin and polysulphated esters.
- Mostly multicellular with some having complex body organisation.
- Food stored as floridean starch, very similar to amylopectin and glycogen in structure.
- Asexual spores and gametes are non-motile
- Sexual reproduction is oogamous and accompanied by complex post fertilisation developments.
- Eg. *Polysiphonia, Porphyra, Gracilaria Gelidium* etc.

6 BRYOPHYTES (Mosses and Liverworts)
- Bryophytes commonly grow in moist shaded area in the hills.
- Called Amphibians of plant kingdom, because these plants can live in soil but are dependent on water for sexual reproduction.
- Rhizoids may be unicellular or multicellular.
- Main plant Body is haploid (gametophyte)
- Multicellular sex organ (♂ antheridium &♀ archegonium)
- Antherozoids are biflagellated.
- Some mosses provide food for herbaceous mammals, bird & other animals.
- Species of *Sphagnum* provide peat used as fuel and as packing material for trans-shipment of living material as they hold water.
- Mosses (along with Lichens) are of great ecological importance, they decompose rocks making substrate suitable for growth of higher plants. They play an important role in plant succession on bare rocks/soil.
- Mosses form dense mats on soil, reduce the impact of falling rain and prevent soil erosion.

BRYOPHYTES ARE DIVIDED INTO

LIVERWORTS
- Plant body thalloid.
- Thallus dorsi-ventral, appressed to the substrate.
- Leafy members have tiny leaf-like appendages in two rows on stem-like structures.
- Asexual reproduction is by fragmentation and gemmae.
- Gemmae are green, multicellular, asexual buds formed in gemma cups located on thalli.
- Sporophyte is differentiated into a foot, seta and capsule. After meiosis spores are produced in the capsule, which germinate to produce free-living gametophytes. Eg. *Marchantia.*

MOSSES
- Gametophytes consist of two stages
  1. Protonema; 2. Leafy-stage
- **Protonema stage:** develops directly from a spore. Protonema is creeping, green, branched and frequently filamentous stage.
- **Leafy stage:** develops from secondary protonema as a lateral bud. They consist of upright, slender axes bearning spirally arranged leaves, attached to the soil through multi-cellular branched rhizoids. It also bears sex-organs.
- **Vegetative reproduction:** by fragmentation and budding in secondary protonema.
- Sporophyte in mosses is more elaborate than in liverworts. They have more elaborate mechanism of spore dispersal.
- **Eg:** *Funaria, Polytrichum* and *Sphagnum*.

7 PTERIDOPHYTES (Horsetails and Ferns)
- Evolutionarily, they are the first terrestrial plants with vascular tissues.
- Found in cool, damp, shady places, though some flourish in sandy-soil.
- Main plant body is sporophyte (2n), with true root, stem and leaves.
- Leaves are small (microphylls) as in *Selaginalla* or large (macrophylls) as in ferns.
- Sporophytes bear sporangia subtended by sporophyll, which may be compact called strobili or cones, as in *Selaginella*, *Equisetum*.

$$\underset{(2n)}{\text{Sporangia}} \rightarrow \underset{(2n)}{\text{Sporemother Cell}} \xrightarrow{\text{Meiosis}} \underset{(n)}{\textbf{Spores}}$$

- Spores germinate to produce inconspicuous, small, multi-cellular, free-living, mostly photosynthetic thalloid gametophytes called prothallus.
- Gametophytes need cool, damp, shady places to grow. This specific requirement and need of water for fertilisation limit the spread of living pteridophytes and restricted to narrow geographical regions.
- Male and female sex organs are antheridia and archegonia.
- Majority are homosprous, but genera like *Selaginella* and *Salvinia* are heterosporous. In heterosporous species the female gametophytes are retained on the parent sporophyte. Zygote develops into young embryos within female gametophytes.
  This event is a precursor to seed habit, considered an important step in *Evolution.*
- Used for medicinal purposes and as soil binders, also grown as ornamentals.
- Pteridophytes are further classified into four classes:
  1. **Psilopsida** - *Psilotum*
  2. **Lycopsida** - *Selaginella*, *Lycopodium*
  3. **Sphenopsida** - *Equisetum*
  4. **Pteropsida** - *Dryopteris*, *Pteris*, *Adiantum*

8 GYMNOSPERMS (Gymnos = naked, sperma = seed)

- Plants in which ovules are not enclosed by ovary wall and remain exposed both before and after fertilisation. Seeds that develop post-fertilisation are naked.
- Gymnosperms include medium-sized or tall trees and shrubs.
- The giant redwood tree *Sequoia* is one of the tallest tree species.
- **Roots:** generally tap roots, having fungal association as mycorrhiza *(Pinus)* or coralloid root with N_2-fixing cyanobacteria as in *Cycas*.
- **Stem:** Branched (*Pinus*; *Cedrus*), Unbranched (*Cycas*)
- **Long and Dwarf shoot:** in *Pinus* and *Ginkgo*.
- **Leaf:** Simple *(Pinus)*; pinnate compound (*Cycas*).
- Leaves are well-adapted to withstand extreme temperature, humidity and wind. In the conifers, needle-like leaves reduce surface area. Thick cutile and sunken stomata help to reduce water loss.
- Gymnosperms are heterosporous
- Sporophylls → Microsporophylls → Male cone/strobili/lax; Megasporophylls → Female cone/strobili
- Male and female sporangia borne on microsporophylls and megasporphylls respectively.
- Sporangia → Microsporangia (2n) → Pollen grain (n); Megasporangia/Ovule (2n) —Meiosis of MMC→ 4 Megaspores → one develops into **Female gametophyte/Endosperm** (n)
- *Pinus* is monoecious, i.e., male and female cone or strobili are borne on same tree; *Cycas is dioecious, i.e.,* male cone and megasporophylls are borne on different trees. (Female cone is absent in *Cycas*).
- Male gametophyte, *i.e.,* pollen grains are highly reduced and confined to limited number of cells.
- Female gametophytes bear two or more archegonia or female sex organs. The multicellular female gametophyte is retained within megasporangium.
- Male and female gametophytes do not have an independent free living existence.
- Pollen grains are carried by air currents and come in contact with opening of ovules.
- Fertilisation is by pollen-tube formation which carries male gametes. Zygote forms embryo and ovules form naked seeds.

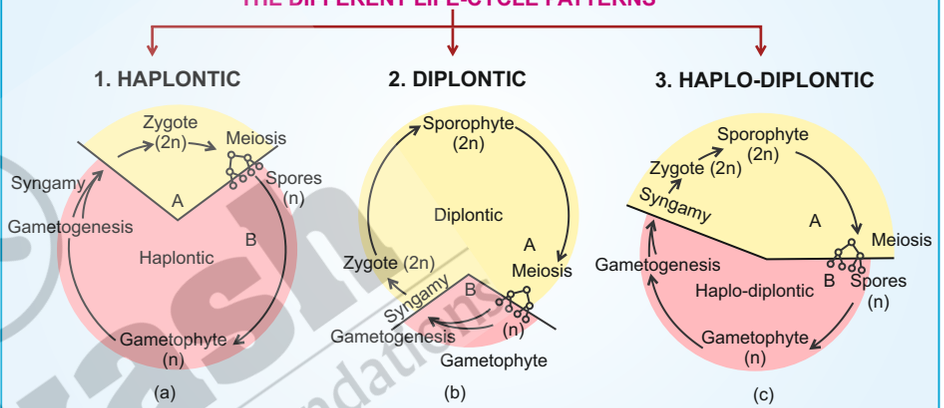
9 ANGIOSPERMS

- In angiosperms or the flowering plants, pollen grains and ovules develop in specialised structures called flowers. Seeds are enclosed in fruits.
- Angiosperms are an exceptionally large group of plants occurring in wide range of habitats.
- Smallest angiosperm is *Wolffia*.
- They are divided into two classes: Dicots having seeds with two cotyledons, reticulate venation in leaf and tetra or pentamerous flowers and Monocots having single cotyledon seed, parallel venation in leaves and trimerous flowers.
- Pollination is by wind or various other agencies.
- Double-fertilisation is unique to the angiosperms. Syngamy produces zygote and triple-fusion produces triploid primary endosperm nucleus (PEN).
- Zygote develops in embryo (with one or two cotyledons) and PEN develops into endosperm (3n) which provides nourishment to the developing embryo. The ovules develop into seeds and the ovaries develop into fruits.

10 PLANT LIFE-CYCLES AND ALTERNATION OF GENERATIONS

- In plants both haploid and diploid cells can divide by mitosis, which leads to the formation of haploid and diploid plant bodies.
- The haploid plant body produces gametes by mitosis, so called gametophytes.
- After fertilisation zygote also divides by mitosis to produce diploid sporophyte plant body.
- Haploid spores are produced by the sporophyte by meiosis which divide to form haploid body again, thus there is alternation of generation between haploid gametophyte and spore producing sporophyte during sexual reproduction in plants.

THE DIFFERENT LIFE-CYCLE PATTERNS



1. **HAPLONTIC:** Sporophytic generation represented only by single-cell zygote. There are no free living sporophytes. Meiosis in zygote produces haploid spores, which divide mitotically to form dominant, photosynthetic free-living gametophyte.
   E.g., Many algae such as *Volvox, Spirogyra* and some species of *Chlamydomonas*.
2. **DIPLONTIC:** Sporophyte dominant, free-living and photosynthetic. The gametophytic phase is represented by single to few-celled gametophyte.
   E.g., All seed bearing plants, *i.e.,* gymnosperms and angiosperms and alga like *Fucus* sp.
3. **HAPLO-DIPLONTIC:**
   (a) Gametophyte dominant, independent, photosynthetic which alternates with totally or partially dependent sporophyte *e.g.,* All bryophytes.
   (b) Sporophyte dominant, independent, photosynthetic, vascular which alternates with saprophytic/autotropic independent but short-lived gametophyte.
   e.g., All pteridophytes
   - Some alga like *Ectocarpus, Polysiphonia,* Kelps are also haplodiplontic.

Sharpen Your Understanding

1. Artificial system of classification based on androecium structure was given by [NCERT Pg. 29]
   (1) Linnaeus
   (2) George Bentham
   (3) Joseph Hooker
   (4) R.H. Whittaker
2. Natural classification systems were based on [NCERT Pg. 29]
   (1) Evolutionary relationships
   (2) Only external features
   (3) Natural affinities among organisms
   (4) Superficial features
3. Chemical constituents of the plants are used to resolve confusion by taxonomists these days. It comes under [NCERT Pg. 30]
   (1) Phylogenetic system
   (2) Cytotaxonomy
   (3) Karyotaxonomy
   (4) Chemotaxonomy
4. The classification system which assumes that organisms belonging to the same taxa have a common ancestor is a [NCERT Pg. 30]
   (1) Natural system
   (2) Artificial system
   (3) Phylogenetic system
   (4) System based on chromosome number

NCERT Based MCQs

5. Which of the following algae shows isogamous sexual reproduction with flagellated gametes? [NCERT Pg. 30]
   (1) *Spirogyra*
   (2) *Ulothrix*
   (3) *Volvox*
   (4) *Fucus*
6. Hydrocolloids like algin are produced by [NCERT Pg. 32]
   (1) Brown algae
   (2) Red algae
   (3) Green algae
   (4) Blue-green algae
7. Agar a commercial product used to grow microbes and in ice-creams and jellies are obtained from [NCERT Pg. 32]
   (1) *Gelidium* and *Gracilaria*
   (2) *Chlorella* and *Volvox*
   (3) *Ectocarpus* and *Dictyota*
   (4) *Polysiphonia* and *Fucus*
8. Pyrenoids, the storage bodies located in the chloroplasts of most members of chlorophyceae contain protein besides [NCERT Pg. 32]
   (1) Glycogen
   (2) Starch
   (3) Cellulose
   (4) Amylopectin
9. Members of phaeophyceae vary in colour from olive green to various shades of brown depending upon the amount of the pigment [NCERT Pg. 32]
   (1) Chl- a & b
   (2) Chl-d
   (3) Fucoxanthin
   (4) r-phycoerythrin
10. Gametes are pear-shaped and bear two laterally attached flagella in [NCERT Pg. 33]
    (1) *Polysiphonia*
    (2) *Porphyra*
    (3) *Gelidium*
    (4) *Dictyota*
11. Polysulphate esters are found in the cell wall of [NCERT Pg. 33]
    (1) Green algae
    (2) Brown algae
    (3) Red algae
    (4) Golden-brown algae
12. The creeping, green, branched, frequently filamentous stage of the gametophyte of mosses, which develops directly form spore is called [NCERT Pg. 36]
    (1) Leafy stage
    (2) Secondary protonema
    (3) Primary protonema
    (4) Prothallus

13. Bryophytes are called amphibians of the plant kingdom because [NCERT Pg. 35]
(1) They live on soil but depend on water for sexual reproduction
(2) They have main plant body as gametophyte
(3) They occur in humid and shaded localities
(4) They play important role in plant succession

14. The inconspicuous, small, multi-cellular, free-living mostly photosynthetic thalloid gametophytes produce in pteridophytes is called [NCERT Pg. 38]
(1) Strobilus (2) Protonema
(3) Prothallus (4) Gemmae

15. Which of the following genera of pteridophytes is heterosporous? [NCERT Pg. 38]
(1) *Equisetum* (2) *Salvinia*
(3) *Pteris* (4) *Psilotum*

16. The coralloid roots of *Cycas* are associated with N_2-fixing [NCERT Pg. 38]
(1) Fungi (2) *Rhizobium*
(3) Mycorrhiza (4) Cyanobacteria

17. In monocotyledons flowers are mainly [NCERT Pg. 40]
(1) Trimerous
(2) Pentamerous
(3) Tetramerous
(4) Hexamerous

18. The smallest angiosperm is [NCERT Pg. 40]
(1) *Eucalyptus* (2) *Zamia*
(3) *Wolffia* (4) *Hydrilla*

19. Which of the following algae shows haplo-diplontic life cycle pattern? [NCERT Pg. 43]
(1) *Fucus*
(2) *Chlamydomonas*
(3) *Polysiphonia*
(4) *Volvox*

20. All seed-bearing plants show which of the following life-cycle pattern? [NCERT Pg. 42]
(1) Haplontic (2) Diplontic
(3) Haplo-diplontic (4) Both (1) and (3)

Thinking in Context

1. _____ is carried out using computers and is based on all observable characters. [NCERT Pg. 30]

2. Cytotaxonomy is based on _____ like chromosome number, structure and behaviour. [NCERT Pg. 30]

3. In algae, the most common asexual spore is _____. [NCERT Pg. 30]

4. _____ is unicellular alga rich in proteins, which is used as food supplement even by space travellers. [NCERT Pg. 32]

5. At least a half of the total _____ on earth is carried out by algae through photosynthesis. [NCERT Pg. 32]

6. Members of chlorophyceae are usually grass-green in colour due to the dominance of pigments _____. [NCERT Pg. 32]

7. Food is stored as complex carbohydrates, which may be in the form of _____ in phaeophyceae i.e., brown algae. [NCERT Pg. 33]

8. Majority of the red algae are marine with greater concentrations found in the _____. [NCERT Pg. 33]

9. The food in red-algae is in the form of _____ which is very similar to amylopectin and glycogen in structure. [NCERT Pg. 33]

10. A along with B are the first organisms to colonise rocks and hence are of great ecological importance. [NCERT Pg. 35]

11. Asexual reproduction in liverworts takes place by the formation of specialized structures called _____. [NCERT Pg. 35]

12. Vegetative reproduction in mosses is by fragmentation and budding in the _____. [NCERT Pg. 36]

13. The gametophytes of pteridophytes require cool, damp, shady places to grow. Because of this specific restricted requirement and need of water for fertilisation. the spread of _____ is limited to narrow geographical regions. [NCERT Pg. 38]

14. In heterosporous pteridophytes, development of the zygotes into young embryo take place within the female gametophytes. This event is a precursor to the _____ considered an important step in evolution. [NCERT Pg. 38]

15. In gymnosperms stems are branched in _____. [NCERT Pg. 38]

16. The gymnosperms are _____, they produce haploid microspores and megaspores. [NCERT Pg. 39]

❑ ❑ ❑

17. In gymnosperms, the male and the female gametophytes do not have an independent _____. [NCERT Pg. 39]

18. In angiosperms the ovules develop into A and the B develop into fruit. [NCERT Pg. 41]

19. Depending on the A possessed and the type of B, algae are classified into three classes. [NCERT Pg. 43]

20. The main plant body of a Bryophyte is gamete producing and is called a _____. [NCERT Pg. 43]

Morphology of Flowering Plants

4 Chapter

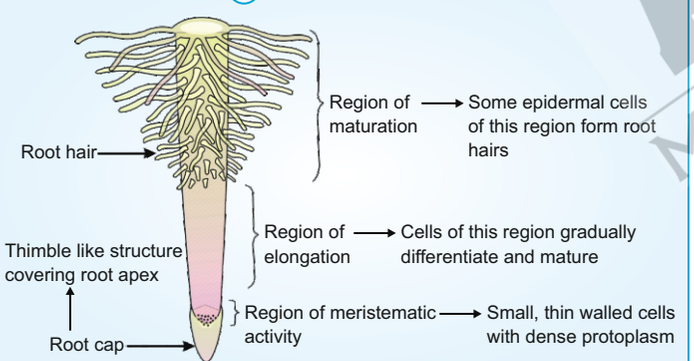
1 INTRODUCTION

- Angiosperms show a large diversity in morphology. Possibly the variation in different parts are due to the adaptations to various habitats.
- A plant has root system and shoot system

2 THE ROOT

- Elongation of radicle form primary root
- Primary root bears lateral roots of several orders that are referred to as secondary, tertiary etc. roots.
- Types of roots
- **Tap root system :** • Includes primary root and its branches
  • Seen mainly in dicots *eg.* Mustard
- **Fibrous root system :** In monocots, primary root is short lived and replaced by a large number of roots originate from the base of the stem.
- **Adventitious roots :** Roots that arise from parts of plants other than radicle *eg.* grass, *Monstera* and banyan tree.
- **Functions of roots :**
  - Absorption of water and minerals from soil.
  - Provide anchorage to plant parts.
  - Storage of reserve food materials.
  - Synthesis of plant growth regulators (PGRs)

3 REGIONS OF ROOT



4 MODIFICATIONS OF ROOT

Storage of food

- Tap root – Carrot, turnip
- Adventitious root – Sweet potato

Prop root

- Arise from branches to support them
- *eg.* Banyan

Stilt root

- Supporting root coming out from lower nodes
- *eg.* Maize sugarcane

Pneumatophore

- Root growing vertically upward for oxygen in plants of swampy area
- *eg. Rhizophora*

5 THE STEM

- Develops from plumule
- Bears nodes, internodes, buds (terminal or axillary).
- **Functions :**
  - Spread out branches bearing leaves, flowers, fruits.
  - Conducts water, minerals and photosynthates

MODIFICATIONS OF STEM

- **Underground stem:** For storage of food, also act as organ of perennation to tide over conditions unfavourable for growth.
  eg. potato, ginger, turmeric, *Colocasia*, Zaminkand
- **Tendrils:** Axillary bud may modify into tendril, help plants to climb.
  eg. Grapevines and Gourds (Cucumber, Pumpkin, Watermelon).
- **Thorn:** Axillary buds modify into woody pointed thorn *eg. Bougainvillea, Citrus*
- **Flat or cylindrical photosynthetic stem:** *eg. Opuntia* (flattened), *Euphorbia* (cylindrical)

SOME OTHER MODIFICATIONS OF STEM

- In mint and jasmine a slender lateral branch arise from base of the main axis and after growing aerially arch downward and touch the ground.
- Aquatic plants like *Pistia* and *Eichhornia* have lateral branch with short internodes and each node bear rosette of leaves and tuft of roots.
- In banana, pineapple and *Chrysanthemum* lateral branches arise from basal and underground stem, grow horizontally and then come out obliquely upward to form leafy shoots.
- Underground stem of grass and strawberry spread to new niches and when older part dies new plants are formed. Underground storage stem also acts as organ of perrenation

6 THE LEAF

- Lateral generally flat structure, develops at node and bear a bud in its axil.
- Arise from shoot apical meristem and arranged in acropetal order.
- Consist of 3 parts, Leaf base, Petiole and Lamina
- Two lateral small leaf like structures at leaf base, are called stipules.
- Leaf base may expand into sheath like structure covering stem partially or wholly in monocots.
- Leaf base may become swollen in leguminous plants called **pulvinus**.

TYPES OF LEAVES

- **SIMPLE LEAF :** Lamina is entire or when incised, incision do not reach midrib
- **COMPOUND LEAF :** Incision of lamina reaches up to the midrib breaking it into leaflets. It is of two types

(i) Pinnately compound-leaflets are present on a common axis, the rachis. *eg.* Neem

(ii) Palmately compound-leaflets are attached at a common point *i.e.* at the tip of petiole. *eg.* silk cotton

7

- **Reticulate**
  - Veinlets form network
  - *eg.* generally in dicots
- **Parallel**
  - Veins run parallel to each other
  - *eg.* most monocots

Venation — LEAF — Phyllotaxy

- **Alternate :** Single leaf at each node arranged in alternate manner *eg.* china rose, mustard, sunflower
- **Opposite :** Pair of leaves arise at each node *eg.* Guava, *Calotropis*
- **Whorled :** More than two leaves arise at each node *eg.Alstonia*

Modifications of leaves

- Tendril *eg.* Pea
- In Australian *Acacia* petiole expands and become photosynthatic
- Spines *eg.* Cacti (for defence)
- Fleshy leaves for storage *eg.* Onion, Garlic
- For traping insect *eg.* venus-fly trap, pitcher plant (insectivorous plant)

8 THE INFLORESCENCE

- Flower is a modified shoot
- During flowering
  - Shoot apical meristem modifies into floral meristem
  - Internode do not elongate and axis gets condensed
- **Solitary flower :** Shoot tip transforms into a flower
- Arrangement of flowers on floral axis is called inflorescence

Two major types

Racemose
- Main axis continues to grow
- Flowers borne laterally in acropetal succession

Cymose
- Main axis terminates into a flower (limited growth)
- Flowers borne in basipetal succession

9 THE FLOWER (REPRODUCTIVE UNIT)

Flower can be divided into two equal halves in any plane passing through centre *eg.* chilli, mustard, *Datura* — Actinomorphic (Radial symmetry)

Flower can be divided into two similar halves only in one particular vertical plane *eg.* Pea, bean *Cassia*, gulmohur — Zygomorphic (Bilateral symmetry)

Symmetry

FLOWER — Types:
- Flower either have androecium or carpels — Unisexual
- Flower have both stamens and carpels — Bisexual

Types:
- **Trimerous –** Floral appendages are multiple of 3
- **Tetramerous –** Floral appendages are multiple of 4
- **Pentamerous –** Floral appendages are multiple of 5

Types:
- Hypogynous
  - Gynoecium occupies highest position, other parts are situated below it.
  - Superior ovary
  - *Eg.* BMC → China rose, Mustard, Brinjal
- Perigynous
  - Gynoecium situated in centre, other parts located at the rim of thalamus
  - Ovary half inferior
  - *Eg.* 2PR → Rose, Peach, Plum
- Epigynous
  - Margin of thalamus grows upward enclosing ovary completely and get fused with it, other parts arise above the ovary.
  - Ovary inferior
  - *Eg.* Guava, Cucumber and ray florets of sunflower

- A flower is asymmetric (irregular) if it cannot be divided into similar halves by any vertical plane passing through the centre. *eg.*-Canna
- Flowers with bracts (reduced leaf) found at the base of pedicle, called bracteate and without bract called ebracteate.

10 PARTS OF A FLOWER

CALYX
- Outermost whorl
- Members called sepal
- Protect flower in bud stage
- Generally green

MAY BE
- Gamosepalous (sepals united)
- Polysepalous (sepals free)

COROLLA
- Members called petals
- Brightly coloured

MAY BE
- Gamopetatous (petal united)
- Polypetalous (petals free)

ANDROECIUM
- Composed of stamens
- Stamens consist of filament + anther
- Each anther is bilobed and each lobe has two chambers
- Sterile stamen – Staminode
- Male reproductive part

GYNOECIUM
- Made of one or more carpels
- Carpel consist of stigma style and ovary
- Each ovary bears one or more ovules attached to a flat cushion like placenta.
- Carpels may be free, apocarpous (*eg.* lotus, rose) or united, syncarpous (tomato, mustard)

- When calyx and corolla are not distinct termed as perianth (unit tepal) *eg.* lily.

Aestivation :
- Mode of arrangement of sepals or petals in floral bud w.r.t. other members of the same whorl.

TYPES

VALVATE
- Sepale/petals in a whorl just touch one another at the margin without overlapping
- *eg. Calotropis.*

TWISTED
- One margin of the appendage overlaps the next one and so on.
- *eg.* china rose, lady's finger, cotton.

IMBRICATE
- Margins of sepals or petals overlap one another but not in any particular direction.
- *eg. Cassia*, gulmohur.

VEXILLARY
- Five petals, one largest (standard) overlaps two lateral petals (wings) which in turn overlap two smallest anterior petals (keel)
- *eg.* Pea, bean

11 STAMEN

- Attachment with other floral whorl
  - Attachment with petals epipetalous (brinjal)
  - Attachment with perianth epiphyllous (lily)
- Attachment with each other
  - Free → Polyandrous
  - United with each other in one bundle
    Monadelphous
    eg. China rose
  - United in two bundles
    Diadelphous
    eg. Pea in
  - United in more than two bundles – Polyadelphous

There may be a variation in the length of filaments within a flower as in *Salvia* and mustard.

12 PLACENTATION

- Arrangement of ovules within the ovary

TYPES

MARGINAL
- Placenta forms a ridge along ventral suture of ovary and ovules are borne on it forming two rows
  eg. pea

AXILE
- Placenta axial, ovules attached on it in a multilocular ovary.
  eg. china rose tomato, lemon

PARIETAL
- Ovules develop on inner wall of ovary or on peripheral part. Ovary is one chambered but become two chambered due to false septum
  eg. Mustard, *Argemone*

FREE CENTRAL
- Ovules are borne on central axis and septa are absent
  eg. Primrose Dianthus

BASAL
- Placenta develops at the base of ovary and a single ovule is attached to it
  eg. sunflower marigold.

13 THE FRUIT AND SEED

OVULE → (After fertilization)
- Turns into seed

Consists of
- Seed coat (Testa, tegmen)
- Embryo

OVARY →
- Ripens into → Fruit

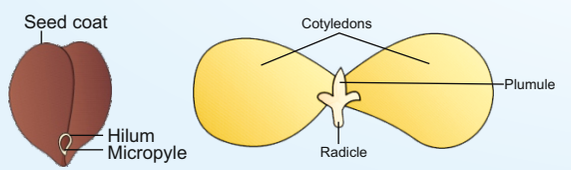
Consists of
- Seeds
- Pericarp

Pericarp: May be dry or fleshy

Divided into
- Epicarp
- Mesocarp
- Endocarp

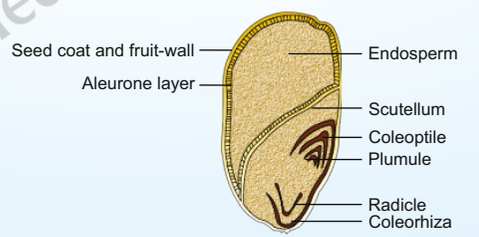
DICOT SEED

- Contains two cotyledons
- Usually lack endosperm except castor
- Embryo consists of embryonal axis (radicle + plumule) and 2 cotyledons
- Hilum is a scar on the seed coat.
- Above hilum is a small pore called micropyle
- *Eg.* bean, gram, pea



MONOCOT SEED

- Single large shield shaped cotyledon called scutellum
- Endospermous. In orchid non-endospermic
- In cereals seed coat is membranous and generally fused with fruit wall
- In maize, endosperm is bulky and stores food. The outer covering of endosperm separates the embryo by a proteinaceous layer called aleurone layer.



- Fruit formed without fertilization is called parthenocarpic fruit.
- Mango and coconut are drupe type of fruits, develop from monocarpellary superior ovaries and are one seeded. In mango, mesocarp is fleshy edible and in coconut it is fibrous. Both have hard stony endocarp

15 DESCRIPTION OF SOME IMPORTANT FAMILIES

Character/feature	Fabaceae	Solanaceae	Liliaceae
	Earlier called Papillionoideaea, subfamily of Leguminosae	Commonly called potato family	A monocotyledonous family also called lily family
Stem	Erect or climber	Herbaceous, rarely woody solid/hollow, hairy/glabrous, underground as in potato	Underground bulbs/corms/rhizome
Leaves	Alternate, pinnately compound pulvinate, stipulate, venation reticulate	Alternate, simple, rarely pinnate, reticulate venation	Mostly basal, alternate, linear, exstipulate, parallel venation
Inflorescence	Racemose	Solitary, axillary or cymose as in *Solanum*	Solitary/cymose, often umbellate clusters
Flower	Bisexual, zygomorphic	Bisexual, actinomorphic	Bisexual, actinomorphic
Calyx	5, gamosepalous, valvate/imbricate aestivation	5, gamosepalous, persistent, valvate aestivation	**Perianth:** Tepal 6(3 + 3), often united in tube, valvate aestivation
Corolla	5, polypetalous, papilionaceous corolla, vexillary aestivation	5, gamopetalous, valvate aertivation	
Androecium	10, diadelphous, anther dithecus	5, epipetalous	6(3 + 3), epitepalous
Gynoecium	Superior ovary, monocarpellary, unilocular, many ovules, marginal placentation	Bicarpellary, obliquely placed, syncarpous, superior, bilocular, placenta swollen, axile placentation, many ovules	Tricarpellary, syncarpous, superior ovary, trilocular, axile placentation, many ovules
Fruit and seed	Legume, non-endospermic seed	Berry/capsule, endospermous seed	Capsule rarely berry, endospermous seeds
Floral formula	$\%\,\varphi\,K_{(5)}\,C_{1+2+(2)}\,A_{(9)+1}\,\underline{G}_{1}$	$\oplus\,\varphi\,K_{(5)}\,\overset{\frown}{C}_{(5)}\,A_{5}\,\underline{G}_{(2)}$	$Br\,\oplus\,\varphi\,\overset{\frown}{P}_{(3+3)}\,A_{3+3}\,\underline{G}_{(3)}$
Floral diagram			

ECONOMIC IMPORTANCES

Fabaceae
- **Pulses** (gram, arhar, sem, moong, soyabean)
- **Edible oil** (Soyabean Groundnut)
- **Dye** (*Indigofera*)
- **Fibres** (Sunhemp)
- **Fodder** (*Sesbania Trifolium*)
- **Ornamental** (Lupin, sweet pea)
- **Medicine** (muliathi)

Solanaceae
- **Food** – (Tomato, potato, brinjal)
- **Spice** – (Chilli)
- **Medicine** – (Belladonna, Ashwagandha)
- **Fumigatory** – Tabacoo
- **Ornamental** – *Petunia*

Liliaceae
- **Vegetable** – (*Asparagus*)
- **Medicine** – (*Aloe*)
- **Ornamental** (Tulip, *Gloriosa*)
- **Colchicine** (*Colchicum autumnale*)

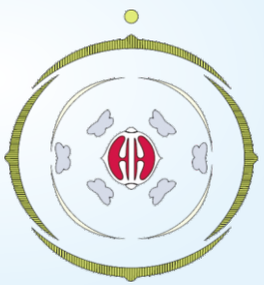
14 Semi technical description of a typical flowering plant

A. Symbols used in floral formula :
- Calyx – K
- Corolla – C
- Perianth – P
- Androecium – A
- Gynoecium – G
- Superior ovary – $\underline{G}$
- Inferior ovary – $\overline{G}$
- Male flower – ♂
- Female flower – ♀
- Bisexual flower – ⚥
- Actinomorphic flower – ⊕
- Zygomorphic flower – %

Floral formula of mustard

$\oplus\,\varphi\,K_{2+2}\,C_{4}\,A_{2+4}\,\underline{G}_{(2)}$

Floral diagram of mustard



Sharpen Your Understanding

NCERT Based MCQs

1. Stilt roots are found in [NCERT Pg. 67]
   (1) Sugarcane (2) *Rhizophora*
   (3) Banyan (4) Turnip

2. Thorns are [NCERT Pg. 68]
   a. Modified axillary buds
   b. Found in *Opuntia*
   c. Modifications of stem to protect plants from browsing animals.
   (1) a and b only (2) b and c only
   (3) a and c only (4) All a, b and c

3. Which of the following is **not** true for *Pistia* and *Eichhornia*? [NCERT Pg. 69]
   (1) Stem has short internodes
   (2) Rosette of leaves are found on nodes
   (3) Stem modifies to store food
   (4) Each node bear tuft of roots

4. Inferior ovary is seen in all of the following plants, **except** [NCERT Pg. 73]
   (1) Guava
   (2) Cucumber
   (3) Ray florests of sunflower
   (4) Brinjal

5. Epidermal cells of which region of root form root hairs? [NCERT Pg. 67]
   (1) Root cap
   (2) Maturation zone
   (3) Elongation zone
   (4) Meristematic zone

6. Which of the given option has pair of plants in which stem is modified to store food? [NCERT Pg. 68]
   (1) Potato, turnip
   (2) Zaminkand, turmeric
   (3) Sweet potato, *Colocasia*
   (4) Ginger, carrot

7. In some leguminous plants leaf base is [NCERT Pg. 70]
   (1) Called pulvinus
   (2) Sheath like, covering stem partially or completely
   (3) Modified to spine
   (4) Both (1) and (3)

8. Palmately compound leaves are found in [NCERT Pg. 71]
   (1) *Alstonia* (2) Guava
   (3) Silk cotton (4) Neem

9. In some flowers like lily [NCERT Pg. 72]
   (1) Calyx and corolla are present
   (2) Perianth is the outermost floral whorl
   (3) Accessory organs are absent
   (4) Corolla are fused with stamens

10. Flowers are asymmetric in [NCERT Pg. 72]
    (1) *Cassia* (2) *Bean*
    (3) *Datura* (4) Canna

11. In lady's finger, corolla shows [NCERT Pg. 74]
    (1) Valvate aestivation
    (2) Vexillary aestivation
    (3) Twisted aestivation
    (4) Imbricate aestivation

12. Select the **wrong** match [NCERT Pg. 75]
    (1) Diadelphous stamens – Pea
    (2) Epiphyllous stamens – Lily
    (3) Polyadelphous stamens – China rose
    (4) Epipetalous stamens – Brinjal

13. In lotus [NCERT Pg. 75]
    a. Gynoecium has single carpel
    b. Gynoecium is apocarpous
    c. Carpels are numerous and united
    (1) Only a is true
    (2) Both b and c are true
    (3) Only b is true
    (4) Both a and c are true

14. Match the columns and select the **correct** option. [NCERT Pg.76]

	Column-I (plant)	**Column-II (Placentation)**
a.	Primrose	(i) Basal
b.	Maize	(ii) Parietal
c.	*Argemone*	(iii) Free central

(1) a(iii), b(i), c(ii) (2) a(i), b(iii), c(ii)
(3) a(iii), b(ii), c(i) (4) a(ii), b(i), c(iii)

15. In maize seed, aleurone layer [NCERT Pg. 77]

(1) Is proteinous

(2) Is diploid tissue

(3) Is outer covering of seed coat

(4) Represents its single cotyledon

16. Drupe fruits [NCERT Pg. 76]

(1) Are dry fruits

(2) Develop from monocarpellary inferior ovary

(3) Have well differentiated pericarp

(4) Develop without fertilisation

17. In floral formula of fabaceae family the androecium is represented **correctly** as [NCERT Pg. 79]

(1) $A_{(10)}$

(2) A_{9+1}

(3) A_{8+2}

(4) $A_{(9)+1}$

18. Select the **incorrect** match [NCERT Pg. 79]

(1) Fabaceae – *Muliathi*

(2) Solanaceae – Belladonna

(3) Liliaceae – *Aloe*

(4) Brassicaceae – *Indigofera*

19. The ornamental plant of solanaceae family is [NCERT Pg. 80]

(1) Lupin

(2) *Petunia*

(3) Tulip

(4) *Gloriosa*

20. Which of the given is **not** true for gynoecium of members of liliaceae family? [NCERT Pg. 81]

(1) Tricarpellary

(2) Superior ovary

(3) Parietal placentation

(4) Syncarpous

Thinking in Context

1. Leaves originate from _____ and are arranged in an _____ manner. [NCERT Pg. 69]

2. Some plants of arid regions modify their stems into flattened structure like in _____ or fleshy cylindrical structures as in _____. [NCERT Pg. 68]

3. Leaves are converted into _____ for climbing as in _____ [NCERT Pg. 71]

4. In _____ type of inflorescence, flowers are borne in _____ order [NCERT Pg. 72]

5. Flower with ____ symmetry can be divided into two similar halves in one particular vertical plane [NCERT Pg. 72]

6. Ovary in _____ flowers is said to be superior like _____. [NCERT Pg. 73]

7. If the margins of sepals or petals overlap one another but not in any particular direction as in _____ or _____, the aestivation is called _____ aestivation. [NCERT Pg. 74]

8. A sterile stamen is called _____ [NCERT Pg. 75]

9. The stamens may be united into one bunch called _____ as in _____ [NCERT Pg. 75]

10. Ovules are borne on central axis and septa is absent in _____ placentation. [NCERT Pg. 75]

11. In _____ and _____ there may be variation in length of filaments within a flower. [NCERT Pg. 75]

12. In mango and coconut, fruits develop from _____ ovaries. [NCERT Pg. 76]

13. Generally monocots seeds are _____ but some as in _____ are _____ [NCERT Pg. 77]

14. Monocot seeds consist of one large and shield shaped cotyledon known as _____ [NCERT Pg. 77]

15. Fabaceae was earlier called _____ a sub family of _____ [NCERT Pg. 78]

16. _____ are ornamental plants of Fabaceae family. [NCERT Pg. 79]

17. In tomato gynoecium is _____ and _____ [NCERT Pg. 80]

18. The mesocarp is fibrous in _____ [NCERT Pg. 76]

19. Seed coat is membranous and fused with fruit wall in _____ seeds [NCERT Pg. 77]

20. Petiole expand become green synthesise food in _____ [NCERT Pg. 77]

❑ ❑ ❑

Anatomy of Flowering Plants

5 Chapter

1 INTRODUCTION

- **Anatomy :** Study of internal structure of plants
- Internal structures also show adaptation to diverse environments.

2 THE TISSUES

- Group of cells having a common origin and usually performing a common function is called tissue.

TYPES

Meristematic tissues

- Actively dividing cells
- Two types according to appearance in life

Primary meristem (Appear early in life) → **Apical meristem**

- Found at tips of roots and shoots
- Some shoot apical meristem cells that are left behind during stem elongation and leaf formation constitute **axillary buds**.
- Axillary buds are capable of forming a branch or a flower.

Secondary meristem (appear later than primary meristem) → **Intercalary meristem**

- Occurs between mature tissues
- Occurs in grasses, regenerate parts removed by grazing herbivores

Also called **Lateral meristem**

- Cylindrical meristem found in mature regions of roots and shoots

TYPES

Intrafascicular Meristem	Interfascicular Meristem	Cork Cambium
Found between xylem and phloem in a conjoint vascular bundle	Found between two vascular bundles	Extrastelar cambium formed in cortical region

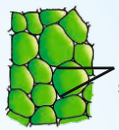
Permanent tissues

- Newly formed structurally and functionally specialised cells
- Do not divide further
- Two types — Simple, Complex

3 SIMPLE PERMANENT TISSUES (MADE OF ONLY ONE TYPE OF CELLS)

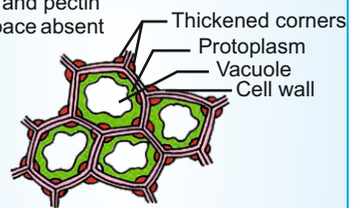
Parenchyma

- Forms major component within organs
- Spherical, oval, round, polygonal or elongated in shape
- Thin walled, living
- Cellulosic cell wall
- May have small intercellular spaces
- **Functions**
  (1) Storage
  (2) Secretion
  (3) Photosynthesis (if have chlorophyll)



Collenchyma

- Occurs in layers below epidermis
- Cells may be oval, spherical or polygonal in shape
- Thick walled, living
- Corners of cell deposited with cellulose, hemicellulose and pectin
- Intercellular space absent



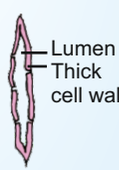
Functions

(1) Provide mechanical support to growing parts of plants
(2) May perform photosynthesis (if cells contain chloroplast)

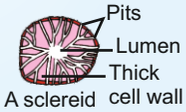
Sclerenchyma

- Long, narrow cells with thick lignified wall
- Dead
- May be elongated and pointed-**Sclerenchyma fibre**
- May be spherical, oval or cylindrical-**Sclereids** (Common in fruits, nuts, pulp of guava, pear, etc.)

Function: Mechanical support



A fibre



A sclereid

4 COMPLEX PERMANENT TISSUES (MADE OF MORE THAN ONE TYPE OF CELLS)

Types

Xylem (Four components)

- **Tracheid**
  - Elongated, tube like with tapering ends, lignified, dead and without protoplasm
  - Water transporting element
- **Vessel**
  - Long cylindrical tube, absent in gymnosperm
  - Multicelled, dead, devoid of protoplasm, lignified with large central cavity
  - Main water conducting element in angiosperms
- **Xylem Parenchyma**
  - Living, thin walled
  - Involved in radial conduction of water, may store food
- **Sclerenchyma Fibres**
  - Dead, lignified wall with obliterated lumen

Phloem (Four components)

- **Sieve tube elements** (Gymnosperms have sieve cells)
  - Long, tube like, perforated end walls, lack nucleus at maturity
  - Peripheral cytoplasm with large central vacuole
  - Transport of food material
- **Companion cell** (Gymnosperms have albuminous cells)
  - Specialised parenchyma cell, connected to sieve tubes by pit fields
  - Helps to maintain pressure gradient in sieve tubes.
  - The functions of sieve tubes are controlled by the nucleus of companion cells.
- **Phloem parenchyma**
  - Elongated, tapering cylindrical cells
  - Stores food material, resin, mucilage, latex etc.
  - Absent in most of the monocots
- **Bast fibres (Phloem fibres)**
  - Elongated, sclerenchymatous, unbranched, pointed needle like apices
  - Jute, flax and hemp produce commercial bast fibres.
  - Generally absent in primary phloem but found in secondary phloem.

5

Xylem types

- Primary xylem
  - Protoxylem (First formed with narrow vessel)
  - Metaxylem (Later formed with broader vessel)
- Secondary xylem — Formed during secondary growth

Phloem types

- Primary phloem
  - Protophloem (first formed and have narrow sieve tubes)
  - Metaphloem (Later formed and have broad sieve tubes)
- Secondary phloem — Formed during secondary growth

- **Endarch** - Protoxylem lies towards pith/centre and metaxylem towards periphery e.g., stems
- **Exarch** - Protoxylem lies towards periphery and metaxylem towards pith e.g., roots

7 COMPARISON BETWEEN DICOT AND MONOCOT ROOT

Features	Dicot root	Monocot root
Epiblema	With root hairs	With root hairs
Cortex	Thin walled parenchymatous with intercellular space	Thin walled parenchymatous with intercellular space
Endodermis	Barrel shaped cells with casparian strip	Barrel shaped cells with casparian strip
Pericycle	Thick walled parenchymatous, form lateral roots and vascular cambium	Thick walled parenchymatous, form lateral roots
Vascular bundle	Radial, exarch, 2-4 xylem and phloem patches	Radial, exarch, usually more than 6 xylem bundles (polyarch)
Pith	Poorely developed or absent	Well developed

8 COMPARISON BETWEEN DICOT AND MONOCOT STEM

	Features	Dicot stem	Monocot stem
Cortex	Epidermis	With cuticle and stomata	With cuticle and stomata
	Hypodermis	Collenchymatous	Sclerenchymatous
	Cortical layer	Parenchymatous	Large parenchymatous
	Endodermis	Starch rich referred to as starch sheath	Absent
	Pericycle	Semi-lunar patches of sclerenchyma	Absent
	Vascular bundle	Conjoint, open, endarch and arranged in a ring	Conjoint, closed, scattered and each surrounded by sclerenchymatous sheath, smaller peripheral ones, larger central ones, water containing cavity in vascular bundle
	Pith	Parenchymatous with intercellular spaces	Absent

6 THE TISSUE SYSTEM

Epidermal tissue system

- Forms outermost covering of plant body
- **Epidermis**
  - Parenchymatous, usually single layered, outermost covering
  - Often covered by waxy cuticle (absent in roots)
- **Stomata**
  - Consist of guard cells and subsidiary cells
  - Bean/kidney shaped guard cells - Dicot and Dumbell shaped - Monocot
  - Stomatal aperture + guard cells + subsidiary cells = stomatal apparatus
- **Root hairs**
  - Unicellular elongation of epidermal cells
  - Absorb water and mineral from soil
- **Trichomes**
  - In shoot system usually multicellular
  - Branched/unbranched, soft or stiff
  - Can be secretory, prevent water loss

Ground tissue system

- **In leaves**
  - Ground tissue consists of thin walled chloroplast containing cells called **mesophyll**
- **In stem and root**
  - Made up of all the tissues except epidermis and vascular bundles
  - Consist of parenchymatous cortex, pericycle, pith, medullary rays and conjunctive tissue (between xylem and phloem in roots)
  - Hypodermis - found in stem absent in roots

Vascular tissue system types

- Consists of xylem and phloem
- Presence/absence of cambium
  - **Open** - cambium present e.g. Dicot stem
  - **Closed** - cambium absent e.g., monocot stem
- According to arrangement of xylem and phloem
  - **Conjoint** Xylem and phloem on same radius e.g., stem, leaves
  - **Radial** Xylem and phloem are on different radii in alternate manner e.g., root

9 COMPARISON BETWEEN DICOT AND MONOCOT LEAF

Features	Dicotyledonous leaf	Monocotyledonous leaf
Stomata	More on lower (abaxial) surface as compared to upper (adaxial) one. It is called dorsiventral leaf	Equally distributed on both adaxial and abaxial epidermis, isobilateral leaf
Epidermis	Covered by cuticle	Covered by cuticle, may have large, empty, colourless bulliform cells on upper epidermis, to minimise water loss.
Mesophyll	Two types - Adaxially placed palisade parenchyma (elongated cells, vertically and parallely arranged to each other), spongy parenchyma - loosely arranged with air cavities, below the palisade cells	Only spongy parenchyma is found, palisade parenchyma absent
Vascular bundle	Conjoint, size vary according to thickness of veins, has thick walled bundle sheath	Conjoint, nearly similar sized due to parallel venation

10 SECONDARY GROWTH

- Occur in most dicots to increase girth
- Tissue involved are lateral meristem - vascular cambium and cork cambium.

Vascular cambium

- Form secondary vascular tissues
- **Formation :** In dicot stem formed by Intrafascicular cambium and Interfascicular cambium (formed by dedifferentiation of cells of medullary rays)
- **Activity:** Vascular cambium cuts off cells
  - Towards pith → Form secondary xylem
  - Towards periphery → Form secondary phloem
- Since cambium is more active towards innerside, thus amount of secondary xylem produced will be more than secondary phloem
- Primary and secondary phloem gradually get crushed while primary xylem remains more or less intact
- Vascular cambium also produces secondary medullary rays in radial direction

Cork cambium

- Replaces outer broken cortex and epidermis
- **Formation :** In dicot stem formed by dedifferentiation of cortex cells
- Couple of layer thick and composed of narrow thin walled nearly rectangular cells
- **Activity :** Phellogen or cork cambium cuts off cells
  - Towards outer side → Form suberin deposited impervious cells, cork/phellem
  - Towards inner side → Form parenchymatous secondary cortex, phelloderm
- Phellem + Phellogen + Phelloderm → Periderm
- **Bark :** Non technical term referring all tissues exterior to vascular cambium, it can be early bark (produced early in the season) or late bark (produced in the end of season)

Lenticels :

- Lense shaped opening formed by rupturing of epidermis
- At certain region phellogen produces closely arranged parenchymatous cells instead of cork cells.
- Permit gaseous exchanges in woody parts.

11 DIFFERENT TYPES OF WOODS

Spring wood	Autumn wood
Form in spring season	Form in autumn season
Also called early wood	Also called late wood
Cambium usually more active in spring	Cambium is less active in autumn
Contains more xylary elements	Contains fewer xylary elements
Vessels have wider cavities	Vessel have narrow cavities
Lighter in colour, lower density	Darker in colour, higher density

Spring wood + Autumn wood ⇒ One annual ring (in temperate region plants) (used to estimate age of tree)

Heart wood	Sapwood
Secondary xylem of center most region	Formed by secondary xylem of peripheral region
Dead with lignified wall,	Living
Dark in colour, hard, durable	
Deposited with tannin, resin etc.	Lighter in colour
Do not conduct water but provide mechanical support	Involved in conduction of water and minerals

12 SECONDARY GROWTH IN ROOTS

Occurs through

Vascular cambium

- Completely secondary in origin
- **Formation :** by
  i. A portion of pericycle
  ii. Tissues just below phloem
- **Activity :** similar to dicot stem
- In roots, cambium do not show seasonal activity

Cork cambium

- Formed by cells of pericycle, rest activity is similar to dicot stem

- Endodermis is innermost layer of cortex in roots and dicot stem.
- Primary meristem contributes to the formation of primary plant body
- Secondary meristems are responsible for producing secondary tissue
- **Stele :** All tissues on the innerside of endodermis such as pericycle, vascular bundles and pith.

Sharpen Your Understanding

1. All of the following are primary meristems, **except** [NCERT Pg. 85]
   (1) Shoot apical meristem
   (2) Intercalary meristem
   (3) Interfascicular cambium
   (4) Root apical meristem
2. The common feature between parenchyma and collenchyma cells is [NCERT Pg. 86]
   (1) Being living
   (2) Having secondary cell wall
   (3) Providing mechanical support
   (4) Having pectin deposited at corners of cells
3. Which of the following tissue is commonly found in the fruit walls of nuts? [NCERT Pg. 87]
   (1) Parenchyma
   (2) Sclereids
   (3) Intercalary meristem
   (4) Collenchyma
4. Identify the xylary element on the basis of below given features, [NCERT Pg. 87]
   (a) Cylindrical tube like structure
   (b) Absent in gymnosperms
   (1) Tracheids
   (2) Vessel
   (3) Xylem parenchyma
   (4) Xylem fibres

NCERT Based MCQs

5. In roots [NCERT Pg. 87]
   (a) Xylem is exarch type
   (b) Protoxylem lies towards pith
   (c) Xylem is endarch type
   Choose the **correct** one(s).
   (1) a and b (2) b and c
   (3) a only (4) c only
6. Which one is **not** true for companion cells? [NCERT Pg. 88]
   (1) Specialised parenchymatous cells
   (2) Connected to sieve tubes by pit fields
   (3) Helps to maintain pressure gradient in sieve tubes
   (4) Thick walled cells
7. Trichomes may [NCERT Pg. 89]
   (a) Be multicellular and unbranched
   (b) Be soft
   (c) Help in preventing water loss
   (d) Involve in mineral and water absorption
   (1) a, b and d only (2) b and c only
   (3) a, b and c only (4) All a, b, c and d
8. In leaves, ground tissue consist of [NCERT Pg. 89]
   (1) Pith (2) Pericycle
   (3) Cortex (4) Mesophyll
9. Conjoint open vascular bundles are found in [NCERT Pg. 90]
   (1) Monocot stem
   (2) Dicot leaf
   (3) Dicot stem
   (4) Monocot leaf
10. Which of the given structure is **absent** in monocot stem? [NCERT Pg. 93]
    (1) Hypodermis
    (2) Cortex
    (3) Endodermis
    (4) Water containing cavities in vascular bundles
11. Casparian strips are seen in [NCERT Pg. 92]
    (1) Root endodermis
    (2) Stem endodermis
    (3) Root pericycle
    (4) Stem pericycle
12. Isobilateral leaves differ from dorsiventral leaves as former **cannot** have [NCERT Pg. 93,94]
    (1) Palisade parenchyma
    (2) Cuticle
    (3) Bulliform cells
    (4) Spongy parenchyma

13. Choose the **odd** one for bulliform cells [NCERT Pg. 94]
(1) Found on abaxial epidermis
(2) Large in size
(3) Empty
(4) Colourless cells

14. Spring wood [NCERT Pg. 96]
(1) Is made of primary xylem
(2) Is darker in colour
(3) Has vessel with wider lumen
(4) Is of higher density

15. Read the below given statements and identify **correct** one(s). [NCERT Pg. 96]
A. Annual rings are seen in roots of plants of temperate regions
B. Heart wood is resistant to insect attacks
C. Sapwood lies towards peripheral region
(1) B only (2) B and C only
(3) C only (4) All A, B and C

16. Bark does **not** includes [NCERT Pg. 97]
(1) Cork
(2) Phelloderm
(3) Secondary phloem
(4) Pith

17. Match the columns and select the correct option. [NCERT Pg. 97, 94, 89]

	Column I		Column II
(A)	Lenticel	(i)	Help to minimize water loss
(B)	Stomata	(ii)	Gaseous exchange
(C)	Bulliform cells	(iii)	Control transpiration

(1) A-ii, B-iii, C-i
(2) A-iii, B-i, C-ii
(3) A-i, B-iii, C-ii
(4) A-i, B-ii, C-iii

18. Periderm includes all, **except** [NCERT Pg. 96]
(1) Phellem
(2) Phelloderm
(3) Cork cambium
(4) Secondary xylem

19. Secondary growth is **absent** in [NCERT Pg. 98]
(1) Gymnosperms
(2) Roots
(3) Stems
(4) Leaves

20. Bast fibers [NCERT Pg. 88]
(1) Are living cells
(2) Of jute are commercially important
(3) Are round structures
(4) Are absent in primary and secondary phloem

Thinking in Context

1. During formation of leaves and elongation of stem, some cells left behind from shoot apical meristem constitute _____. [NCERT Pg. 85]

2. _____ regenerates parts removed by grazing herbivores. [NCERT Pg. 85]

3. _____ provide mechanical support to growing parts of the plant like petiole of a leaf. [NCERT Pg. 86]

4. In flowering plants __a__ and __b__ are water transporting elements. [NCERT Pg. 87]

5. Radial conduction of water takes place by _____. [NCERT Pg. 87]

6. In gymnosperms, phloem has __a__ and __b__. [NCERT Pg. 88]

7. Phloem parenchyma is absent in most of the _____. [NCERT Pg. 88]

8. Guard cells possess __a__ and control __b__ and __c__ of stomata. [NCERT Pg. 89]

9. Outer side of epidermis is often covered by waxy material called __a__ which is absent in __b__. [NCERT Pg. 89]

10. The conjoint vascular bundles usually have phloem situated on _____ of xylem. [NCERT Pg. 90]

11. In roots, the __a__ cells which lie between the xylem and phloem are called __b__. [NCERT Pg. 91]

12. All the tissues on the inner side of endodermis constitute _____. [NCERT Pg. 91]

13. In _____ roots pith is large and well developed. [NCERT Pg. 91]

14. In dicot stem, endodermis is referred as _____. [NCERT Pg. 92]

15. In dorsiventral leaves vascular bundles are surrounded by __a__ walled __b__. [NCERT Pg. 93]

16. After continuous secondary growth __a__ and __b__ get gradually crushed. [NCERT Pg. 95]

17. Phellogen is made of __a__ walled nearly __b__ cells. [NCERT Pg. 96]

18. Cork is impervious to water due to _____ deposition. [NCERT Pg. 96]

19. Bark refers to a number of tissue viz. __a__ and __b__. [NCERT Pg. 97]

20. In dicot root, vascular cambium is _____ in origin. [NCERT Pg. 97]

❑ ❑ ❑

Cell : The Unit of Life

6 Chapter

1 INTRODUCTION

- What makes an organism living? The answer to this is the presence of the basic unit of life the cell in all living organisms. All organisms are composed of cells.

2 WHAT IS A CELL?

- Cell is the fundamental structural and functional unit of all living organisms. Anything less than a complete structure of a cell does not ensure independent living.
- Anton Von Leeuwenhoek first saw and described a live cell.

3 CELL THEORY

- In 1838, Matthias Schleiden, a German botanist, examined a large number of plants and observed that all plants are composed of different kinds of cells which form the tissues of the plant. At the same time, Schwann (1839) a British Zoologist, reported that animal cells had a thin layer called plasma membrane. He concluded that plant cells have cell walls. Schleiden and Schwann together formulated the **cell theory** but this theory did not explain as to how-new cells are formed.
- Rudolf Virchow explained that new cells arise from pre-existing cells (*Omnis cellula-e cellula*) and finally modified the cell theory as:
  (i) All living organisms are composed of cells and products of cells
  (ii) All cells arise from pre-existing cells.

4 AN OVERVIEW OF CELL

- Cells differ greatly in size, shape and activities for example, Mycoplasma is smallest cell while egg of an ostrich is the largest isolated single cell. Nerve cells are some of the longest cells.
- The cytoplasm is main arena of cellular activities in both plant and animal cells.
- Ribosomes are non-membrane bound organelles found in both eukaryotic and prokaryotic cells. Apart from cytoplasm, they are also found in mitochondria, chloroplast and on rough ER.
- Animal cells contain another non-membrane bound organelle called centrosome which helps in cell division.
- Cells that have membrane bound nuclei are called eukaryotic cells that lack a membrane bound nucleus called prokaryotic cells.

5 PROKARYOTIC CELLS

- Lack membrane bound cell organelles.
- Are represented by bacteria, blue green algae, Mycoplasma or PPLO.
- In addition to genomic DNA, many bacteria have small circular DNA outside the genomic DNA called plasmids. Plasmid DNA confers certain unique phenotypic characters to such bacteria. One such character is resistance to antibiotics. Plasmid DNA is used to monitor bacterial transformation with foreign DNA.
- All prokaryotes have a cell wall surrounding the cell membrane (except Mycoplasma).

Cell envelope and its modifications

- Most prokaryotic cells have cell envelope, which is tightly bound three layered structure.
- The outermost glycocalyx followed by cell wall and then the plasma membrane.
- Glycocalyx may be a loose sheath called slime layer or thick and tough called capsule.
- The cell wall prevents bacteria from bursting or collapsing.
- Extension of plasma membrane into the cell in the form of vesicles, tubules and lamellae are mesosomes. It helps in cell wall formation, DNA replication, distribution of daughter cells, respiration, secretion process and increase the surface area of plasma membrane.
- In cyanobacteria, chromatophores contain pigments.
- Each layer of the cell envelope performs distinct function, they act together as a single protective unit. The plasma membrane is selectively permeable in nature and interacts with the outside world. It is structurally similar to that of eukaryotes.
- Bacteria may be motile or non-motile. If motile they have flagella, composed of three parts filament, hook and basal body.
- Pili and fimbriae do not play role in motility.
- Bacteria on the basis of the differences in the cell envelope can be Gram positive or Gram negative.

Ribosomes and inclusion bodies

- Ribosomes are 70S, has subunits 50S and 30S. Several ribosomes may attach to a single mRNA and form a chain called **polyribosome** or **polysome**.
- Ribosomes are associated with plasma membrane.
- The ribosomes of a polysome translate the mRNA into proteins.

Inclusion bodies

- Reserve material is stored in the form of inclusion bodies in prokaryotic cytoplasm. Eg. phosphate granules, cyanophycean granules and glycogen granules.
- Gas vacuoles are found in blue green and purple and green photosynthetic bacteria.

6 EUKARYOTIC CELLS

- Besides the nucleus eukaryotic cells have other membrane bound structure called organelles like ER, Golgi complex etc.
- The eukaryotes include all the protists, plants, animals and fungi. Plant cells have large vacuole. Animals cells have centrioles which are almost absent in plant cells.
- Ribosomes are of 80S (in cytoplasm). Small subunit is 40S and large 80S.

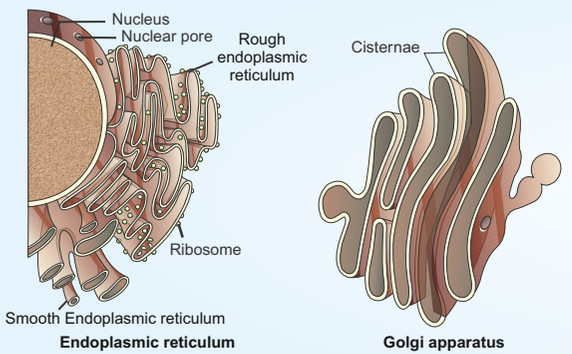
Cell Membrane

- Chemical studies on the cell membrane, especially in human RBC enabled scientists to deduce the possible structure of plasma membrane.
- Cell membrane is mainly composed of proteins and lipids (mainly phospholipids).
- Phospholipids consist of polar head (outward) and non-polar tail (hydrophobic) inner side. In human RBC 52% is proteins and 40% lipids.
- Membrane proteins can be integral or peripheral.
- Most accepted model for structure of cell membrane is **fluid mosaic model** given by **Singer and Nicolson** (1972).
- Membrane is selectively permeable. Many molecules can move across the membrane without any requirement of energy is called passive transport. Movement of water by diffusion is called osmosis. Many molecules require energy/ATP for their transport called active transport, e.g. Na^+/K^+ pump.
- The quasi-fluid nature of lipid enables lateral movement of proteins within the overall bilayer. This ability to move within the membrane is measured as its fluidity.
- Polar molecules cannot move through the non-polar lipid bilayer.
- The fluid nature of membrane is important for functions like cell growth, formation of intercellular junctions, secretion, endocytosis, cell division etc.

7 CELL WALL

- Non-living rigid structure called the cell wall forms an outer covering of the plasma membrane in fungi and plants. The cell wall of a young plant cell, the primary wall is capable of growth which gradually diminishes as the cell matures and the secondary wall is formed on inner side (towards membrane) of the cell. The middle lamella is a layer mainly of calcium pectate.
- Algae have cell wall made up of cellulose, galactans, mannans and calcium carbonate. In plants it consists of cellulose, hemicellulose, pectin and proteins.

8 ENDOMEMBRANE SYSTEM

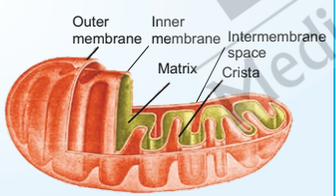


- While each of the membranous organelles is distinct in terms of its structure and function, many of these are considered together as an endomembrane system because their functions are coordinated.

Endoplasmic reticulum (ER)	Golgi apparatus	Lysosome	Vacuole
Reticulum of tiny tubular structures scattered in the cytoplasm is called ER.	These were named Golgi bodies after discoverer name Camillo Golgi.	These are membrane bound vesicular structures formed by the process of packaging in the Golgi apparatus.	The vacuole is the membrane bound space found in the cytoplasm, membrane is called tonoplast.
The ER which has ribosomes on surface are called RER, in absence of ribosomes they appear smooth called SER.	They consist of cisternae, which are concentrically arranged near the nucleus with distinct convex cis or the forming face and concave trans or the maturing face.	They are rich in hydrolytic enzymes (lipases, proteases carbohydrases), optimally active at acidic pH.	Contain water, sap, excretory product and other materials not useful for the cell. In *Amoeba,* contractile vacuole is important for excretion.
RER is involved in protein synthesis whereas SER is involved in lipid synthesis.	Principally performs the function of packaging of materials. It is the important site for formation of glycoproteins and glycolipids.	These enzymes are capable of digesting carbohydrates, proteins, lipids and nucleic acids.	In many cells, as in protists, food vacuoles are formed by engulfing the food particles.

9 MITOCHONDRIA

- Mitochondria unless specifically stained are not easily visible under microscope.
- Each mitochondria is a double membrane bound structure with inner compartment called matrix. The two membranes have their own specific enzymes.
- The outer membrane forms the continuous limiting boundary of the organelle and inner membrane forms cristae.
- Mitochondria are the sites of aerobic respiration. They produce cellular energy in the form of ATP, hence called 'power house of the cell'. The matrix has single circular DNA molecule, a few RNA molecules, ribosomes (70S) and the components required for the synthesis of proteins. Here 'S' (Svedberg's unit) stands for sedimentation coefficient. It is an indirect measure of density and size.

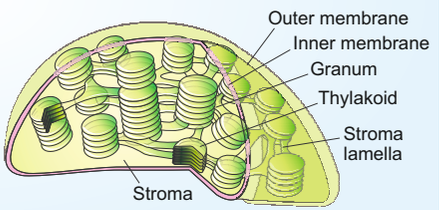


Structure of mitochondrion (Longitudinal section)

Mitochondria divide by fission.

10 PLASTIDS

- Plastids are found in all plant cells and in euglenoids. Based on the pigments plastids can be classified into chloroplasts, chromoplasts and leucoplasts.
- The chloroplast contain chlorophyll and carotenoid pigments. The leucoplast are colourless plastids. Amyloplasts store carbohydrates e.g. Potato, Elaioplasts store oils and fats whereas the aleuroplast store proteins.
- Chloroplast are also double membrane bound structure which has membranous sac like structure called thylakoids and the matrix is called stroma. It also contains small, ds circular DNA and ribosomes. Carotenoid is fat soluble pigment eg., carotene, xanthophyll etc.
- The ribosomes of the chloroplasts (70S) are smaller than cytoplasmic ribosomes.
- Thylakoids are arranged in stacks called grana (singular-granum). Flat membranous tubules called the stroma lamellae connecting the thylakoids of the different grana.
- Stroma contain required enzymes for carbohydrate and protein synthesis.
- Chlorophyll pigments are present in the thylakoids.



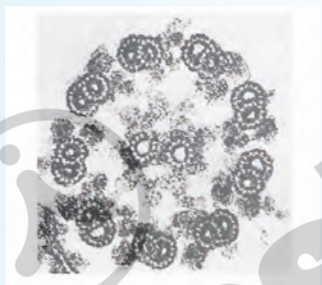
Sectional view of chloroplast

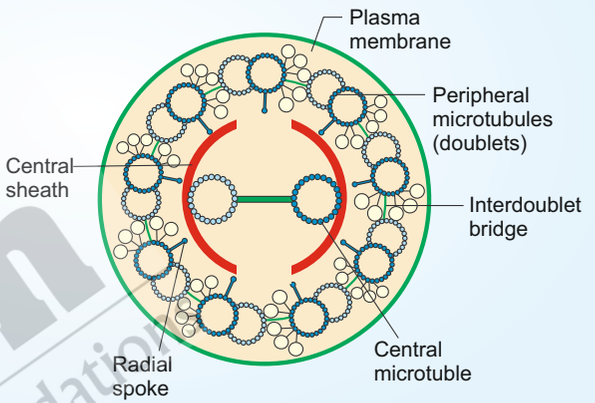
11 CYTOSKELETON

- An elaborate network of filamentous proteinaceous structures present in the cytoplasm is collectively referred to as the cytoskeleton.
- It is involved in many functions such as mechanical support, motility, maintenance of the shape of the cell.

12 CILIA AND FLAGELLA

- Cilia and flagella are hair like outgrowths of the cell membrane. Flagella are comparatively longer and responsible for cell movement.
- The prokaryotic bacteria also possess flagella but these are structurally different from eukaryotic flagella.
- The central core is called axoneme and the arrangement of axonemal microtubules is referred to as the 9 + 2 array.
- Both cilium and flagellum arise from centriole like structure called basal bodies. They are covered will plasma membrane.





Section of cilia/flagella showing different parts (a) Electron micrograph (b) Diagrammatic representation of internal structure

13 CENTROSOME AND CENTRIOLES

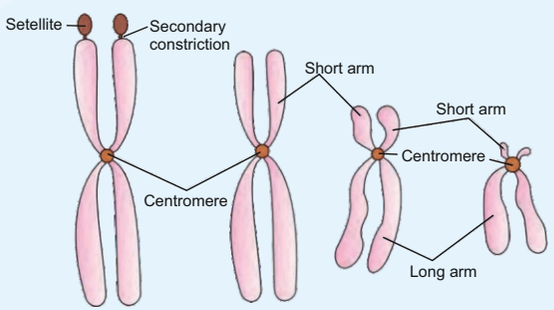
- Centrosome is an organelle usually containing two cylindrical structures called centrioles. They are surrounded by amorphous pericentriolar materials and lie perpendicular to each other.
- The central part of the proximal region of the centriole is proteinaceous called the hub, which is connected with tubules of the peripheral triplets (nine) by radial spokes made of protein.

14 NUCLEUS

- Nucleus as a cell organelle was first described by Robert Brown as early as 1831. Later the material of nucleus was given the name chromatin by Flemming.
- Interphase nucleus has chromatin, nuclear matrix and nucleolus. Nucleus has the membranes and the space between two membranes is perinuclear space.
- Outer membrane usually remains continuous with the endoplasmic reticulum and also bears ribosomes on it.
- The nuclear matrix or the nucleoplasm contains nucleolus and chromatin.
- During different stages of cell division, cells show structured chromosomes. Chromatin contains DNA, some basic histones, some non-histones and some RNA.
- Every chromosome has primary constriction called centromere on the sides of which disc shaped structures called kinetochores are present.
- Based on the position of centromere, the chromosome can be classified into four types.
  - Metacentric – Centromere is in the middle
  - Sub metacentric – Centromere slightly away from the middle
  - Acrocentric – Centromere situated close to one end
  - Telocentric – Centromere at terminal position
- Sometimes a few chromosomes have non staining secondary constrictions at a constant location. This gives the appearance of a small fragment called the satellite.
- Nucleolus is not a membrane bound structure and it is a site for active ribosomal RNA synthesis.

15 MICROBODIES

- Many membrane bound minute vesicles called microbodies that contain various enzymes, are present in both plant and animal cells.



Types of chromosomes based on the position of centromere

Sharpen Your Understanding

NCERT Based MCQs

1. Who first saw and described a living cell? [NCERT Pg. 125]
   (1) Robert Brown
   (2) Robert Hooke
   (3) Anton Von Leeuwenhoek
   (4) Matthias Schleiden
2. Select the **incorrect** statement. [NCERT Pg. 126]
   (1) Schleiden and Schwann together formulated the cell theory
   (2) The onion cell has a distinct cell wall
   (3) The cytoplasm is the main arena of the cellular activities
   (4) Ribosomes are membrane bound cell organelles
3. Prokaryotes do not have [NCERT Pg. 128]
   (1) Cell membrane
   (2) Cell wall
   (3) Nucleus
   (4) Genomic DNA
4. All of the following are layers of cell envelope in prokaryotes, **except** [NCERT Pg. 128]
   (1) Cell wall
   (2) Glycocalyx
   (3) Cell membrane
   (4) Nuclear membrane
5. Select the **incorrect** statement. [NCERT Pg. 128-129]
   (1) Bacterial cells may be motile or non-motile
   (2) The pili are elongated tubular structures made of a special protein
   (3) Mesosome helps in DNA replication
   (4) Gram positive bacteria do not take gram stain
6. Gas vacuoles are found in all, **except** [NCERT Pg. 129]
   (1) Blue green algae
   (2) Purple photosynthetic bacteria
   (3) Green photosynthetic bacteria
   (4) Mycoplasma
7. Which of the following cell organelles is absent in higher plant cells but present in animal cells? [NCERT Pg. 129]
   (1) Ribosomes
   (2) Mitochondria
   (3) Centrioles
   (4) Lysosome
8. Select the **odd** one w.r.t. cell organelles of endomembrane system. [NCERT Pg. 133]
   (1) Golgi
   (2) ER
   (3) Vacuole
   (4) Peroxisome
9. Select the **incorrect** statement for mitochondria. [NCERT Pg. 135]
   (1) Double membrane bound structure
   (2) Matrix has 70S ribosomes
   (3) The cristae decrease the surface area
   (4) The two membranes have their own specific enzymes
10. Mark the **odd** one w.r.t. chloroplast. [NCERT Pg. 136]
    (1) The stroma contains enzymes required for the synthesis of proteins and carbohydrates
    (2) Has 80S ribosomes
    (3) Possess thylakoids
    (4) Inner membrane is relatively less permeable than outer
11. Both eukaryotic cilia and flagella emerge from [NCERT Pg. 137]
    (1) Hook (2) Filament
    (3) Basal body (4) Centriole
12. Select the **incorrect** one for nucleolus. [NCERT Pg. 138]
    (1) Is spherical structure
    (2) Membrane less
    (3) Site for active ribosomal RNA synthesis
    (4) Found in cytoplasm
13. Ribosomes [NCERT Pg. 136]
    (1) Are composed for RNA and proteins
    (2) Are surrounded by single membrane
    (3) Are only found in eukaryotes
    (4) Are composed of a single subunit

14. Chlorophyll pigments are present in [NCERT Pg. 136]

(1) Stroma
(2) Thylakoids
(3) Matrix
(4) Lysosome

15. Mark the **incorrect** w.r.t. cilia and flagella. [NCERT Pg. 137]

(1) They are covered by plasma membrane
(2) Axoneme has number of microtubules
(3) Microtubules arrangement is 9 + 0
(4) The peripheral doublets are interconnected by linkers

16. Plant cell wall mainly contains all, **except** [NCERT Pg. 132]

(1) Cellulose
(2) Pectins
(3) Hemicellulose
(4) Calcium carbonate

17. Select the **incorrect** one for active transport. [NCERT Pg. 132]

(1) Exemplified by Na^+/K^+ pump
(2) ATP is utilised
(3) Molecules move against the concentration gradient
(4) Is energy independent

18. DNA containing cell organelles are [NCERT Pg. 135]

(1) Chloroplast (2) Lysosome
(3) Mitochondria (4) Both (1) and (3)

19. Golgi apparatus is involved in [NCERT Pg. 134]

(1) Formation of proteins
(2) Packaging and sorting of materials
(3) Formation of lipids
(4) Oxidation of carbohydrates

20. Which one is **not** a double membrane bound cell organelle? [NCERT Pg. 126]

(1) Plastid
(2) Lysosome
(3) Mitochondria
(4) Nucleus

Thinking in Context

1. _____ are some of the longest cells. [NCERT Pg. 127]

2. The _____ determines the shape of the cell and provides a strong structural support to prevent the bacterium from bursting or collapsing. [NCERT Pg. 128]

3. In some prokaryotes like cyanobacteria, there are other membranous extensions into the cytoplasm called _____ which contain pigments. [NCERT Pg. 129]

4. Several ribosomes may attach to a single mRNA and form a chain called _____. [NCERT Pg. 129]

5. In human beings, the membrane of the erythrocyte has approximately __A__ percent protein and __B__ percent lipids. [NCERT Pg. 131]

6. Many molecules can move briefly across the membrane without any requirement of energy and this is called _____. [NCERT Pg. 132]

7. The smooth endoplasmic reticulum is the major site for synthesis of _____. [NCERT Pg. 133]

8. Hydrolytic enzymes optimally active at the _____ pH. [NCERT Pg. 134]

9. The vacuole is bound by a single membrane called _____. [NCERT Pg. 134]

10. The mitochondria divide by _____. [NCERT Pg. 135]

11. Amyloplasts store _____. [NCERT Pg. 135]

12. Like mitochondria, the chloroplasts are also _____ organelles. [NCERT Pg. 136]

13. The core of cilia and flagella is called _____. [NCERT Pg. 137]

14. The material of the nucleus stained by the basic dyes was given the name _____ by Flemming. [NCERT Pg. 138]

15. The _____ chromosome has centromere slightly away from the middle of the chromosome. [NCERT Pg. 139]

16. The _____ contains nucleolus and chromatin. [NCERT Pg. 138]

17. The lipid component of the membrane mainly consists of _____. [NCERT Pg. 131]

18. The middle lamella is a layer mainly composed of _____. [NCERT Pg. 132]

19. In *Amoeba* the _____ is important for excretion. [NCERT Pg. 134]

20. Mitochondria are sites of _____. [NCERT Pg. 135]

❑ ❑ ❑

Cell Cycle and Cell Division

7 Chapter

1 INTRODUCTION

- All cells reproduce by dividing into two, with each parental cell giving rise to two daughter cells each time they divide.
- Growth and reproduction are characteristics of cells, indeed of all living organisms.
- Such cycles of growth and division allows single cell to form a structure consisting of millions of cells.

2 CELL CYCLE

- It is sequence of events by which a cell duplicates its genome, synthesises the other constituents of the cell and eventually divides into two daughter cells.
- Cell growth results in disturbing the ratio between the nucleus and cytoplasm. It therefore becomes essential for the cell to divide to restore the nucleo-cytoplasmic ratio.
- Cell growth (in terms of cytoplasmic increase) is a continous process
- Duration of cell cycle can vary from organism to organism and also from cell type to cell type.

  e.g., Yeast- cell cycle duration - 90 minutes,

  Human cell cycle duration - 24 hours but cell division proper lasts for only about an hour.

3 PHASES OF CELL CYCLE

Interphase

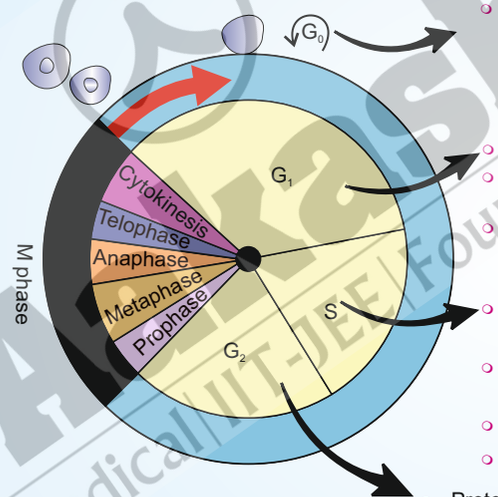
- Called resting phase
- Cell is preparing for division by undergoing both cell growth and DNA replication in an orderly manner.
- It lasts more than 95% of the duration of cell cycle

M-phase

- Actual cell division phase
- Starts with nuclear division (karyokinesis) and usually ends with division of cytoplasm (cytokinesis)

4 INTERPHASE

- Divided further into three phases
  - (i) G_1 phase (Gap 1)
  - (ii) S phase (Synthesis)
  - (iii) G_2 phase (Gap 2)



- Some cells do not divide further, exit G_1 phase to enter an inactive stage called **quiescent stage** (G_0) of the cell cycle.
- Cells in this stage remain metabolically active but no longer proliferate unless called on to do so depending on the requirement of the organism. eg Heart cells

- Interval between mitosis and initiation of DNA replication.
- Cell is metabolically active and continuously grows but does not replicate its DNA.
- Most of the cell organelles duplicate

- This phase marks the phase of DNA replication and chromosome duplication.
- Amount of DNA per cell doubles but there is no increase in initial chromosome number
- In animal cells, centriole duplicates in cytoplasm.
- DNA replication begins in nucleus.

- Proteins are synthesised in preparation for mitosis while cell growth continues

In animal cells mitotic division is only seen in diploid somatic cells. Plant cells show mitotic division in both haploid and diploid cells.

- Most dramatic period of cell cycle
- Chromosome number in parent and progeny cells is the same hence called equational division.

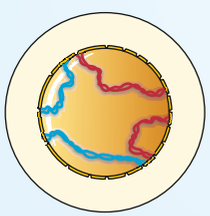
5 M PHASE (MITOSIS)

Divided into

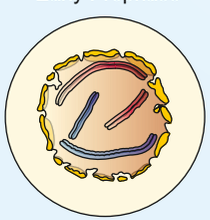
KARYOKINESIS

1. PROPHASE

- First phase, follows the S and G_2 phases of interphase.
- Marked by the initiation of condensation of chromosomal material which becomes untangled.
- Centrosome starts to move towards opposite poles.
- The completion of prophase can be marked by-
  (i) Chromosomes condense to form compact mitotic chromosome.
  (ii) Each centrosome reach at pole and radiates out microtubules called **asters**. The two asters together with spindle fibres form mitotic apparatus.
- At the end of prophase cells do not show Golgi complex, ER, nucleolus and nuclear envelope.



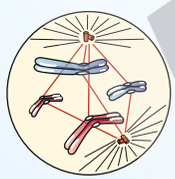
Early Prophase



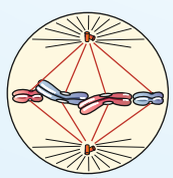
Late Prophase

2. METAPHASE

- The complete disintegration of the nuclear envelope marks the start of metaphase.
- Condensation of chromosomes is completed and can be observed clearly under microscope and morphology of chromosomes is most easily studied.
- Each chromosome has two sister chromatids which are held together by the centromere.
- All the chromosome coming to lie at equator.
- Each chromosome connected by its kinetochore to spindle fibre from one pole and its sister chromatid connected by its kinetochore to spindle fibre from the opposite pole.
- The plane of alignment of the chromosomes at metaphase is referred to as metaphase plate.



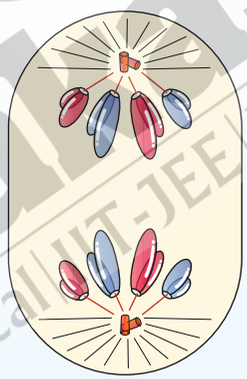
(a)
Transition to Metaphase



(b)
Metaphase

3. ANAPHASE

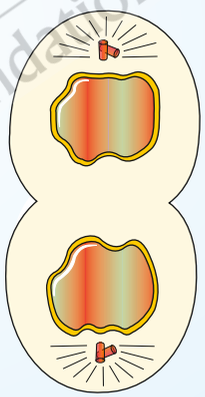
- Centromere of each chromosome split simultaneously and chromatids separate.
- Two daughter chromatids, now referred to as daughter chromosome begin their migration towards the two opposite poles.
- The centromere of each chromosome remain directed towards the pole and arms trailing behind. (leading to different shapes of chromosomes)



Anaphase

4. TELOPHASE

- Final stage of karyokinesis.
- Chromosomes that have reached their respective poles decondense and lose their individuality.
- Nuclear envelope develops around the chromosome cluster at each pole forming two daughter nuclei.
- Nucleolus, Golgi complex and ER reform.



Telophase

CYTOKINESIS

- It is division of cytoplasm at the end of which cell division gets completed.
- In animal cells it is achieved by the appearance of a furrow in the plasma membrane.
- In plant cells cytokinesis is achieved by wall formation, which starts in the centre of the cell and grows outward to meet the existing lateral wall.
- The formation of new cell wall begins with the formation of a simple precursor, called the cell plate that represents the middle lamella between the wall of two adjacent cells.
- When karyokinesis is not followed by cytokinesis as a result of which multinucleate condition arises leading to formation of syncytium, eg. liquid endosperm in coconut.

Kinetochore is disc shaped structure at the surface of centromere, serves as the site of attachment of spindle fibres

6 SIGNIFICANCE OF MITOSIS

- Mitosis usually results in identical genetic complement in daughter cells.
- Growth of multicellular organisms.
- Cell repair
- Mitotic division in apical and lateral meristem results continuous growth of plants throughout their life.
- In some lower plants and in some social insects haploid cells also divide by mitosis.

7 MEIOSIS

- Specialised kind of cell division that reduces the chromosome number by half results in the production of haploid daughter cells.
- Meiosis ensures the production of haploid phase in the life cycle of sexually reproducing organisms whereas fertilization restores the diploid phase.
- Meiosis involves two sequential cycles of nuclear division i.e. **meiosis I** and **meiosis II** but only single cycle of DNA replication.
- Meiosis I initiated after parental chromosomes have replicated.
- Four haploid cells are formed at the end of meiosis II.

8 MEIOSIS I (Reductional Phase)

Prophase I

- Typically longer and more complex when compared to prophase of mitosis

Leptotene

- Chromosomes become gradually visible under the light microscope.
- The compaction of chromosomes continues throughout leptotene.

Zygotene

- Homologous chromosomes called **synapsis.**
- Synapsis is accompanied by formation of complex structure called synaptonemal complex.
- The complex formed by a pair of synapsed homologous chromosomes is called **bivalent** or a **tetrad**
- Leptotene and zygotene are relatively short lived compared to the pachytene.

Pachytene

- Four chromatids of each bivalent become distinct and clearly appears as tetrads.
- Appearance of recombination nodule, the sites at which crossing over occurs between non-sister chromatids of the homologous chromosomes.
- Crossing over is exchange of genetic material between two homologous chromosomes. It is an enzyme mediated process, enzyme involved is called recombinase.
- Crossing over leads to recombination of genetic material which is completed by the end of pachytene leaving chromosomes linked at the sites of crossing over.

Diplotene

- Beginning of diplotene is recognised by the dissolution of synaptonemal complex and tendency of the recombined homologous chromosomes of the bivalent to separate from each other except at the site of crossovers.
- This x-shaped structures (site of crossing over) are called chiasmata.
- In oocytes of some vertebrates, diplotene can last for months or years (dictyotene).

Diakinesis

- This is marked by terminalisation of chiasmata
- Chromosomes are fully condensed and meiotic spindle is assembled to prepare the homologous chromosomes for separation
- By the end of diakinesis, the nucleolus disappears and nuclear envelope also breaks down.
- Diakinesis represents transition to metaphase.

METAPHASE I

- Bivalent chromosomes align on the equatorial plate (Double metaphasic plate)
- Microtubules from the opposite poles of the spindle attach to the kinetochore of homologous chromosomes

ANAPHASE I

- Homologous chromosomes separate, while sister chromatids remain associated at their centromere.

TELOPHASE I

- The nuclear membrane and nucleolus reappear
- Cytokinesis follows and this is called as dyad of cells.

9 INTERKINESIS

- It is the stage between two meiotic divisions.
- It is generally short lived.
- No DNA replication
- It is followed by prophase II.

10 MEIOSIS II-(Equational Phase) - Resembles a normal mitosis

PROPHASE II

- It is initiated immediately after cytokinesis
- The nuclear membrane disappears by the end of prophase II.
- Chromosomes become compact.

METAPHASE II

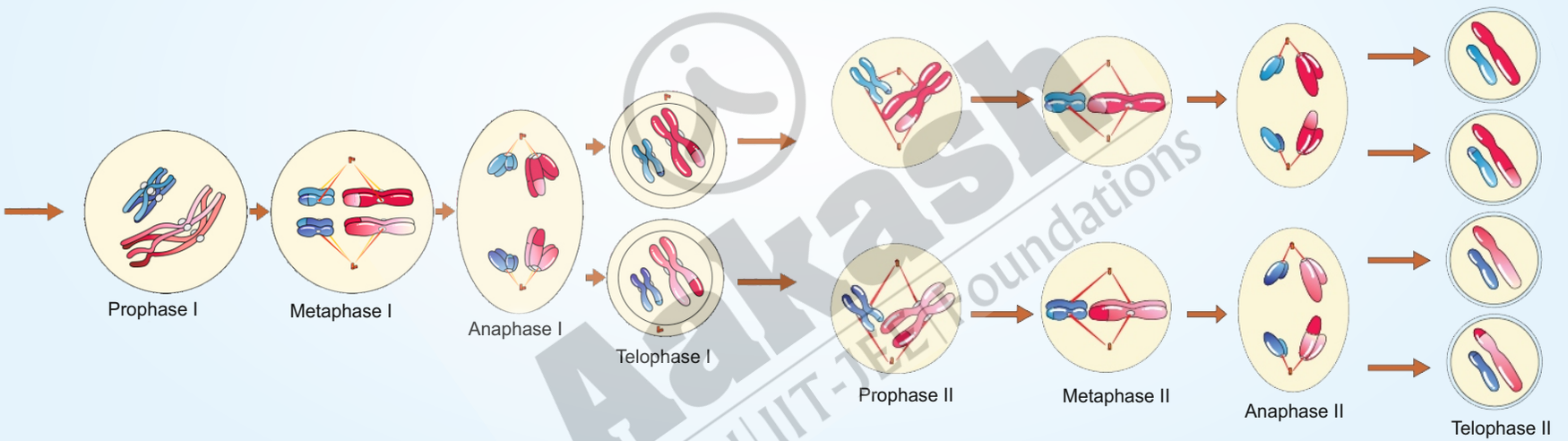
- Chromosomes align at the equator
- Microtubules from opposite poles of the spindle get attached to the kinetochore of sister chromatids

ANAPHASE II

- Splitting of centromere allowing chromosomes to move towards opposite poles of the cell by shortening of microtubules attached to the kinetochores.

TELOPHASE II

- Meiosis ends with telophase II
- Two groups of chromosomes once again get enclosed by a nuclear envelope
- Cytokinesis follow resulting in the formation of tetrad of cells.



11 Significance of meiosis

- Conservation of specific chromosome number of each species is achieved across generation in sexually reproducing organisms, paradoxically results in reduction of chromosome number by half.
- Increases genetic variability in the population of organisms which is important for the process of evolution.

Sharpen Your Understanding

1. Cell cycle includes- [NCERT Pg. 162]
   (a) Duplication of genome
   (b) Cell growth (c) Cell division
   (d) Synthesis of other cell constituents
   (1) Only (a) and (c)
   (2) Only b
   (3) Only (b) and (c)
   (4) All (a), (b), (c) and (d)

2. In yeast, cell cycle is completed in about- [NCERT Pg. 163]
   (1) 24 hours (2) 24 minutes
   (3) 90 minutes (4) 90 hours

3. Human cells can divide- [NCERT Pg. 163]
   (1) Once in approximately every 24 hours
   (2) Twice in every 24 hours
   (3) Once in every 24 minutes
   (4) Once in every 90 minutes

4. Read the following statements and choose the **correct** option. [NCERT Pg. 163]
   Statement A: The M-phase represents the phase when actual cell division occurs
   Statement B: Interphase represents the phase between two successive M-phases
   (1) Only statement A is correct
   (2) Only statement B is correct
   (3) Both the statements are incorrect
   (4) Both the statements are correct

5. Match the columns and choose the **correct** option [NCERT Pg. 163 &164]

Column I	Column II
(a) G_1 phase	(i) Quiescent stage of the cell cycle.
(b) G_2 phase	(ii) DNA denoted as 2C, increases to 4C
(c) Synthesis phase	(iii) Proteins are synthesized in preparation for mitosis
(d) G_0 phase	(iv) Cell contain initial amount of DNA i.e., 2C

   (1) a-iv, b-iii, c-i, d-ii (2) a-iv, b-iii, c-ii, d-i
   (3) a-iii, b-i, c-iv, d-ii (4) a-ii, b-iv, c-iii, d-i

6. Most dramatic period of cell cycle is- [NCERT Pg. 164]
   (1) Gap 1 only (2) M-phase
   (3) S-phase only (4) Interphase

7. Prophase is marked by the initiation of- [NCERT Pg. 164]
   (1) DNA synthesis
   (2) Decondensation of chromosomal material
   (3) Condensation of chromosomal material
   (4) Centriole duplication

NCERT Based MCQs

8. Choose the **incorrect** match [NCERT Pg. 164 & 165]
   (1) Beginning of movement of centrosome to opposite poles – Prophase
   (2) Two asters with spindle fibres – Mitotic apparatus
   (3) Attachment of spindle fibres to kinetochores – Metaphase
   (4) Chromosome move to opposite poles – Metaphase

9. The complete disintegration of the nuclear envelope marks beginning of - [NCERT Pg. 165]
   (1) Telophase (2) Metaphase
   (3) Prophase (4) Anaphase

10. Read the following statements and identify them as true (T) or false (F) and accordingly choose **correct** option.
   A. Splitting of centromere takes place during anaphase of mitosis.
   B. During metaphase of mitosis each chromatid of a chromosome remain connected to pole of its side by spindle fibre.
   C. Nucleolus, Golgi complex and ER reform during end of prophase.
   D. In animal cells cytokinesis is carried out by furrow formation. [NCERT Pg. 165-166]

	A	B	C	D
(1)	T	T	F	F
(2)	T	T	F	T
(3)	F	T	T	T
(4)	T	F	F	T

11. During which of the given phases, homologous chromosomes separate, while sister chromatids remain associated at their centromere? [NCERT Pg. 169]

(1) Anaphase of mitosis

(2) Anaphase II

(3) Anaphase I

(4) Metaphase I

12. A bivalent is [NCERT Pg. 168]

(1) Pair of non-homologous chromosomes

(2) The complex formed by a pair of synapsed homologous chromosomes.

(3) Formed during pachytene stage

(4) More clearly visible at zygotene stage

13. Synaptonemal complex dissolves during- [NCERT Pg. 168]

(1) Leptotene

(2) Diakinesis

(3) Zygotene

(4) Diplotene

14. (a) Disappearance of nucleolus

(b) Terminalisation of chiasmata

(c) Represent transition to metaphase

Above given characteristics are related to- [NCERT Pg. 168]

(1) Metaphase I

(2) Diakinesis

(3) Diplotene

(4) Prophase II

15. Which one is **odd** w.r.t. significance of meiosis? [NCERT Pg. 167 & 170]

(1) Increase genetic variability in organisms

(2) Helps in restorage of original chromosome number in a sexually reproducing species.

(3) Ensure production of haploid phase

(4) Cell repair

16. Which one is **incorrect** w.r.t. interkinesis? [NCERT Pg. 169]

(1) It is phase between two stages of a meiosis

(2) It is generally short lived

(3) It includes DNA replication along with duplication of other organelles.

(4) Followed by prophase II

17. During which phase of meiosis centromere splits? [NCERT Pg. 169]

(1) Anaphase I

(2) Anaphase II

(3) Telophase II

(4) Telophase I

18. Recombination between non-sister chromatids of a homologous pair of chromosomes is completed by the end of- [NCERT Pg. 168]

(1) Zygotene

(2) Diplotene

(3) Pachytene

(4) Diakinesis

19. Choose **incorrectly** matched pair- [NCERT Pg. 163,164,165 & 168]

(1)	Chiasmata formation	–	Diplotene
(2)	Radiation of microtubules from microtubules from centrosome	–	Aster
(3)	G_0 phase	–	Cell exit the G_1 Phase
(4)	Centriole duplication	–	G_2 phase

20. Alignment of bivalents on equatorial plate occurs during [NCERT Pg. 168]

(1) Metaphase of mitosis

(2) Metaphase II

(3) Prophase I

(4) Metaphase I

Thinking in Context

1. The interphase lasts more than _____ of the duration of cell cycle. [NCERT Pg. 163]
2. Interphase is also called __a__ , is the time during which cell is preparing for division by undergoing both __b__ and __c__ in orderly manner. [NCERT Pg. 163]
3. G_1 phase corresponds to the interval between mitosis and initiation of _____. [NCERT Pg. 163]
4. In S and G_2 phases the new DNA molecules formed are _____ but interwined. [NCERT Pg. 164]
5. The two asters together with spindle fibres form _____. [NCERT Pg. 164]
6. Chromosomal material condenses to form compact _____. [NCERT Pg. 164]
7. Condensation of chromosomes is completed by the stage called _____. [NCERT Pg. 165]
8. Kinetochore is a small disc shaped structure at the surface of the _____. [NCERT Pg. 165]
9. Chromosomes move away from the equatorial plate during _____. [NCERT Pg. 165]
10. During _____ chromosomes cluster at opposite poles and their identity is lost as discrete elements. [NCERT Pg. 166]
11. Cell plate represents _____ between the walls of two adjacent cells. [NCERT Pg. 166]
12. Dissolution of __a__ results separation of homologous chromosomes of bivalents from each other except at the X-shape site of crossover called __b__ .[NCERT Pg. 168]
13. In oocyte of some _____, diplotene can last for months or years. [NCERT Pg. 168]
14. The process of association of homologous chromosomes is called __a__ , which takes place during __b__ . [NCERT Pg. 168]
15. Meiosis ensures production of __a__ phase in the life cycle of sexually reproducing organisms during __b__ in plants and animals. [NCERT Pg. 167]
16. Meiosis involves __a__ sequential cycles of nuclear division and only single cycle of __b__ . [NCERT Pg. 167]
17. Meiosis ends with __a__ , results formation of __b__ of cells. [NCERT Pg. 170]
18. Most of the cell organelle duplication occurs during _____ phase. [NCERT Pg. 171]
19. Mitosis is _____ in which the chromosome number of the parent is conserved in the daughter cells. [NCERT Pg. 171]
20. G_2 phase is the period of _____ growth. [NCERT Pg. 171]

❑ ❑ ❑

Transport in Plants

8 Chapter

1 INTRODUCTION

- In a flowering plant the substances that would need to be transported are water, mineral nutrients, organic nutrients and plant growth regulators.
- Water and mineral nutrients are taken up by roots and food is synthesised in the leaves.
- But plants do not have a circulatory system.
- So in plants, there are two broad strategies for transport, short-distance and long-distance.
- Short-distance movement is through-diffusion, cytoplasmic streaming and active transport; and transport through longer distances is through vascular system (xylem and phloem) and is called TRANSLOCATION.
- Transport in xylem is essentially UNIDIRECTIONAL (of water and minerals) from roots to leaves through the stems.
- Organic and mineral nutrients undergo MULTIDIRECTIONAL transport.
- From SENESCENT plant parts nutrients are withdrawn and moved to growing plants. So the transport is complex but orderly. Each organ is receiving some substances and giving out some other.

2 SHORT DISTANCE MOVEMENT

Property	Simple Diffusion	Facilitated Diffusion	Active Transport
1. Need special membrane proteins	No	Yes	Yes
2. Highly selective	No	Yes	Yes
3. Transport saturates	No	Yes	Yes
4. Uphill movement	No	No	Yes
5. Need ATP	No	No	Yes

1. Diffusion is the only means for gaseous movement with in the plant body.
2. **Porins** are proteins that form large pores in outer membrane of Plastids, Mitochondria and some Bacteria.
3. In facilitated diffusion extracellular molecule is bound to transport protein which then rotates and releases the molecule inside the cell, e.g., water channels-made of 8 different types of aquaporins.

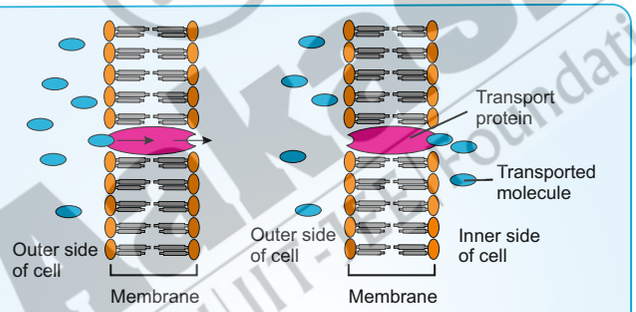


Fig. : Facilitated diffusion

4. Passive symports and antiports
   - In symport two molecules move together in the same direction and in opposite direction in antiport
   - In uniport a molecule moves across a membrane independent of other molecules in one direction.

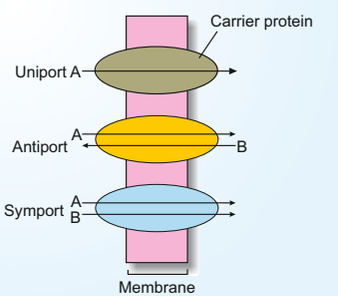


Fig. : Facilitated diffusion

3 PLANT-WATER RELATIONS

Water is essential for all physiological activities of plant. Because of its high demand water is often the limiting factor for plant growth and productivity.

Terms :

1. **Water Potential :** water molecules possess kinetic energy. The greater the concentration of water in a system, the greater is its kinetic energy or water potential.
   (i) Pure water have greatest water potential
   (ii) Water moves from a system at higher water potential to the one having low water potential.
   (iii) It is denoted by Psi or Ψ and expressed in pascals.
   (iv) Water potential of pure water at standard temperature. Which is not under any pressure, is taken as zero.
2. **Solute Potential :** The magnitude of lowering of water potential due to dissolution of solute is called solute potential or Ψ_S
   (i) Ψ_S is always negative.
   (ii) More the solute molecules, the lower is the Ψ_S
3. For a solution at atmospheric pressure.
   (Water potential) $\Psi_W = \Psi_S$ (Solute potential)
4. Numerically osmotic pressure is equivalent to the osmotic potential but the sign is opposite.
5. Osmotic pressure is the positive pressure applied, while osmotic potential is negative.
6. **Pressure Potential :** Pressure builds up in a plant system when water enters a plant cell due to diffusion, it makes the cell **turgid**, this increases the **pressure potential**.
   (i) It is usually positive
   (ii) Though negative potential or tension in xylem plays a major role in water transport.
7. **Water Potential** is affected by both solute and pressure potential.
   The relationship is : $\Psi_W = \Psi_S + \Psi_P$

OSMOSIS

1. Refer specifically to the diffusion of water across a differentially or selectively permeable membrane.
2. Net direction and rate of osmosis depends on both pressure gradient and concentration gradient.
3. Water moves from higher chemical potential to region of lower chemical potential until equilibrium is reached.

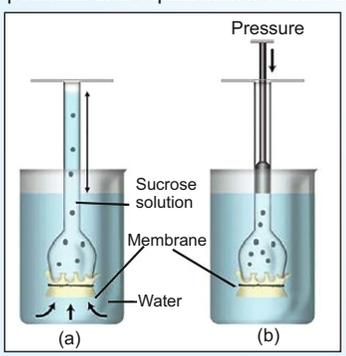
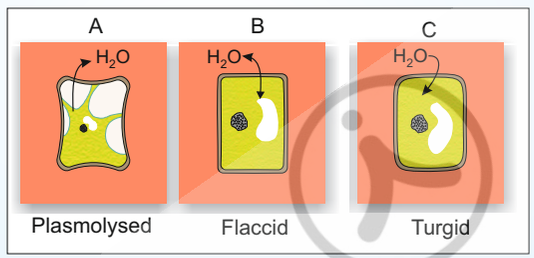


Fig.: Demonstration of osmosis-Thistle funnel experiment

PLASMOLYSIS

1. Occurs when water moves out of the cell and cell membrane of plant cell shrinks away from its cell wall.
2. This happens when a cell or tissue is placed in hypertonic solution.
3. The process of plasmolysis is reversible. When cells are placed in hypotonic solution the cell regains its shape.
4. When water flow into the cell and out of the cells are in equilibrium, the cells are said to be flaccid.



IMBIBITION

1. Special type of diffusion when water is absorbed by solids-colloids causing them to increase in volume
2. Water potential gradient between the absorbent and the liquid imbibed is essential for imbibition.
3. For any substance to imbibe any liquid, affinity between the adsorbant and the liquid is also a pre-requisite.

Example : Absorption of water by seeds and dry wood

Watermelon has over 92% water, herbaceous plants have only 10 to 15% of fresh weight as dry wt. A seed many appear dead but it still has water.

1. Transport proteins of endodermal cells are control points, where a plant adjusts the quantity and types of solutes that reach xylem
2. Root endodermis because of suberin, actively transports ions in one direction.

4 LONG DISTANCE TRANSPORT

1. Diffusion is a slow process. It can account for only short distance movement.
2. Long distance movement of water and minerals and food generally occur by mass or bulk flow.
3. Mass flow is en masse movement due to pressure differences between the two points.
4. Bulk movement is through vascular tissues called TRANSLOCATION.
5. Xylem mainly translocates WATER, MINERAL SALTS, some ORGANIC NITROGEN and HORMONES.
6. PHLOEM translocates a variety of organic and inorganic solutes.
7. Water is absorbed by two distinct pathways :
   - **Apoplast :** A system of adjacent cell wall except at casparian strips of endodermis. This movement is dependent on the gradient.
   - **Symplast:** A system of interconnected protoplasts.

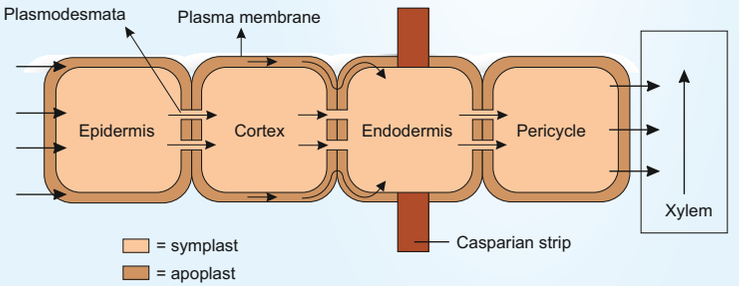


Fig.: Pathway of water movement in plants

7. In some plants symbiotic **mycorrhizal** association of fungus with root system help in water and mineral absorption eg. *Pinus* seeds.

5 WATER MOVEMENT UP A PLANT

1. Root Pressure : Only provide a modest push in overall process of water transport. They do not play a major role in water movement up tall plants.
   - The greatest contribution of root pressure is to re-establish the continuous chains of water molecules in xylem.
   - In many herbaceous plants, grass blades, root pressure is the cause of loss of water in the form of liquid droplets called GUTTATION.
2. **TRANSPIRATION PULL :** Cohesion-tension-transpiration pull model of water transport accomplishes water movement in tall plants.

↓

Transpiration is the evaporative loss of water by plants through stomata.

↓

The opening of stomata is caused due to change in turgidity of guard cells.

↓

Opening is also aided by radial orientation of cellulose microfibrils in cell wall of guard cell.

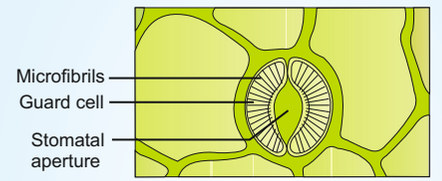


Fig. : Stomatal aperture with guard cells

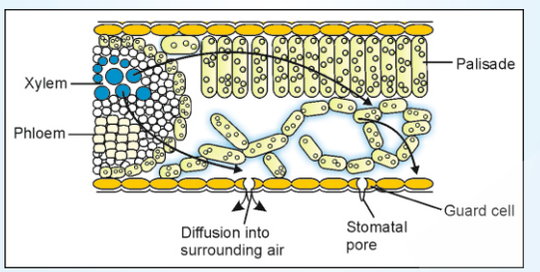


Fig. : Water movement in the leaf

↓

Transpiration driven ascent of xylem sap depends mainly on physical properties of water.

6 TRANSPIRATION & PHOTOSYNTHESIS- A COMPROMISE

1. An actively photosynthesising plant has an insatiable need for water
2. Photosynthesis is limited by available water which can be swiftly depleted by transpiration.
3. A C_4 plant loses only half as much water as a C_3-plant for the same amount of CO_2 fixed.
4. Temperature, light, humidity and wind speed affect transpiration.
5. Plant factors like number and distribution of stomata, percent of open stomata, water status of plants, canopy etc. affect transpiration.

7 UPTAKE AND TRANSPORT OF MINERAL NUTRIENTS

1. Plants obtain their carbon and most of their oxygen from CO_2 in the atmosphere. However, their remaining nutritional requirements are obtained from water and minerals in the soil.
2. Most minerals must enter the root by active absorption into the cytoplasm of epidermal cell.
3. The active uptake of ions is partly responsible for the water potential gradient in roots and therefore for the uptake of water by osmosis.
4. Some ions also move into epidermal cells passively.
5. Mineral ions are frequently REMOBILISED from older, senescing, dying parts (leaves) to younger leaves.
6. Elements most readily mobilised are phosphorus, nitrogen and potassium. Some elements like calcium are not remobilised.

8 PHLOEM TRANSPORT : PRESSURE FLOW OR MASS FLOW HYPOTHESIS

1. Food, primarily SUCROSE, is transported by vascular tissue phloem from source to sink.
2. **Source :** Leaf (synthesise food), roots (storage)
3. **Sink :** Where needed or stored (buds of trees)
4. Since source - sink relation is variable, so direction of movement of phloem can be bi-directional.
5. Phloem sap is mainly water and sucrose, but other sugars, hormones and amino-acids are also translocated through phloem.
6. GIRDLING EXPERIMENT
   (i) Identifies the tissues through which food is transported.
   (ii) It shows that phloem is the tissue responsible for food translocation.
   (iii) And transport takes place in one direction, i.e. towards the roots

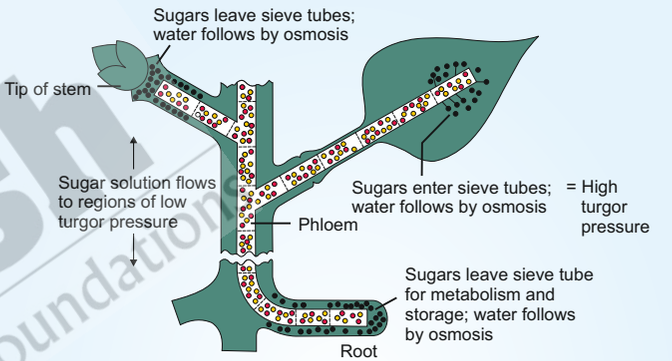


Fig. : Mechanism of translocation

MASS FLOW HYPOTHESIS

1. The accepted mechanism used for the translocation of sugars from source to sink is called the pressure flow hypothesis.
2. Glucose (Prepared at the source) → Sucrose (Converted to disaccharide) → Companion cell ← Loading (Active transport) → Living phloem sieve tube cells → Water from xylem → Builds osmotic pressure → Unloading (Active transport) → Sink (used or stored)
3. Loading and unloading are active processes.

Sharpen Your Understanding

1. Select the **odd** one out w.r.t passive transport. [NCERT Pg. 192]
   (1) Nutrients move across membrane by diffusion
   (2) It is always down the concentration gradient
   (3) It requires energy
   (4) It is always a uphill movement

2. Phloem sap is mainly : [NCERT Pg. 190]
   (1) Water and sucrose
   (2) Glucose and water
   (3) Amino-acids and water
   (4) Hormones only

3. Which of the following element is not remobilized in plants? [NCERT Pg. 190]
   (1) Nitrogen (2) Calcium
   (3) Potassium (4) Phosphorus

4. Root endodermis has the ability to actively transport ions in one direction only because of the layer of : [NCERT Pg. 189]
   (1) Lignin (2) Cutin
   (3) Algin (4) Suberin

5. The plant factor that affect transpiration is: [NCERT Pg. 187]
   (1) Humidity (2) Wind speed
   (3) Canopy structure (4) Light

6. Water loss in its liquid phase, in the form of droplets around special openings of veins near the tip of grass blades is due to [NCERT Pg. 186]
   (1) Guttation
   (2) Transpiration
   (3) Root pressure
   (4) Both (1) and (3) are correct

7. Symplastic system is the system of [NCERT Pg. 185]
   (1) Inter connected protoplasts
   (2) Dead tissues
   (3) Adjacent cell walls
   (4) Mass flow of water

8. The bulk movement of substances through the vascular tissues of plant is called [NCERT Pg. 184]
   (1) Facilitated diffusion
   (2) Active transport
   (3) Translocation
   (4) Translation

9. In the mycorrhizal association of a fungus and the root system of plants, the plants provide to the fungi: [NCERT Pg. 186]
   (1) Minerals
   (2) Water
   (3) N-containing compounds
   (4) Lipids

NCERT Based MCQs

10. Seedlings have been able to emerge out of the soil into the open and are able to establish due to : [NCERT Pg. 183]
    (1) Root pressure (2) Guttation
    (3) Transpiration (4) Imbibition

11. When the external solution balances the osmotic pressure of the cytoplasm, it is said to be [NCERT Pg. 182]
    (1) Hypotonic (2) Hypertonic
    (3) Isotonic (4) Plasmolysed

12. What occupies the space between the cell wall and the shrunken protoplast in the plasmolysed cell? [NCERT Pg. 182]
    (1) Hypertonic solution
    (2) Hypotonic solution
    (3) Isotonic solution
    (4) Pure water

13. Leaf surfaces are cooled, sometimes 10 to 15 degrees, due to evaporative cooling, by the process of [NCERT Pg. 189]
    (1) Photosynthesis (2) Transpiration
    (3) Root pressure (4) Guttation

14. By convention, the water potential of pure water at standard temperatures, which is not under any pressure is taken to be [NCERT Pg. 179]
    (1) Minimum (2) Negative
    (3) Positive (4) Zero

15. Solute potential for a solution is always: [NCERT Pg. 179]

(1) Zero

(2) Negative

(3) Positive

(4) Equal to other solutions

16. If a pressure greater than atmospheric pressure is applied to pure water or a solution, its water potential : [NCERT Pg. 179]

(1) Increases

(2) Decreases

(3) Remains unaffected

(4) Becomes positive

17. Active transport is [NCERT Pg. 178]

(1) Downhill transport

(2) Non-selective

(3) Not dependent on ATP

(4) Uphill movement

18. Molecules move across a membrane independent of other molecules in one direction in the [NCERT Pg. 177]

(1) Symport

(2) Antiport

(3) Uniport

(4) Co-port

19. Select the **odd** one out w.r.t. diffusion? [NCERT Pg. 176]

(1) A slow process

(2) Dependent on a living system

(3) Affected by temperature

(4) It is a passive process

20. In rooted plants, transport of water and minerals in xylem is essentially [NCERT Pg. 175]

(1) Bi-directional

(2) Multi-directional

(3) Uni-directional

(4) Non-directional

Thinking in Context

1. The more the solute molecules _____ is the solute potential. [NCERT Pg. 179]
2. If the external solution is more dilute than the cytoplasm, it is called _____ solution. [NCERT Pg. 181]
3. The pathways of adjacent cell-walls that is continuous throughout the plant, except at the casparian strips of the endodermis in the roots, is the system of _____ [NCERT Pg. 185]
4. The inner wall of each guard cell, towards the stomatal aperture is _____ [NCERT Pg. 187]
5. Usually the lower surface of leaf has a greater number of stomata in _____ [NCERT Pg. 187]
6. The evolution of the C_4-photosynthetic system is probably one of the strategies for maximizing the availability of CO_2 while minimizing _____. [NCERT Pg. 189]
7. The chief sinks for mineral elements are the growing regions of the plant, such as the _____ [NCERT Pg. 190]
8. Ions are absorbed from the soil by both _____ transport. [NCERT Pg. 189]
9. Measurements reveal that the forces generated by transpiration can create pressures sufficient to lift a xylem sized column of water over _____. [NCERT Pg. 188]

10. Less than _____ of the water reaching the leaves is used in photosynthesis and plant growth. [NCERT Pg. 187]

11. The translocation in phloem is explained by _____. [NCERT Pg. 193]

12. The most acceptable model to explain the transport of water in plants is _____. [NCERT Pg. 192]

13. The potential energy of water molecules which helps in the movement of water is called _____. [NCERT Pg. 192]

14. On the trunk of a tree, a ring of bark up to a depth of the phloem layer, can be carefully removed, this is called _____. [NCERT Pg. 192]

15. _____ maintains the shape and structure of the plants by keeping cells turgid. [NCERT Pg. 189]

16. *Pinus* seeds cannot germinate and establish without the presence of _____. [NCERT Pg. 186]

❑ ❑ ❑

17. We can study water loss from a leaf using _____. [NCERT Pg. 187]

18. Movement of chloroplast in the cells of the *Hydrilla* leaf is due to _____. [NCERT Pg. 185]

19. Water is absorbed along with mineral solutes by the root hairs purely by _____. [NCERT Pg. 184]

20. Numerically osmotic pressure is equivalent to the _____. [NCERT Pg. 181]

Mineral Nutrition

9 Chapter

① INTRODUCTION

The basic needs of all living organisms are essentially the same. They require macro-molecules such as carbohydrates, proteins and fats, and water and minerals for their growth and development. This chapter focuses mainly on inorganic plant nutrition and the mechanism of biological nitrogen fixation.

② Methods to Study the Mineral Requirements of Plants

In 1860, Julius von Sachs, a prominent German botanist demonstrated, for the first time, that plants could be grown to maturity in a defined nutrient solution in complete absence of soil. This technique of growing plants in a nutrient solution is known as hydroponics. By this method, essential elements were identified and their deficiency symptoms were discovered.

③ Criteria for essentiality

(a) The element must be absolutely necessary for supporting normal growth and reproduction.
(b) The requirement must be specific and not replaceable by another element.
(c) The element must be directly involved in the metabolism of the plant.

Based upon the above criteria only a few elements have been found to be absolutely essential for plant growth and metabolism. These elements are further divided into two broad categories based on their quantitative requirements, macronutrients and micronutrients.

④

Macronutrients	Micronutrients
They are generally present in plant tissues in large amounts (in excess of 10 m mole kg^{-1} of dry matter) These include C, H, O, N, P, S, K, Ca, Mg	Also called trace elements, are needed in very small amount (less than 10 m mole kg^{-1} of dry matter) These include Fe, Mn, Cu, Mo, Zn, B, Cl, Ni

Essential elements can also be grouped into four broad categories on the basis of their diverse functions. These categories are :

(i) Components of biomolecules and structural elements of cells (C, H, O and N)
(ii) Components of energy related chemical compounds in plants. (Mg in chlorophyll and P in ATP)
(iii) Activate or inhibit certain enzymes, (Mg^{2+} activates RUBISCO and PEPcase, Zn^{2+} activate alcohol dehydrogenase and Mo activate nitrogenase)
(iv) Essential elements which alter osmotic potential (K).

⑤ Role of Macro and Micronutrients

Essential elements perform several functions. They participate in various metabolic processes in the plant cells. Various forms and functions of essential nutrient elements are given below.

S. No.	Mineral element	Absorbed as	Required in	Functions
1.	Nitrogen	NO_3^-, NO_2^- or NH_4^+	All parts of the plants, particularly meristems	Major constituents of proteins, nucleic acids, vitamins and hormones
2.	Phosphorus	$H_2PO_4^-$ or HPO_4^{2-}	Developing fruits, seeds, storage organs, young meristems	Constituent of cell membrane, certain proteins, all nucleic acids
3.	Potassium	K^+	Meristems, buds, leaves and root tips	Maintain turgidity of cells, required for opening and closing of stomata
4.	Calcium	Ca^{2+}	Meristems and differentiating tissues	Required for middle lamella, mitotic spindle and for certain enzymes. Accumulates in older leaves
5.	Magnesium	Mg^{2+}	Seeds, leaves, growing areas of root and stem	Constituent of ring structure of chlorophyll and helps to maintain ribosome structure
6.	Sulphur	SO_4^{2-}	Young leaves and meristems	Constituent of two amino acids cysteine and methionine and main constituents of several coenzymes and vitamins
7.	Iron	Fe^{3+}	All parts of plants	Main constituents of ferredoxin and cytochromes. It activates catalase enzyme and is essential for the formation of chlorophyll
8.	Manganese	Mn^{2+}	Leaves and seeds	The best defined function of manganese is in the splitting of water to liberate oxygen during photosynthesis
9.	Zinc	Zn^{2+}	All parts of the plants	Activates various enzymes especially carboxylases, also needed for auxin synthesis
10.	Copper	Cu^{2+}	All parts of the plants	Associated with certain enzymes involved in redox reactions
11.	Boron	BO_3^{3-} or $B_4O_7^{2-}$	Leaves and seeds	Required for uptake and utilisation of Ca^{2+}, membrane functioning, pollen germination, cell elongation and carbohydrate translocation
12.	Molybde-num	MoO_2^{2+}	All parts of plants and commonly in roots	Component of nitrogenase and nitrate reductase
13.	Chlorine	Cl^-	All parts of the plants	Essential for water splitting reaction in photosynthesis and for anion and cation balance in cells

⑥ Deficiency Symptoms of Essential Elements

The concentration of the essential element below which plant growth is retarded is termed as critical concentration. The element is said to be deficient when present below the critical concentration. Due to deficinecy of critical elements plants show deficiency symptoms. The parts of the plants that show the deficiency symptoms also depend on the mobility of the element in the plant.

⑦ Deficiency symptoms in plants include :

(a) **Chlorosis** : Due to deficiency of N, K, Mg, S, Fe, Mn, Zn and Mo.
(b) **Necrosis** : Due to deficiency of Ca, Mg, Cu, K
(c) **Inhibition of cell division :** Due to deficiency of N, K, S, Mo
(d) **Delay in flowering :** Due to deficiency of N, S, Mo.
(e) Stunted plant growth.

Mobile Elements :

- Transported from older leaves to younger leaves.
- Deficiency symptoms first appear in older/senescent leaves. Example N, K, Mg

Immobile Elements :

- Not transported out of the mature leaves.
- Deficiency symptoms tend to appear first in the young leaves. Example Ca.

⑧ Toxicity of micronutrients

The requirements of micronutrient is always in low amounts while their moderate decrease causes the deficiency symptoms and a moderate increase cause toxicity. Any mineral ion concentration in tissues that reduces the dry weight of tissues by about 10 percent is considered toxic. Many a times, excess of an element may inhibit the uptake of another element.

For example, manganese competes with iron and Mg for uptake and with Mg for binding with enzymes. Mn also inhibit calcium translocation in shoot apex.

Apart from 17 essential elements there are 4 beneficial elements - Na, Si, Co, Se required by higher plants.

9 Mechanism of absorption of elements :

- Process of absorption can be demarcated into two phases.
- In the first phase, the rapid uptake of ions is into apoplast. It is passive.
- In the second phase the ions move into symplast. It requires energy; so it is active.

The movement of ions is called flux, the inward movement is influx and the outward movement is efflux.

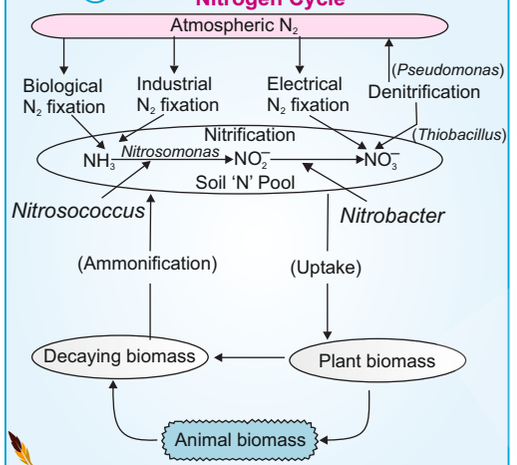
10 Translocation of solutes

Mineral salts are translocated through xylem along with the ascending stream of water, which is pulled up through plant by transpiration pull.

11 Soil as Reservoir of Essential Elements

Soil consists of a wide variety of substances.
Soil not only supplies minerals but also harbours nitrogen fixing bacteria.

12 METABOLISM OF NITROGEN : Nitrogen Cycle



The nitrifying bacteria are chemoautotrophs.

13 Biological nitrogen fixation

Only certain prokaryotic species are capable of fixing nitrogen. Reduction of nitrogen to ammonia by living organisms is called biological nitrogen fixation. Enzyme nitrogenase is exclusively present in prokaryotes.

$$N \equiv N \xrightarrow{\text{Nitrogenase}} NH_3$$

14 N_2 fixers

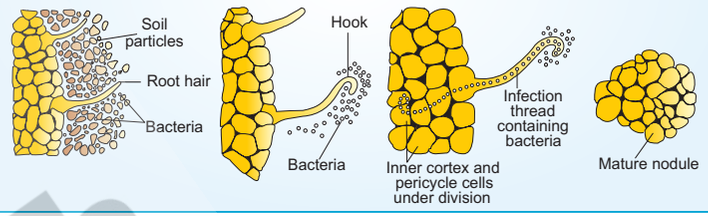
Bacteria	Nitrogen fixation	Aerobic/ anaerobic
Azotobacter	Free living	Aerobic
Beijerinckia	Free living	Aerobic
Bacillus	Free living	Anaerobic
Clostridium	Free living	Anaerobic
Rhodospirillum	Free living	Anaerobic
Anabaena	Symbiotic or	–
Nostoc	free living	–
Rhizobium	Symbiotic	–
Frankia	Symbiotic	–

Rhizobium fixes nitrogen in legumes whereas *Frankia* in non-leguminous plants such as *Alnus*.

15 Nodule formation

Nodule formation involves a sequence of multiple interactions between *Rhizobium* and roots of host plant. Principal steps in the nodule formation are as follows :

- Rhizobia multiply, colonise the surroundings of the roots and get attached to epidermal and root hair cells. Root hair curls and bacteria invade the root hair.
- An infection thread is produced carrying the bacteria into the cortex of the root where they initiate nodule formation in the cortex.
- The nodule thus formed, establishes a direct vascular connection with the host for exchange of nutrients.

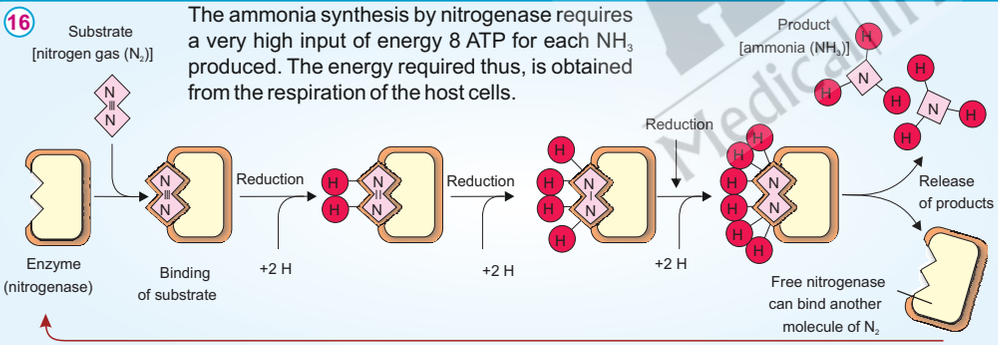


- Nodule contains nitrogenase and leghaemoglobin.
- Nitrogenase is Mo-Fe protein and highly sensitive to the molecular oxygen, thus requires anaerobic conditions.
- To protect nitrogenase nodule contains an oxygen scavenger called laghaemoglobin.

Rhizobium and *Frankia* live as aerobes under free living condition but as symbionts during nitrogen fixing events they become anaerobic.

16

The ammonia synthesis by nitrogenase requires a very high input of energy 8 ATP for each NH_3 produced. The energy required thus, is obtained from the respiration of the host cells.



Steps of conversion of atmospheric nitrogen to ammonia

17 Fate of Ammonia

At physiological pH, the ammonia is protonated to form NH_4^+ ions while most of the plants can assimilate nitrate as well as ammonia ions, the latter is quite toxic to plants and hence cannot accumulate in them.

- NH_4^+ is used to synthesize amino acids in plants by two ways:

Reductive amination	Transamination
In this process, ammonia reacts with α-ketoglutaric acid and forms glutamic acid. α-ketoglutaric acid + NH_4^+ + NADPH $\xrightarrow[\text{Dehydrogenase}]{\text{Glutamate}}$ Glutamate + H_2O + NADP	It involves transfer of amino group from one amino acid to the keto group of a keto acid. Glutamic acid is the main amino acid from which the transfer of amino group takes place and other amino acids are formed through transamination. The enzyme transaminase catalyses this reaction

The two most important amides - Asparagine and glutamine found in plants are a structural part of proteins. They are formed from two amino acids namely aspartic and glutamic acid respectively.

Amides contain more nitrogen than amino acids, they are transported to other parts of the plant via xylem vessels. Nodules of some plants like soyabean export fixed nitrogen as ureides (High N : C ratio)

Sharpen Your Understanding

1. All of the following are criteria for essentiality of an element, **except** [NCERT Pg. 195]
   (1) The element must be absolutely necessary for supporting normal growth and reproduction
   (2) The requirement of the element must be specific and not replaceable by another element
   (3) The element must be directly involved in the metabolism of the plant
   (4) In absence of the element the plants should complete their life cycle
2. Which of the following is **not** a macronutrient? [NCERT Pg. 196]
   (1) Carbon (2) Hydrogen
   (3) Oxygen (4) Boron
3. Essential element that is component of energy related chemical compound in plants is [NCERT Pg. 196]
   (1) Iron in Heme
   (2) Oxygen in carbon dioxide
   (3) Magnesium in chlorophyll
   (4) Hydrogen in water
4. Which of the following is a trace element? [NCERT Pg. 196]
   (1) Nickel (2) Phosphorus
   (3) Sulphur (4) Potassium
5. The process of conversion of nitrogen to ammonia is termed as [NCERT Pg. 201]
   (1) Ammonification (2) Nitrification
   (3) Nitrogen fixation (4) Denitrification
6. Ammonia is oxidized to nitrite by the bacteria [NCERT Pg. 201]
   (1) *Nitrocystis* (2) *Nitrosomonas*
   (3) *Nitrobacter* (4) Both (1) and (3)
7. Denitrification is carried out by bacteria [NCERT Pg. 201]
   (1) *Bacillus* (2) *Pseudomonas*
   (3) *Nitrobacter* (4) *Nitrococcus*
8. Select the **incorrect** statement. [NCERT Pg. 202]
   (1) Only certain prokaryotic species are capable of fixing nitrogen
   (2) Enzyme nitrogenase is exclusive to prokaryotes
   (3) *Rhizobium* is free living nitrogen fixer
   (4) *Azotobacter* is free living aerobic microbe
9. Select the **odd** one w.r.t. nitrogen. [NCERT Pg. 197]
   (1) Required by the plants in greatest amount
   (2) Absorbed mainly as NO_3^-
   (3) One of the major constituents of proteins, nucleic acids etc.
   (4) Not required by meristematic cells

NCERT Based MCQs

10. Select the **incorrect** match. [NCERT Pg. 197]
    (1) Phosphorus : Constituent of cell membrane
    (2) Potassium : Maintain turgidity of cells
    (3) Calcium : Required by meristematic tissues
    (4) Iron : Constituent of all proteins
11. Sulphur is found in all, **except** [NCERT Pg. 197]
    (1) Cysteine (2) Methionine
    (3) Thiamine (4) Thymine
12. Which of the following mineral element is required for synthesis of auxin and activates various enzymes especially carboxylases? [NCERT Pg. 198]
    (1) Zn
    (2) Cu
    (3) Mo
    (4) Fe
13. The deficiency symptoms first appear in the young tissues or leaves due to deficiency of [NCERT Pg. 198-199]
    (1) Calcium
    (2) Nitrogen
    (3) Phosphorus
    (4) Potassium

14. Which one is **odd** w.r.t. the deficient element involved in necrosis? [NCERT Pg. 199]
    (1) Zn
    (2) Ca
    (3) Mg
    (4) Cu

15. Select the **odd** one w.r.t. manganese toxicity. [NCERT Pg. 199]
    (1) Appearance of brown spots surrounded by chlorotic veins
    (2) Inhibit calcium translocation in shoot apex
    (3) Competes with magnesium for binding with enzymes
    (4) Loss of chlorophyll

16. Select the **incorrect** one w.r.t. nitrogenase. [NCERT Pg. 202-203]
    (1) Sensitive to oxygen
    (2) Is Mo-Fe protein
    (3) Protected by leg-haemoglobin
    (4) Is found in some plants also

17. To synthesize $2NH_3$ molecules from one N_2 molecule how many ATP molecules are required? [NCERT Pg. 203]
    (1) 8 ATP (2) 4 ATP
    (3) 16 ATP (4) 2 ATP

18. The energy required to fix nitrogen in legumes, is obtained from [NCERT Pg. 204]
    (1) Photosynthesis of bacterial cells
    (2) Respiration of the host cells
    (3) Photosynthesis of the host cells
    (4) Respiration of the bacterial cells

19. In reductive amination, the enzyme required is [NCERT Pg. 204]
    (1) Nitrite reductase
    (2) Glutamate dehydrogenase
    (3) Nitrogenase
    (4) Nitrate reductase

20. Which of the following is amide? [NCERT Pg. 204]
    (1) Glutamic acid
    (2) Asparagine
    (3) Aspartic acid
    (4) Tryptophan

Thinking in Context

1. Technique of growing plants in a nutrient solution is called _____. [NCERT Pg. 194]

2. _____ is one of the beneficial element. [NCERT Pg. 196]

3. _____ is an activator for both ribulose bisphosphate carboxylase-oxygenase and phosphoenol pyruvate carboxylase. [NCERT Pg. 196]

4. _____ plays an important role in opening and closing of stomata. [NCERT Pg. 196]

5. Nitrifying bacteria are _____. [NCERT Pg. 201]

6. Decomposition of organic nitrogen of dead plants and animals into ammonia is called _____. [NCERT Pg. 201]

7. The movement of ions is usually called _____ [NCERT Pg. 201]

8. Chlorosis is _____. [NCERT Pg. 199]

9. _____ is immobile element [NCERT Pg. 198-199]

10. Some elements like _____ delay flowering if their concentration in plants is low. [NCERT Pg. 199]

11. _____ is limiting nutrient for both natural and agricultural eco-systems. [NCERT Pg. 201]

12. _____ is required for pollen germination. [NCERT Pg. 198]

13. _____ is essential for the water-splitting reaction in photosynthesis. [NCERT Pg. 198]

14. During transamination, _____ is the main amino acid from which the transfer of NH_2 takes place. [NCERT Pg. 204]

15. At physiological pH, the ammonia is protonated to form _____. [NCERT Pg. 204]

16. The concentration of the essential element below which plant growth is retarded is termed as _____. [NCERT Pg. 198]

17. Plants obtain iron in the form of _____ ions. [NCERT Pg. 196]

18. _____ is a constituent of the ring structure of chlorophyll and helps to maintain ribosome structure. [NCERT Pg. 197]

19. Micronutrient or _____ are needed in very small amounts. [NCERT Pg. 196]

20. _____ activates catalase enzyme and is essential for formation of chlorophyll. [NCERT Pg. 197]

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Photosynthesis in Higher Plants

10 Chapter

1 INTRODUCTION

- Green plants synthesise the food they need, by photosynthesis and all other organisms depend on them for their needs.
- Photosynthesis is a physico-chemical process by which plants use light energy to drive the synthesis of organic compounds.
- The use of energy from sunlight by plants doing photosynthesis is the basis of life on earth.
- Photosynthesis is important due to two reasons : (a) It is the primary source of all food on earth and (b) It is also responsible for the release of oxygen into the atmosphere.

2 WHAT DO WE KNOW?

- Experiment for starch formation on variegated leaf or a leaf that was partially covered with black paper & exposed to light showed that photosynthesis occurred only in green part of leaves in the presence of light.
- Experiment where a part of leaf is enclosed in a test-tube with some KOH soaked cotton (which absorbs CO_2), while other half is exposed to air and set-up kept in light proved that CO_2 is needed for photosynthesis.

3 EARLY EXPERIMENTS

(1) Joseph Priestley
Using a burning candle, a mouse, mint plant and a bell jar for closed space, hypothesised that plants restore to the air whatever burning candles or breathing animals remove.

(2) Jan Ingenhousz
In an elegant experiment with an aquatic plant, showed that in bright sunlight plants produce oxygen.

(3) Julius von Sachs
Found that glucose is made in green plant parts and stored as starch.

(4) T. W. Engelmann
Using a prism, green alga *Cladophora* and aerobic bacteria, described the action spectrum of photosynthesis, which roughly resembles the absorption spectrum of chlorophyll- a and b.

(5) Cornelius van Niel
- Demonstrated that photosynthesis is essentially a light dependent reaction in which hydrogen from suitable oxidisable compound reduces CO_2 to carbohydrates.
- H_2S is hydrogen donor for purple & green sulphur bacteria. H_2O, the hydrogen donor in green plants is oxidised to O_2.
- The oxidation product is sulphur or sulphate in purple & green sulphur bacteria and not O_2. Hence it was inferred that O_2 evolved by green plants comes from H_2O and not from CO_2. This was later proved by using radioisotopic techniques.

The correct equation, for the overall process:

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

4 WHERE DOES PHOTOSYNTHESIS TAKE PLACE

- In green parts of the plants, mainly in the mesophyll cells in the leaves, which have large number of chloroplasts.
- Usually the chloroplasts align themselves along the walls of mesophyll cells to get optimum quantity of the incident light.

CHLOROPLAST ALIGNMENT

PARALLEL	PERPENDICULAR
In low or optimum light intensity to get maximum incident light	In extremely high light intensity to avoid photo-oxidation.

There is a clear DIVISION OF LABOUR within the chloroplast.

CHLOROPLAST

MEMBRANOUS SYSTEM	STROMA
(Grana + Stroma lamellae)	Enzymatic reactions to synthesise sugar, which in turn forms starch, takes place
Responsible for trapping light & synthesis of ATP and NADPH.	Dependent on products of light reactions (ATP & NADPH)
Directly light driven, called LIGHT REACTION (photochemical reactions)	By convention called DARK REACTIONS (Carbon reactions)

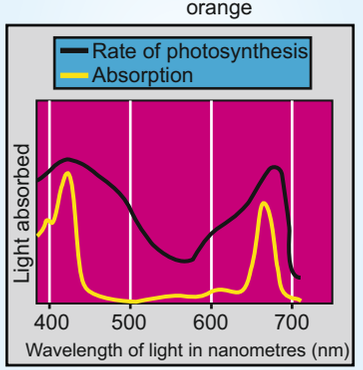
- However, this should not be construed to mean that the dark reaction occur in darkness or that they are not light-dependent.

5 HOW MANY TYPES OF PIGMENTS ARE INVOLVED IN PHOTOSYNTHESIS

- Leaf-pigments of any green plant can be separated through paper chromatography
- The colour in leaves is due to four pigments, that have the ability to absorb light, at specific wavelengths.

COLOUR OF THE PIGMENTS IN THE CHROMATOGRAM

i. Chlorophyll-a = Bright or blue green
ii. Chlorophyll-b = Yellow-green
iii. Xanthophyll = Yellow
iv. Carotenoids = Yellow to yellow-orange



- The wavelength of light at which there is maximum absorption by chlorophyll-a i.e., in blue and red regions, also shows higher rate of photosynthesis.
- Hence, we can conclude that Chl-a is the chief pigment associated with photosynthesis.

- Chl-b, carotenoids and xanthophyll are accessory pigments. They absorb light and transfer the energy to Chl-a. They enable a wider range of wavelength of incoming light to be utilised for photosynthesis and also protect chlorophyll-a from photo-oxidation.

6 WHAT IS LIGHT REACTION?

- Light reactions or the photochemical phase include:
  (a) Light absorption
  (b) Water splitting
  (c) Oxygen release, and
  (d) ATP and NADPH formation
- Several protein complexes are involved in the process.
- The pigments are organised into two photosystems

PHOTOSYSTEM

PS-I
- LHC-I (Hundreds of pigments) LHC-II
- Reaction centre — One molecule of Chl-a — Reaction centre
- Absorption peak at 700 nm (P700)

PS-II
- Absorption peak at 680 nm (P680)

- Named in the sequence of their discovery and not in the sequence of their function.

7 THE ELECTRON TRANSPORT

- The whole scheme of transfer of electrons starting from PS-II → uphill to the acceptor → down the ETC to PS-I → Excitation of electrons → transfer to another acceptor → finally downhill → to $NADP^+$ → reducing it to NADPH + H^+ is called the z-scheme, due to its characteristic shape.
- This shape is formed when all the carriers are placed in a sequence on a redox potential scale.

8 SPLITTING OF WATER

- PS-II continuously supplies electrons which becomes available by splitting of water.
- Water splitting complex is associated with PS-II, which itself is physically located on inner side of membrane of thylakoid.
- Water split into $2H^+$, [O] & electrons.
- This creates oxygen, one of the net products of photosynthesis.

9 CYCLIC AND NON-CYCLIC PHOTO-PHOSPHORYLATION

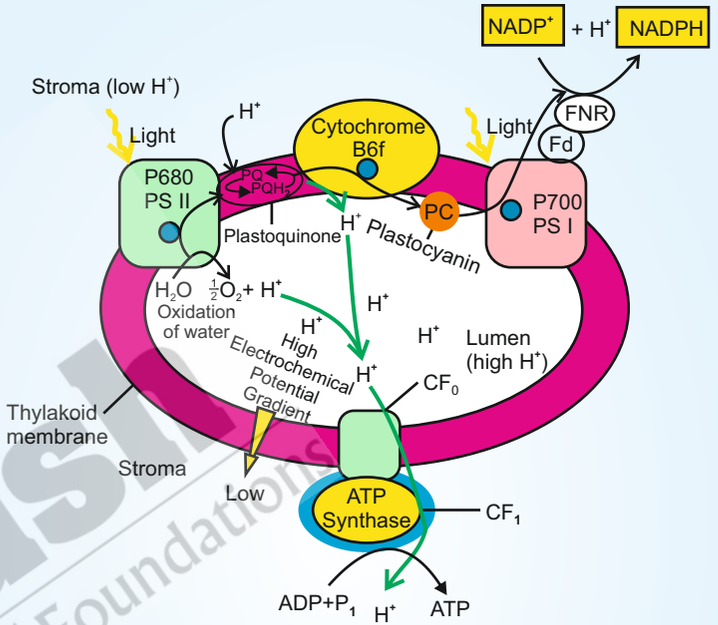
- When both PS-I and PS-II are involved, the process is non-cyclic, producing ATP, NADPH + H^+ and oxygen.
- When only PS-I is functional, cyclic flow takes place to produce only ATP.
- A possible location for cyclic flow is the stroma lamellae membranes which lack PS-II and NADP reductase enzyme.

- Cyclic photo-phosphorylation also occurs when only light of wavelengths beyond 680 nm are available for excitation.
- The membrane or lamellae of the grana have both PS-I and PS-II

10 CHEMIOSMOTIC HYPOTHESIS

- ATP synthesis in photosynthesis is linked to the development of a proton gradient across the membranes of thylakoid and protons accumulate in the lumen of thylakoids.
- The proton gradient is caused by:
  (a) Protons or hydrogen ions produced by splitting of water, accumulate in the lumen of the thylakoids.
  (b) The primary acceptor of electron located towards outer side of membrane transfers its electron to an H carrier, which removes a proton from stroma while transporting an electron to thylakoid lumen.

(c) The NADP reductase enzyme located on stroma side of membrane, removes protons from stroma, while reducing $NADP^+$ to NADPH + H^+.



ATP synthesis through chemiosmosis

- Within chloroplast, protons decrease in stroma and accumulate in lumen. This creates a proton-gradient across thylakoid membrane as well as a measurable decrease in pH in the lumen.
- Breakdown of this gradient leads to synthesis of ATP, when protons move across the membrane to the stroma through transmembrane channel of the CF_0 of the ATP synthase.

ATP synthase (Two parts)

- CF_0 = Embedded in the thylakoid membrane. A transmembrane channel for facilitated diffusion of protons
- CF_1 = Protrudes on outer surface of thylakoid membrane on the side that faces stroma. It synthesise ATP

- Chemiosmosis requires - a membrane, a proton pump, a proton gradient and ATP synthase.

11 WHERE ARE THE ATP AND NADPH USED?

- Of the products of light reaction- ATP, NADPH and O_2, O_2 diffuses out of chloroplast while ATP and NADPH are used to synthesise sugars in the biosynthetic phase of photosynthesis.
  Melvin Calvin used radioactive ^{14}C in algal photosynthesis studies to discover the first CO_2 fixation product, the 3-C organic acid (3-PGA) (C_3 – pathway).
- In another group of plants, the first stable product was 4 carbon, oxaloacetic acid OAA (C_4-pathway).

12 THE CALVIN CYCLE

- The Calvin cycle occurs in all photosynthetic plants; whether they have C_3 or C_4 (or any other) pathways.
- Calvin cycle can be described under three stages:

(1) CARBOXYLATION: Most crucial step.

$$\text{RuBP (5C)} \xrightarrow[\text{CO}_2 + \text{H}_2\text{O}]{\text{RuBisCO}} 2 \times 3\text{–PGA (3C)}$$

(2) REDUCTION: A series of reactions that lead to formation of glucose.
Utilises 2 ATP and 2 NADPH per CO_2.
(The fixation of $6CO_2$ and 6 turns of the cycle are needed to form one molecule of glucose from the pathway).

(3) REGENERATION: Regeneration of RUBP is crucial for the cycle to continue. This step require one ATP.
So, to produce one molecule of glucose in Calvin cycle an input of $6CO_2$ 18 ATP & 12 NADPH are required

13 THE C_4-PATHWAY

- Plants adapted to dry tropical regions have the C_4-pathway.
- C_4-plants are special: They have special type of leaf anatomy, tolerate higher temperatures, show response to high light intensities, lack photorespiration and have greater biomass productivity
- C_4-plants have leaves showing KRANZ ANATOMY the particularly large cells around the vascular bundles, which may form several layers and are called bundle sheath cells, characterised by having a large number of chloroplasts, thick walls impervious to gaseous exchange and no intercellular spaces.
- The pathway is cyclic & called the Hatch and Slack Pathway. It is partly completed in mesophyll & partly in bundle sheath cell.

MESOPHYLL CELL	BUNDLE-SHEATH CELLS
(1) Primary CO_2 acceptor is a 3-C compound PEP.	(1) Malic Acid/Aspartic Acid → CO_2 + 3-Carbon molecule → Transported to mesophyll & converted to PEP
(2) Enzyme for this fixation is PEPcase.	Enters – Calvin cycle a pathway common to all plants.
(3) Lacks RuBisCO	(2) Rich in RuBisCO, but lack PEPcase.
(4) C_4-acid formed is OAA; which forms malic acid or aspartic acid and transported to bundle sheath cells.	

14 PHOTORESPIRATION

- RuBisCo, the most abundant enzyme in the world, has the active site that can bind to both CO_2 and O_2. This binding is competitive. It is the relative concentration of O_2 and CO_2 that determines which of the two will bind to the enzyme.
- RuBisCo, has a much greater affinity for CO_2, when the CO_2: O_2 is nearly equal than for O_2.
- In C_3-plants some O_2 does bind to RuBisCO, and hence CO_2 fixation is decreased, due to the following reaction.

$$\text{RuBP} + O_2 \xrightarrow{\text{RuBisCo}} \text{3 PGA (3C)} + \text{2 phosphoglycolate (2C)}$$

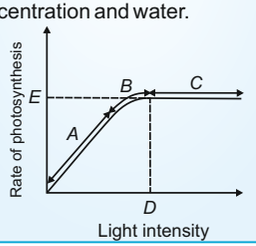
This is called photo-respiration
- In photo-respiration there is neither synthesis of sugars, nor of ATP. It results in release of CO_2 with utilisation of ATP.
- The biological function of photorespiration is not known yet.
- In C_4-plants photo-respiration does not occur, as they have a mechanism that increases the concentration of CO_2 at the enzyme site. This ensures that the RuBisCO functions as a carboxylase minimising the oxygenase activity.

15 FACTORS AFFECTING PHOTOSYNTHESIS

- Photosynthesis is under the influence of several factors, both internal (plant) & external.

Internal Factors:

- The plant factors include the number, size, age & orientation of leaves, mesophyll cells and chloroplasts, internal CO_2 concentration & the amount of chlorophyll.
- The plant or internal factors are dependent on the genetic predisposition & growth of the plant.
- **External factors:** include availability of sunlight, temperature, CO_2 concentration and water.



- **Blackman's Law of Limiting Factor**
  If a chemical process is affected by more than one factor, then its rate will be determined by the factor which is nearest to its minimal value. It is the factor which directly affects the process if its quality is changed.

(i) Light: Light saturation occurs at 10% of the full sunlight. Except for plants in shade or in dense forests, light is rarely a limiting factor in nature.
- There is a linear relationship between incident light & CO_2 fixation rates at low light intensities.
  At higher light intensities, gradually the rate does not show further, increase as other factors become limiting.

(ii) CO_2 concentration: Major limiting factor. The concentration of CO_2 is very low in the atmosphere (0.03 & 0.04%), so increase in concentration upto 0.05% can cause increase in CO_2 fixation rates, beyond this levels it can become damaging over longer periods.
- At low light conditions neither group responds to high CO_2 conditions C_4-plants show saturation at $360\mu 1L^{-1}$ C_3-saturation is seen at $450\mu 1L^{-1}$. Some greenhouse crops like tomatoes and bell pepper show higher yields in CO_2 enriched atmosphere.

(iii) Temperature: Dark reactions being enzymatic are temperature controlled. Light reactions are also temperature sensitivie. C_4-plants show higher yield at high temperature while C_3-plants have a much lower temperature optimum.

(iv) Water: Effect of water as a factor is more through its effect on the plant rather than directly on photosynthesis. Water stress causes the stomata to close hence reducing CO_2 availability. Water stress also makes leaves wilt, thus, reducing the surface area of leaves and their metabolic activity as well.

Sharpen Your Understanding

1. The carbon reactions of photosynthesis takes place in the - [NCERT Pg. 209]
   (1) Stroma lamellae
   (2) Membrane system of grana
   (3) Stroma
   (4) Thylakoid system
2. The green parts in plants synthesise glucose which is stored as starch was found first by: [NCERT Pg. 208]
   (1) Julius von Sachs (2) T.W. Engelmann
   (3) Cornelius van Niel (4) Joseph Priestley
3. Who first inferred that the O_2 evolved by the green plants during photosynthesis comes from H_2O and not from CO_2? [NCERT Pg. 208]
   (1) T.W. Engelmann
   (2) Cornelius van Niel
   (3) Julius von Sachs
   (4) Jan Ingenhousz
4. Plants restore to the air whatever breathing animals and burning candles remove, it was hypothesised by: [NCERT Pg. 207]
   (1) Cornelius van Niel
   (2) Joseph Priestley
   (3) Julius von Sachs
   (4) T.W. Engelmann

NCERT Based MCQs

5. The experiment where a part of a leaf is enclosed in a test-tube containing some KOH soaked cotton, while the other half is exposed to air, and the set up is then placed in light for some time, showed that: [NCERT Pg. 207]
   (1) Light is essential for photosynthesis
   (2) Chlorophyll is needed for photosynthesis
   (3) CO_2 is required for photosynthesis
   (4) Photosynthesis is temperature controlled.
6. T.W. Engelmann described the first action spectrum of photosynthesis, by working on the green alga: [NCERT Pg. 208]
   (1) *Cladophora* (2) *Eurodina*
   (3) *Chlorella* (4) *Ulothrix*
7. Which is the most abundant plant pigment in the world? [NCERT Pg. 210]
   (1) Carotenoids (2) Xanthophyll
   (3) Chlorophyll-b (4) Chlorophyll-a
8. Which of the following photosynthetic pigments, show yellow to yellow-orange colour in the chromatogram? [NCERT Pg. 210]
   (1) Chlorophyll-a (2) Chlorophyll-b
   (3) Carotenoids (4) Xanthophyll
9. The reaction centre chlorophyll-a molecule in PS-I has an absorption peak at: [NCERT Pg. 211]
   (1) 700 nm (2) 680 nm
   (3) 750 nm (4) 400 nm
10. The electrons needed to replace those removed from photosystem-I during the electron transport are provided by: [NCERT Pg. 212]
    (1) Water directly (2) H_2S directly
    (3) Photosystem-II (4) CF_0-CF_1
11. PS-II and NADP reductase enzyme are: [NCERT Pg. 213]
    (1) Required for cyclic photophosphorylation
    (2) Absent on stroma lamellae membranes
    (3) Absent on lamellae of the grana
    (4) Not needed for non-cyclic photophosphorylation
12. CF_0 is embedded in the thylakoid membrane and forms a transmembrane channel that carries out: [NCERT Pg. 215]
    (1) Facilitated diffusion of protons across the membrane
    (2) Electron transport by diffusion
    (3) ATP synthesis in the channel
    (4) Active transport of protons and electrons
13. The first CO_2 fixation product in algal photosynthesis, discovered by radioactive ^{14}C, was found to be: [NCERT Pg. 215]
    (1) a 4-carbon organic acid
    (2) 3-phosphoglyceric acid
    (3) 5-carbon ketose sugar
    (4) Ribulose bisphosphate

14. The basic pathway that results in the formation of sugars, which is common to the C_3 and C_4 plant is: [NCERT Pg. 220]
(1) Hatch and slack pathway
(2) The C_4-pathway
(3) Calvin cycle
(4) Photorespiration

15. The most crucial step of Calvin cycle, where CO_2 is utilized by RuBP is [NCERT Pg. 216]
(1) Carboxylation (2) Regeneration
(3) Reduction (4) Oxygenation

16. In the C_4-plants, mesophyll cells: [NCERT Pg. 219]
(1) Lack PEPcase enzyme
(2) Is the site of Calvin cycle
(3) Lack RuBisCO enzyme
(4) Are impervious to gaseous exchange

17. Select the incorrect statement w.r.t. photorespiration? [NCERT Pg. 220]
(1) In C_4-plants photorespiration does not occur
(2) The biological function of photo-respiration is not known yet
(3) RuBP binds with O_2 to form 2 molecules of 3-PGA
(4) There is no synthesis of ATP or NADPH

18. If C_3-plants like tomatoes and bell pepper are allowed to grow in CO_2 enriched atmosphere, it leads to- [NCERT Pg. 223]
(1) Lower yields
(2) Higher yields
(3) No change in productivity
(4) Very low photosynthesis

19. Select the odd one out w.r.t. external factors affecting photosynthesis? [NCERT 222]
(1) Orientation of leaves
(2) Availability of sunlight
(3) Temperature
(4) CO_2 concentration & water

20. How many turns of Calvin cycle pathway are required for the formation of one molecule of glucose? [NCERT Pg. 217]
(1) One complete turn
(2) Two complete turns
(3) Six turns of cycle
(4) Three complete turns

Thinking in Context

1. Water stress makes leaves wilt, thus, reducing the _____ of the leaves and their metabolic activity as well. [NCERT Pg. 223]

2. Water stress causes the stomata to close hence reducing the _____. [NCERT Pg. 223]

3. Tropical plants have a _____ temperature optimum than the plants adapted to temperate climates. [NCERT Pg. 223]

4. At _____, neither C_3 nor C_4 group of plants respond to high CO_2 conditions. [NCERT Pg. 223]

5. Increase in incident light beyond a point causes the breakdown of chlorophyll and a _____ in photosynthesis. [NCERT Pg. 223]

6. The plant or internal factors are dependent on the _____ and the growth of the plant. [NCERT Pg. 222]

7. C_4-plants lack _____, so productivity and yields are better than C_3 plants. [NCERT Pg. 220]

8. The bundle sheath cells are rich in an enzyme A but lack B . [NCERT Pg. 220]

9. For every _____ entering the Calvin cycle, 3 molecules of ATP and 2 of NADPH are required. [NCERT Pg. 218]

10. The regeneration step of Calvin cycle require _____ for the phosphorylation to form RuBP. [NCERT Pg. 217]

11. The carboxylation step of Calvin cycle, is catalysed by the enzyme _____. [NCERT Pg. 216]

12. Cyclic photophosphorylation occurs when only light of wavelengths _____ are available for excitation. [NCERT Pg. 213]

13. Water splitting complex is associated with _____. [NCERT Pg. 212]
14. _____ is the chief pigment associated with photosynthesis [NCERT Pg. 210]
15. When H_2S is the hydrogen donor for purple and green sulphur bacteria, the oxidation product is _____. [NCERT Pg. 208]
16. Photosynthesis is a _____ process by which the plants use light energy to drive the synthesis of organic compounds. [NCERT Pg. 206]
17. During chromatographic separation of the leaf pigments yellow-green colour in the chromatogram in shown by _____. [NCERT Pg. 210]
18. _____ protect chlorophyll-a from photo-oxidation. [NCERT Pg. 211]
19. _____ is the synthesis of ATP from ADP and inorganic phosphate in the presence of light. [NCERT Pg. 213]
20. In photosynthesis, ATP synthesis is linked to the development of a _____ across a membrane. [NCERT Pg. 213]

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Respiration in Plants

11 Chapter

1 INTRODUCTION

- All living organisms need energy for carrying out daily life activities, like absorption, transport, movement, reproduction or even breathing.
- All the energy required for 'life' processes is obtained by oxidation of macromolecules, called food.
- Cellular respiration is the mechanism of breakdown of food material within the cell to release energy, and trapping it for synthesis of ATP. The process takes place in the cytoplasm and in the mitochondria.
- The compounds that are oxidised during this process are called the respiratory substrates like carbohydrates, proteins, fats and even organic acids.
- The process involves a series of slow step-wise reactions controlled by enzymes and the released energy is trapped as chemical energy in the form of ATP, which is broken down whenever and wherever energy needs to be utilised.

2 DO PLANTS BREATHE?

- Plants have systems in place to ensure O_2 availability, *i.e.* stomata and lenticels for this purpose.
- Each plant part takes care of its own gas-exchange needs. There is very little transport of gases from one plant part to another.
- Roots, stems and leaves respire at rates far lower than animals do.
- Most cells of a plant have at least a part of their surface in contact with air.
- Complete combustion of glucose produces CO_2 and H_2O as end products and yields energy most of which is given as heat.

  $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + Energy
- But plants oxidise glucose in several small steps and energy released is coupled to ATP synthesis.
- Facultative and obligate anaerobes, can respire in absence of O_2.
- All organisms retain this strategy of partial glucose oxidation in absence of oxygen called GLYCOLYSIS.

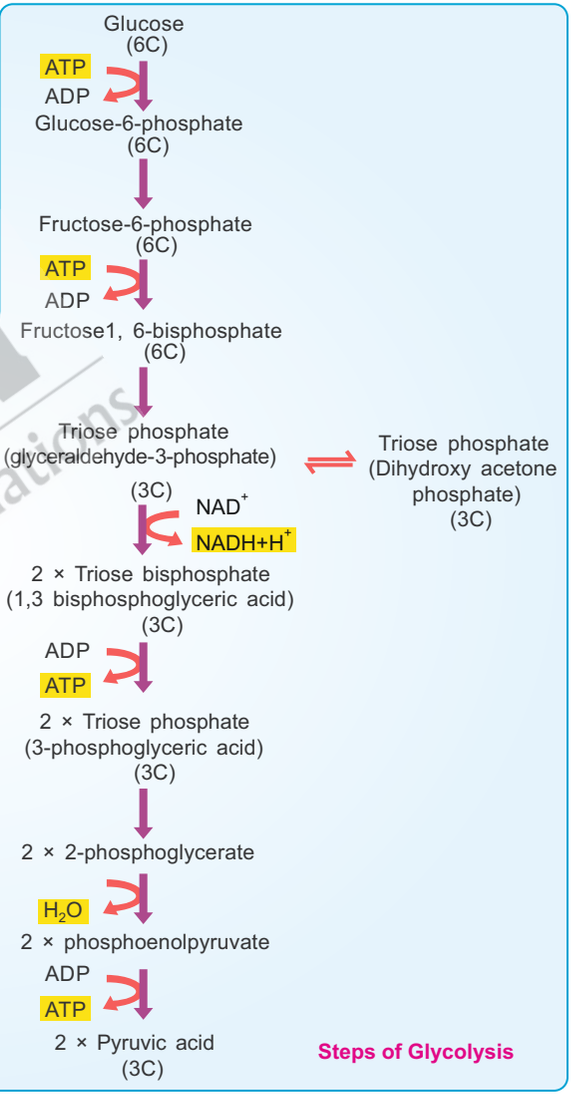
3 GLYCOLYSIS

- Greek-glycos = sugar and lysis = splitting
- Scheme given by Embden, Meyerhof and Parnas, referred as EMP-pathway.
- In anaerobic organisms, it is the only process in respiration.
- Occurs in CYTOPLASM and present in all living organisms.
- In this process glucose undergoes partial oxidation to form two molecules of pyruvic acid.
- In plants, glucose comes from sucrose (the end product of photosynthesis) or from storage carbohydrates.
- Sucrose is converted into glucose and fructose by invertase and these monosaccharides enter the glycolytic pathway readily.
- In glycolysis, a chain of ten reactions produces pyruvate from glucose by the help of different enzymes.
- In glycolysis 2 ATP are utilised and total 4 ATP, 2 $NADH+H^+$ and 2 molecules of pyruvic acid are produced.
- Pyruvic acid is the key product of glycolysis and its metabolic fate depends on cellular need.

PYRUVIC ACID → Three major fates
- 1. Lactic acid fermentation
- 2. Alcoholic fermentation

← UNDER ANAEROBIC CONDITIONS

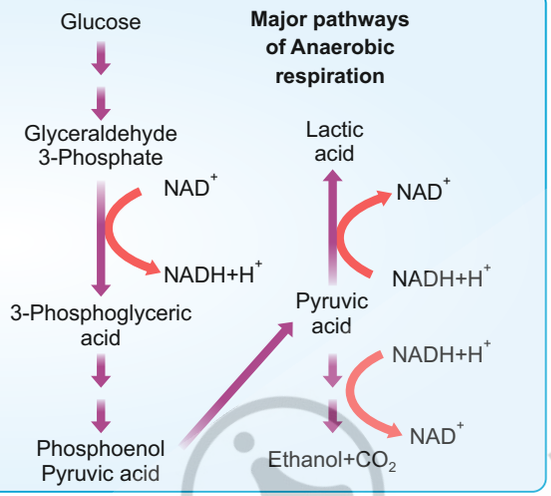
- 3. Krebs' cycle ← AEROBIC; Needs O_2 supply



Steps of Glycolysis

4 FERMENTATION

- In fermentation, by yeast, incomplete oxidation of glucose is achieved under anaerobic conditions to produce CO_2 and ethanol, by the help of enzymes pyruvate decarboxylase and alcohol dehydrogenase.
- Bacteria and in animal cells (muscles during exercise, when oxygen is inadequate for cellular respiration) pyruvate is reduced to lactic acid by lactate dehydrogenase.
- Less than 7% of the energy in glucose is released.
- Also the processes are hazardous as either acid or alcohol is produced.
- Yeast poison themselves to death when concentration of alcohol reaches about 13%.



5 AEROBIC RESPIRATION

- In eukaryotes, it takes place in mitochondria. Leads to complete oxidation of organic substances, in the presence of oxygen and releases CO_2, water and a large amount of energy present in the substrate.
- This type of respiration is most common in higher organisms.
- For aerobic respiration to take place within mitochondria, the final product of glycolysis is transported into mitochondria from cytoplasm.
- Crucial events of aerobic respiration are:
  a. Complete oxidation of pyruvic acid - site = Mitochondrial matrix.
  b. ETS and synthesis of ATP - site = Inner mitochondrial membrane.

6 TRICARBOXYLIC ACID CYCLE (TCA cycle or Kreb's cycle)

(In mitochondrial matrix)

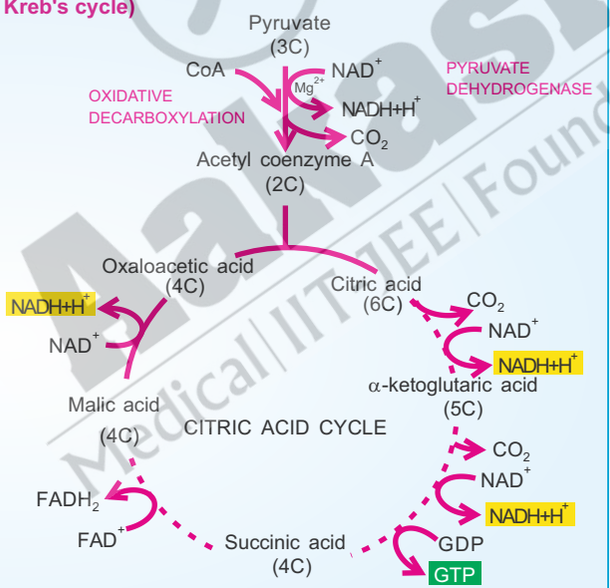
- Acetyl CoA produced by oxidative decarboxylation of pyruvic acid enters the TCA cycle more commonly known as Krebs' cycle. (Scientist Hans Kreb)
- First reaction of Kreb's cycle is condensation, then isomerisation.

$$OAA \xrightarrow[\text{Citrate synthase}]{\text{AcetyCoA}} \text{Citric Acid} \xrightarrow{\text{Isomerises}} \text{Isocitrate}$$

- Followed by two successive decarboxylation to form α-ketoglutarate and the succinyl CoA.
- During conversion of succinyl CoA to succinic acid, substrate level phosphorylation takes place to produce GTP which in a coupled reaction simultaneously produces ATP.
- The summary equation for this phase of respiration is:

$$\text{Pyruvate} + 4NAD^+ + FAD^+ + 2H_2O + ADP + Pi \xrightarrow[\text{MATRIX}]{\text{MITOCHONDRIAL}} 3CO_2 + 4NADH + 4H^+ + FADH_2 + ATP$$

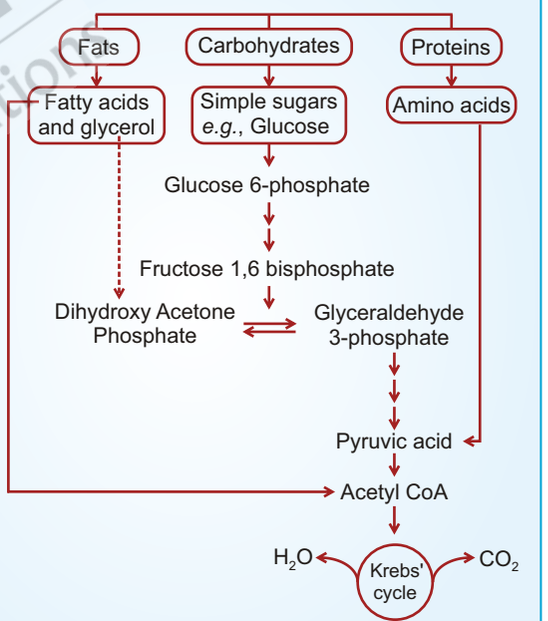
- So, per molecule of glucose, 8 $NADH+H^+$, two $FADH_2$ and 2 ATP are synthesised from pyruvic acid.



Citric Acid Cycle

7 AMPHIBOLIC PATHWAY

- Respiratory pathway is involved in both anabolism and catabolism hence it is called amphibolic pathway.



Interrelationship among Metabolic pathways

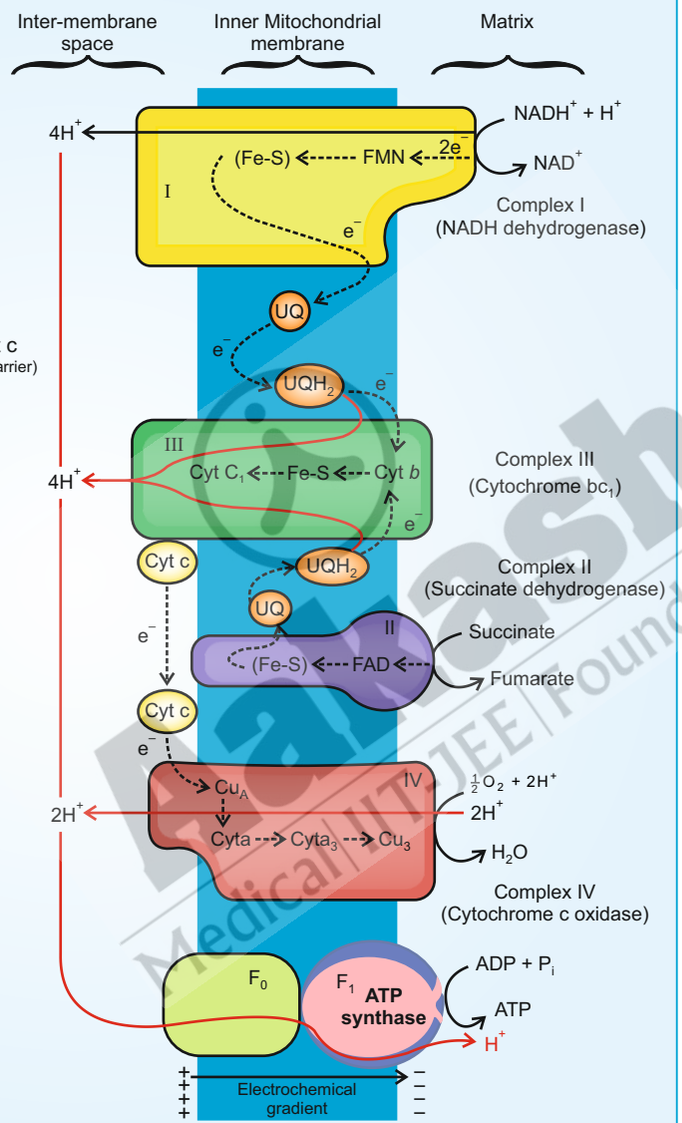
8 ELECTRON TRANSPORT SYSTEM (ETS) AND OXIDATIVE PHOSPHORYLATION

- $NADH+H^+$ and $FADH_2$ are oxidised through ETS and the electrons are passed on to O_2 resulting in formation of H_2O through various complexes in the inner - mitochondrial membrane.
- NADH dehydrogenase (Complex-I) and $FADH_2$ (Complex-II) transfers electrons to

Ubiquinone → Ubiquinol (reduced ubiquinone) → cyt bc_1 (complex III) → cyt c (Mobile carrier) → Complex IV (Cytochrome c oxidase)

- When electrons pass from one carrier to another via complex-I to IV in ETC, they are coupled to ATP synthase (complex-V) for production of ATP from ADP and inorganic phosphate.
- Oxidation of one NADH gives 3 ATP, while one $FADH_2$ gives two ATP.
- The role of oxygen is limited to the terminal stage. Yet the presence of oxygen is vital, since it drives the whole process by removing hydrogen from the system. Oxygen is the final acceptor of hydrogen.
- Complex-V has two major components, F_1-F_0. F_1 is peripheral membrane protein complex and contains site for ATP synthesis and F_0 forms the channel through which protons cross the inner membrane.

  The passage of protons through the channel is coupled to the catalytic site of F_1 for production of ATP. For each ATP produced, $2H^+$ passes through F_0 from the intermembrane space to matrix down the electrochemical proton gradient.



Electron Transport System (ETS)

9 RESPIRATORY BALANCE SHEET

(In reality it is a theoretical exercise, as all pathways work simultaneously and do not take place one after another. Enzymatic rates are controlled by multiple means.)

- There can be a net gain of 38 ATP molecules during aerobic respiration of one molecule of glucose.
- In fermentation there is net gain of only 2 ATP for each molecule of glucose degraded.
- NADH is oxidised to NAD^+ slowly in fermentation, however the reaction is very vigorous in case of aerobic respiration.

10 RESPIRATORY QUOTIENT = (RQ)

- The ratio of volume of CO_2 evolve to the volume of O_2 consumed is RQ.

$$RQ = \frac{\text{Volume of } CO_2 \text{ evolved}}{\text{Volume of } O_2 \text{ consumed}}$$

- It depends on the type of respiratory substrate, used during respiration.
- For, carbohydrates = 1
  Fat = less than 1, (eg-tripalmitin=0.7)
  Protein = about 0.9

11

- Breaking of C-C bonds of complex organic molecules leads to release of lot of energy in cellular respiration.
- Glucose is the preferred substrate, though fats and protein can also yield energy.
- Fermentation takes place in many prokaryotes, unicellular eukaryotes and in germinating seeds.
- In aerobic respiration O_2 is ultimate electron acceptor and it gets reduced to water.

Sharpen Your Understanding

1. Which of the following organisms can prepare their own food by the process of photosynthesis? [NCERT Pg. 226]
   (1) Herbivores
   (2) Saprophytes
   (3) Cyanobacteria
   (4) Heterotrophs
2. In anaerobic organisms, the only process in respiration is [NCERT Pg. 228]
   (1) EMP pathway
   (2) Tricarboxylic acid cycle
   (3) Krebs' cycle
   (4) Citric acid cycle
3. Sucrose is converted into glucose and fructose by the help of the enzyme [NCERT Pg. 229]
   (1) Amylase
   (2) Invertase
   (3) Maltase
   (4) Zymase
4. In glycolysis, a chain of ten reactions, under the control of different enzymes, takes place to produce [NCERT Pg. 229]
   (1) Sucrose from glucose
   (2) Glucose from fructose
   (3) Pyruvate from acetyl CoA
   (4) Pyruvate from glucose

NCERT Based MCQs

5. During glycolysis ATP is utilised in the conversion of [NCERT Pg. 229]
   (1) Glucose into glucose-6- phosphate
   (2) Glucose-6- phosphate into Fructose-6-phosphate
   (3) Phosphoenol pyruvate into pyruvic acid
   (4) 3-phosphoglyceric acid into 2-phosphoglycerate
6. The key product of glycolysis is [NCERT Pg. 229]
   (1) DHAP
   (2) Pyruvic acid
   (3) Phosphoenolpyruvate
   (4) Acetyl CoA
7. For complete oxidation of glucose to CO_2 and H_2O organisms adopt [NCERT Pg. 230]
   (1) Lactic acid fermentation
   (2) Alcoholic fermentation
   (3) Krebs' cycle
   (4) Substrate-level phosphorylation
8. Yeasts poison themselves to death when the concentration of alcohol reaches about [NCERT Pg. 230]
   (1) 5 percent
   (2) < 5 percent
   (3) < 8 percent
   (4) 13 percent
9. The enzyme which catalyses the conversion of pyruvate into acetyl CoA in the mitochondrial matrix is [NCERT Pg. 231]
   (1) Lactate dehydrogenase
   (2) Succinate dehydrogenase
   (3) Pyruvate dehydrogenase
   (4) Pyruvate kinase
10. Substrate level phosphorylation in the TCA-cycle takes place during the conversion of [NCERT Pg. 232]
    (1) Succinyl-CoA to succinic acid
    (2) Oxaloacetic acid to citric acid
    (3) Malic acid to oxaloacetic acid
    (4) Citric acid to isocitric acid
11. Which of the following complex refers to cytochrome-c oxidase complex containing cytochromes a and a_3 and two copper centres? [NCERT Pg. 233]
    (1) Complex-V (2) Complex-IV
    (3) Complex-II (4) Complex-I
12. What will be the respiratory quotient value (RQ) for the fatty acid, tripalmitin? [NCERT Pg. 237]
    (1) >1
    (2) 0.9
    (3) 4.0
    (4) 0.7

13. If fatty acids were to be utilised in the respiratory pathway, they would first be degraded to [NCERT Pg. 235]

(1) Oxaloacetate (2) Pyruvic acid

(3) Acetyl CoA (4) PGAL

14. The respiratory pathway should be considered as [NCERT Pg. 235]

(1) Amphibolic (2) Anabolic only

(3) Catabolic only (4) Synthetic

15. What will be the net gain of ATP molecules for each molecule of glucose used in fermentation? [NCERT Pg. 235]

(1) 36 ATP (2) 38 ATP

(3) 7 ATP (4) Only 2 ATP

16. The peripheral membrane protein complex, which contains the site for synthesis of ATP from ADP and inorganic phosphate, present on the inner mitochondrial membrane is called [NCERT Pg. 234]

(1) F_1 component

(2) F_0 component

(3) Ubiquinone

(4) Cytochrome-c

17. The complex-I of the electron transport system (ETS) present on the inner-mitochondrial membrane is known as: [NCERT Pg. 233]

(1) Succinate dehydrogenase complex

(2) NADH dehydrogenase complex

(3) Cytochrome bc_1 complex

(4) Cytochrome-c oxidase

18. Substrate level phosphorylation in glycolysis takes place during conversion of [NCERT Pg. 229]

(1) 2-phosphoglycerate to 3-PGA

(2) 2-phosphoglycerate to PEP

(3) PEP to pyruvic acid

(4) Glucose-6-phosphate to Fructose-6-phosphate

19. Glycerol would usually enter the respiratory pathway after being converted to [NCERT Pg. 235]

(1) Fructose

(2) PGAL

(3) Amino acid

(4) Proteases

20. The small protein attached to the outer surface of the inner mitochondrial membrane and acts as a mobile carrier for transfer of electrons between complex III and IV in the electron transport system (ETS) is [NCERT Pg. 233]

(1) Ubiquinone

(2) Ferredoxin

(3) Cytochrome-c

(4) F_1 – particle

Thinking in Context

1. In plants, stomata and lenticels allow gaseous exchange by _____ [NCERT Pg. 237]

2. The breaking of C-C bonds of complex organic molecules by oxidation in the cells leading to the release of a lot of energy is called _____ [NCERT Pg. 237]

3. The ratio of the volume of CO_2 evolved to the volume of O_2 consumed in respiration is called the _____ or _____ [NCERT Pg. 236]

4. The NADH synthesised in glycolysis is transferred into the _____ and undergoes oxidative phosphorylation [NCERT Pg. 234]

5. Although the aerobic process of respiration takes place only in the presence of oxygen, the role of oxygen is limited to the _____ of the process. [NCERT Pg. 233]

6. When the electrons pass from one carrier to another via complex I to IV in the electron transport chain, they are coupled to _____ for the production of ATP. [NCERT Pg. 233]

7. The TCA cycle starts with the _____ of acetyl group with oxaloacetic acid and water to yield citric acid. [NCERT Pg. 231]

8. Fermentation takes place under _____ in many prokaryotes and unicellular eukaryotes [NCERT Pg. 230]

9. In glycolysis, glucose and fructose are phosphorylated to give rise to glucose-6-phosphate by the activity of the enzyme _____. [NCERT Pg. 229]

10. In plants, glucose is derived from _____, which is the end product of photosynthesis. [NCERT Pg. 228]

11. The scheme of glycolysis was given by Gustav Embden, Otto Meyerhof and J. Parnas, and is often referred to as the _____. [NCERT Pg. 228]

12. There are sufficient reasons to belive that the first cells on this planet lived in an atmosphere that _____.[NCERT Pg. 228]

13. All living organisms retain the enzymatic machinery to partially oxidise glucose without the help of oxygen, this breakdown of glucose to pyruvic acid is called _____. [NCERT Pg. 228]

14. In _____ glycolysis is the only process in respiration. [NCERT Pg. 228]

15. Some organisms adapted to anaerobic conditions are _____, while in others the requirement for anaerobic condition is obligate. [NCERT Pg. 228]

16. The compounds that are oxidised during the process of respiration are known as _____. [NCERT Pg. 227]

17. What is important to recognise is that ultimately all the food that is respired for life processes comes from _____. [NCERT Pg. 227]

18. Usually _____ are oxidised to release energy, but proteins, fats and even organic acids can be used as respiratory substances in some plants, under certain conditions. [NCERT Pg. 227]

19. In both lactic acid fermentation and alcoholic fermentation, the reducing agent is A which is reoxidised to B . [NCERT Pg. 230]

20. Photosynthesis, takes place within the chloroplasts, whereas the breakdown of complex molecules to yield energy takes place in the A and in the B also only in Eukaryotes. [NCERT Pg. 227]

❑ ❑ ❑

Plant Growth and Development

12 Chapter

1 INTRODUCTION

- All cells of a plant are descendents of the zygote. Development of a mature plant from a zygote follows a precise and highly ordered succession of events.
- Development is the sum of two processes: GROWTH and DIFFERENTIATION.
- During this process a complex body organisation is formed that produce roots, leaves, branches, flowers, fruits, seeds and eventually they die.
- The first step in the process of plant growth is seed germination. The seed germinates when favourable conditions for growth exist in the environment, in absence of favourable conditions they go into a period of suspended growth or rest, and resume metabolic activities on return of favourable conditions and growth takes place.

2 GROWTH

- Growth is irreversible permanent increase in size of an organ or its parts or even an individual cell.
- It is one of the most fundamental and conspicuous characteristic of a living being.
- Growth is accompanied by metabolic processes and occur at the expense of energy.
- Plants retain the capacity of unlimited growth throughout their life due to presence of meristem at certain locations in their body.
- This form of growth wherein new cells are always being added to the plant body by the activity of meristem is called open form of growth. (INDETERMINATE)
- Root apical meristem and shoot apical meristem are responsible for primary growth, i.e., elongation along their axis.
- In dicotyledonous plants and gymnosperms, the lateral meristems like vascular cambium and cork-cambium, which appear later in life and cause increase in girth of the organs called secondary growth.
- **Growth is measurable:** At cellular level, it is principally a consequence of increase in amount of protoplasm. It is measured by a variety of parameters like-increase in fresh weight, dry weight, length, area, volume and cell number.

3 PHASES OF GROWTH

The period of growth is generally divided into three phases MERISTEMATIC, ELONGATION & MATURATION.

(i) The constantly dividing cells at root apex and shoot apex represent meristematic phase of growth.

(ii) Cells proximal to the tip, represent phase of elongation.

(iii) More proximal to the phase of elongation is phase of maturation.

4 GROWTH RATES

Increased growth per unit time is termed as growth rate. it can be arithmetic or geometrical.

(a) Arithmetic growth: Following mitotic cell division, only one daughter cell continues to divide while the other differentiates and matures. So, a linear curve is obtained
e.g., root elongating at a constant rate.
Mathematically, expressed as

$$L_t = L_0 + rt$$

L_t = length at time 't'

L_0 = length at time 'zero'

r = growth rate/elongation per unit time.

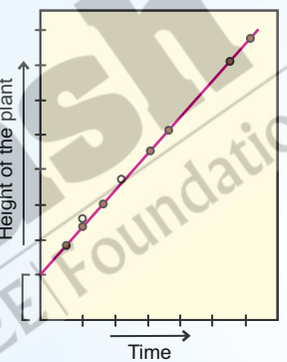


Fig. Linear growth

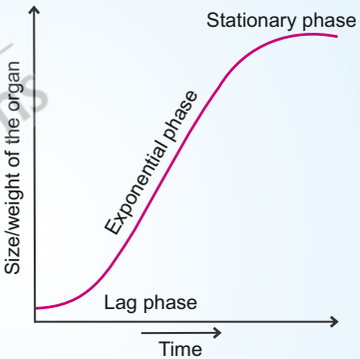


Fig. Sigmoid growth

(b) Geometrical growthŚ: In most systems, initial growth is slow (**lag phase**), it increases rapidly thereafter at an exponential rate (**lag or exponential phase**), as both progeny cells of mitotic cell division retain ability to divide and continue to do so. However with limited nutrient supply, growth slows down leading to **stationary phase**, giving a typical **sigmoid or S-curve**.

- A sigmoid curve is a characteristic of living organism growing in a natural environment. It is typical for all cells, tissues and organs of a plant.

The exponential growth can be expressed as:

$$W_1 = W_0 e^{rt}$$

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

W_0 = initial size at the beginning of period.

r = growth rate; t = time of growth

e = base of natural logarithms.

Here, r = relative growth rate and measure of ability of plant to produce new material called **efficiency index**.

5 QUANTITATIVE COMPARISONS BETWEEN GROWTH OF LIVING SYSTEM CAN BE MADE BY

(i) Measurement and comparison of total growth per unit time called ABSOLUTE GROWTH RATE.

(ii) The growth of given system per unit time expressed on a common basis, e.g., per unit initial parameter is called RELATIVE GROWTH RATE.

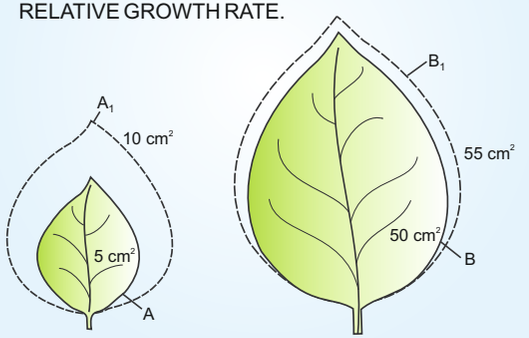


Fig. Absolute and relative growth rates

6 CONDITIONS FOR GROWTH

- **Water:** For cell enlargement, i.e., extension growth by turgidity. Water also provides medium for enzymatic activities.
- **Oxygen:** For aerobic respiration to get metabolic energy.
- **Macro and Micro nutrients:** for synthesis of protoplasm.
- **Temperature:** Optimum range for best growth.
- **Light and Gravity:** also affect certain phases/stages of growth.

9 PLASTICITY

- Plants follow different pathways in response to environment or phases of life to form different kinds of structures. This ability is called **Plasticity**.
- Heterophylly in cotton, coriander and larkspur-leaves of the juvenile plant are different in shape from those in mature plants.
- Environmental heterophylly in buttercup is also an example of plasticity, which shows difference in shape of leaves produced in air and water.

7

DIFFERENTIATION

- The cells derived from root apical and shoot apical meristems and cambium differentiate and mature to perform specific functions, this act leading to maturation in termed differentiation.
  eg. tracheary element

DE-DIFFERENTIATION

- Living differentiated cells, that have lost the capacity to divide can regain capacity of division under certain conditions; this phenomenon is de-differentiation, e.g., formation of interfascicular and cork-cambium from parenchyma cells.

RE-DIFFERENTIATION

- De-differentiated meristems are able to divide and produce cells that once again lose capacity to divide but mature to perform specific functions, i.e., get redifferentiated.
  e.g., secondary xylem, secondary cortex, cork, etc.

8 DEVELOPMENT

- Development includes all changes that an organism goes through during its life cycle from germination of seed to senescence.

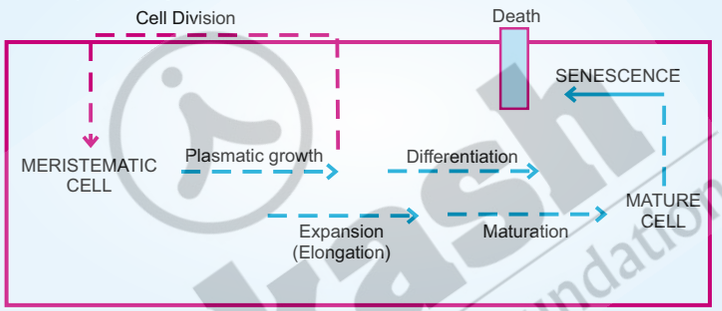


Fig. Sequence of developmental process in a plant cell

10 PLANT GROWTH REGULATORS

- Broadly divided into two groups based on their functions in a living plant body.

Involved in Growth promoting activities	Involved in Growth inhibiting activities
(Like-cell division, cell enlargement, pattern formation, tropic growth, flowering, fruiting and seed formation)	(Like-Response to wounds and stresses of biotic and abiotic origin; dormancy and abscission)
1. Auxin (indole compounds) IAA.	E.g.: Abscisic acid (derivatives of carotenoids)
2. Gibberellins (GA_3, terpenes)	
3. Cytokinin (adenine derivatives) (N^6-furfurylamino purine, kinetin)	

* The gaseous PGR, ETHYLENE, could fit either of the groups, but it is largely an inhibitor of growth activities.

11 PLANT GROWTH REGULATORS

1. AUXIN

- Charles Darwin and his son Francis Darwin studied phototropism in canary grass.
- F.W. Went isolated auxin from tips of coleoptiles of oat seedlings.
- First isolated from human urine.
- Produced by growing apices of stems and roots.
- IAA and IBA isolated from plants.
- NAA, 2,4-D are synthetic.

Physiological effects:

- Initiate rooting in stem cultings.
- Promote flowering in pineapples.
- Help prevent fruit and leaf drop at early stages but promote abscission of older mature leaves and fruits.
- Apical dominance
- Induce parthenocarpy in tomatoes.
- 2, 4-D kill dicot weeds. Used to prepare weed-free lawns.
- Auxin controls xylem differentiation and helps in cell-division.

2. GIBBERELLINS

- Bakanae (foolish seedling) disease in rice was caused by fungal pathogen *G. fujikuroi.* Kurosawa helped understand it. Later the chemical Giberellic acid was identified.
- GA_3 discovered first and remains intensively studied form.
- All GAs are acidic.
- Increase length of grapes stalk.
- Cause fruits like apples to elongate and improve shape.

12

- They delay SENESCENCE.
- Used to speed up malting process in brewing industry.
- Increases length of stem and yield by 20 tonnes per hectare in sugarcane.
- Spraying juvenile conifers with GAs hastens maturity period.
- Promotes BOLTING in beet, cabbages and many plants with rosette habit.

3. CYTOKININ

- Skoog and Miller crystalised cytokinesis promoting active substance and termed it KINETIN a modified form of adenine from autoclaved herring sperm DNA. Kinetin does not occur naturally in plants.
- ZEATIN the naturally occurring cytokinin was isolated from corn-kernels and coconut milk.
- Synthesised in regions of rapid cell-division like root apices, developing shoot buds, young fruits etc.
- Helps produce new leaves, chloroplasts in leaves, lateral shoot growth and adventitious shoot formation. Overcomes apical dominance.
- Promote nutrient mobilisation.
- Helps delay LEAF SENESCENCE.

4. ETHYLENE

- COUSINS helped to identify Ethylene.
- Synthesised in large amounts by tissues undergoing sencescence and ripening fruits.
- Horizontal growth of seedlings, swelling of axis and apical hook formation in dicot seedlings is influenced by ethylene.
- Promotes SENESCENCE and ABSCISSION in leaves and flowers.
- Effective in fruit ripening, by increasing rate of respiration called CLIMACTIC.
- Breaks seed and bud dormancy.
- Initiates germination in peanut seeds, sprouting of potato tubers.
- Promotes rapid internode/petiole elongation in deep water rice plants
- Promotes root growth and root hair formation
- Initiates flowering and helps in synchronising fruit-set in pineapples.
- Induces flowering in MANGO.
- ETHEPHON is source of ethylene. It hastens fruit ripening in tomatoes and apples and accelerates abscission in flowers and fruits. (thinning of cotton, cherry, walnut)
- Promotes female flowers in cucumbers, increasing yield.

5. ABSCISIC ACID

- Regulates abscission and dormancy
- A general plant growth inhibitor and inhibitor of plant metabolism.
- Inhibits seed germination.
- Stimulates closure of stomata
- Plays important role in seed development, maturation and dormancy.
- By inducing dormancy, ABA helps seeds to withstand desiccation and other factors unfavourable for growth.
- In most situations, ABA acts as an antagonist to GAs.

13 PHOTOPERIODISM

Some plants require a periodic exposure to light to induce flowering.
Such plants are able to measure duration of exposure to light.

(a) Long-day plants: require light period exceeding well-defined critical period.

(b) Short-day plants: require light less than critical period

(c) Day-neutral plants: No such co-relation between exposure to light duration and induction of flowering response.

- Flowering in certain plants depends on combination of light and dark exposures and also their relative durations.
- This response of plants to periods of day/night is termed PHOTOPERIODISM.
- The site of perception of light/dark duration are the leaves. A hypothesised hormonal substance is responsible for flowering.

14 SEED DORMANCY

- Controlled by ENDOGENOUS factors, i.e., conditions within the seed itself.
- Impermeable and hard seed coat; presence of chemical inhibitors-ABA, phenolic acids, para-ascorbic acid and immature embryos cause seed dormancy.
- Man made measures like mechanical abrasions, using knives, sand paper or vigorous shaking can break dormancy.
- In nature microbial action, passage through digestive tract of animals can break dormancy.
- Chilling condition, use of gibberellic acid and nitrates can remove effect of inhibitory substances.
- Light and temperature can also break dormancy.

- Development in plants can be under intrinsic and extrinsic control. Intrinsic can be intra cellular (GENETIC) or inter cellular (PGR).
- In plants growth and even differentiation is also open, as cells and tissues of same meristem have different structure at maturity
- PGRs can be having complimentary or antagonistic role, which can be individualistic or synergistic.

15 VERNALISATION

- Vernalisation is either QUALITATIVE or QUANTITATIVE exposure to low temperature for flowering in some plants.
- It prevents PRECOCIOUS reproductive development late in the growing season, and enables the plant to have sufficient time to reach maturity.
- Wheat, barley, rye have winter and spring varieties.
- Subjecting biennials like sugarbeet, cabbages, carrots to cold treatment stimulates a subsequent photoperiodic flowering response.

Sharpen Your Understanding

1. The meristem that cause increase in the girth of the organs in which they are active is [NCERT Pg. 241]
   (1) Root apical meristem
   (2) Shoot apical meristem
   (3) Cork-cambium
   (4) Intercalary meristem
2. One single maize root apical meristem can give rise to more than [NCERT Pg. 241]
   (1) 17,500 new cells per minute
   (2) 17,500 new cells per hour
   (3) 17,500 new cells per day
   (4) 17,500 new cells per week
3. Cells are rich in protoplasm, possess large conspicuous nuclei, with thin cellulosic cell wall and abundant plasmodesmatal connections are see in: [NCERT Pg. 241]
   (1) Meristematic region
   (2) Zone of elongation
   (3) Maturation phase
   (4) Root cap zone
4. The growth curve typical for all cells, tissues and organs of a plant is: [NCERT Pg. 243]
   (1) Arithmetic curve
   (2) Linear curve
   (3) Sigmoid curve
   (4) J-shaped curve

NCERT Based MCQs

5. The living differentiated cells, that have lost the capacity of division can regain the capacity of division under certain conditions. This phenomenon is called [NCERT Pg. 245]
   (1) Differentiation
   (2) De-differentiation
   (3) Re- differentiation
   (4) Specialisation
6. Heterophyllous development due to environment is seen in the case of [NCERT Pg. 246]
   (1) Larkspur (2) Coriander
   (3) Buttercup (4) Cotton
7. The intrinsic intercellular factor which control growth and differentiation in plants is [NCERT Pg. 247]
   (1) Genetic
   (2) PGRs
   (3) Light
   (4) Oxygen and nutrients
8. Auxin was isolated by F.W. Went from tips of coleoptiles of [NCERT Pg. 247]
   (1) Oat seedlings
   (2) Canary grass
   (3) Maize seedlings
   (4) Tomato seedlings
9. The PGR which controls xylem differentiation and helps in cell-division also is [NCERT Pg. 249]
   (1) Auxin (2) Gibberellins
   (3) Cytokinin (4) Ethylene
10. Inhibitor-B, abscission-II and dormin, were proved chemically identical and named. [NCERT Pg. 248]
    (1) Ethylene (2) Gibberellin
    (3) Abscisic acid (4) Auxin
11. Bolting, i.e., internode elongation just prior to flowering in beet, cabbages, and many plants with rosette habit is promoted by the PGR [NCERT Pg. 249]
    (1) Gibberellins (2) Ethylene
    (3) Abscisic acid (4) Cytokinin
12. Which of the following plant growth substance helps to produce new leaves and chloroplasts in leaves [NCERT Pg. 249-250]
    (1) Auxin (2) Gibberellin
    (3) Cytokinin (4) Ethylene
13. Thinning in cotton, cherry and walnut is hastened by [NCERT Pg. 250]
    (1) Auxin
    (2) Ethylene
    (3) Abscisic acid
    (4) Dormin

14. Which of the following occur naturally in plants? [NCERT Pg. 248,249,250]
(1) Ethephon
(2) Kinetin
(3) Naphthalene acetic acid
(4) Indole butyric acid

15. The PGR which helps the seeds to withstand desiccation and other factors unfavourable for growth is [NCERT Pg. 250]
(1) Abscisic acid (2) Ethylene
(3) Cytokinin (4) Auxin

16. The plants which need to be exposed to light for a period less than the critical duration before the flowering is initiated in them are called [NCERT Pg. 251]
(1) Long-day plants
(2) Indeterminate plants
(3) Short day plants
(4) Day-neutral plants

17. The phenomenon which prevents precocious reproductive development late in the growing season, and enables the plants to have sufficient time to reach maturity is [NCERT Pg. 252]
(1) Dormancy
(2) Vernalisation
(3) Photoperiodism
(4) Mechanical abrasion

18. Seed dormancy is due to [NCERT Pg. 252]
(1) Endogenous control
(2) Conditions within seed itself
(3) External environment
(4) Option (1) and (2) are correct

19. Which PGR promotes rapid internode/petiole elongation in deep water rice plants, which helps leaves/upper parts of the shoot to remain above water? [NCERT Pg. 250]
(1) Ethylene
(2) Abscisic acid
(3) Cytokinin
(4) Gibberellins

20. The widely used herbicide, used to kill dicotyledonous weeds, which does not affect mature monocotyledonous plants is [NCERT Pg. 249]
(1) Naphthalene acetic acid
(2) 2,4-dichlorophenoxy acetic acid
(3) Gibberellic acid
(4) Para-ascorbic acid

Thinking in Context

1. Plant growth is unique because plants retain the capacity for _____ throughout their life. [NCERT Pg. 240]

2. The cells of _____ attain their maximal size in terms of wall thickening and protoplasmic modifications. [NCERT Pg. 242]

3. The cells derived from root apical and shoot-apical meristems mature to perform specific functions. This act of maturation is termed as _____ [NCERT Pg. 245]

4. Broadly, development is considered as the sum of _____. [NCERT Pg. 247]

5. _____ help overcome the apical dominance and promote nutrient mobilization. [NCERT Pg. 250]

6. _____ promotes root growth and root hair formation, thus helping the plants to increase their absorption surface. [NCERT Pg. 250]

7. In most situations _____ acts as an antagonist to gibberellic acids. [NCERT Pg. 250]

8. Where there is no such correlation between exposure to light duration and induction of flowering response, the plants are called _____ [NCERT Pg. 251]

9. Horizontal growth of seedlings, swelling of the axis and apical hook formation in dicot seedlings in plants is influenced by _____ [NCERT Pg. 250]

10. The intercellular, intrinsic factor which controls both growth and differentiation in plants are the chemicals such as _____ [NCERT Pg. 247]

11. Cytokinins were discovered as kinetin, from the autoclaved _____ [NCERT Pg. 249]

12. In most higher plants, the growing apical buds inhibits the growth of the lateral (axillary) buds, a phenomenon called _____. [NCERT Pg. 248]

13. _____ usually results in the growth of lateral buds and is widely applied in tea plantations, hedge-making etc. [NCERT Pg. 248]

14. _____ confirmed the release of a volatile substance from ripened oranges that hastened the ripening of stored unripened bananas. [NCERT Pg. 248]

15. _____ breaks seed and bud dormancy, initiates germination in peanut seeds, sprouting of potato tubers. [NCERT Pg. 250]

16. The site of perception of light/dark duration are the _____ in plants [NCERT Pg. 252]

17. _____ refers specially to the promotion of flowering by a period of low temperature [NCERT Pg. 252]

18. Effect of inhibitory substances on seeds can be removed by subjecting the seeds to chilling conditions or by application of chemicals like _____. [NCERT Pg. 253]

19. Ethylene enhances respiration rate during ripening of the fruits. This rise in rate of respiration is called _____. [NCERT Pg. 250]

20. Increased vacuolation, cell enlargement and new cell wall deposition are the characteristics of the cells in the _____. [NCERT Pg. 242]

❑ ❑ ❑

ANSWERS

Class XI

Chapter-1 : The Living World

Sharpen Your Understanding

1. (2) 2. (2)
3. (2) 4. (2)
5. (4) 6. (3)
7. (2) 8. (4)
9. (3) 10. (3)
11. (2) 12. (3)
13. (4) 14. (3)
15. (2) 16. (3)
17. (4) 18. (2)
19. (4) 20. (1)

Thinking in Context

1. Unicellular organisms
2. Filamentous algae
3. Cellular organisation
4. Solanaceae
5. Specific epithets
6. Class
7. Decreasing
8. Monocotyledonae
9. Herbarium
10. Lucknow
11. One
12. Flora
13. *Mangifera indica*
14. Mammalia
15. Latin
16. *Panthera*
17. Polymoniales
18. 1.7 to 1.8
19. Living reactions
20. Consciousness

Chapter-2 : Biological Classification

Sharpen Your Understanding

1. (3) 2. (2)
3. (4) 4. (3)
5. (4) 6. (4)
7. (3) 8. (3)
9. (4) 10. (4)
11. (4) 12. (4)
13. (2) 14. (4)
15. (3) 16. (4)
17. (2) 18. (1)
19. (4) 20. (4)

Thinking in Context

1. R.H. Whittaker
2. Bacteria
3. A : Structure, B : Behaviour
4. Halophiles
5. Chlorophyll a
6. Chemoautotrophic
7. Fission
8. Protista
9. A : Diatoms; B : Desmids
10. Diatoms
11. Protein
12. Fruiting bodies
13. Animals
14. Parasites
15. Karyogamy
16. A : Zoospores; B : Aplanospores
17. Dung
18. Basidiomycetes
19. Bladderwort
20. Non-cellular

Chapter-3 : Plant Kingdom

Sharpen Your Understanding

1. (1)
2. (3)
3. (4)
4. (3)
5. (2)
6. (1)
7. (1)
8. (2)
9. (3)
10. (4)
11. (3)
12. (3)
13. (1)
14. (3)
15. (2)
16. (4)
17. (1)
18. (3)
19. (3)
20. (2)

Thinking in Context

1. Numerical taxonomy
2. Cytological information
3. Zoospore
4. *Chlorella*
5. CO_2-fixation
6. Chlorophyll a and b
7. Laminarin or mannitol
8. Warmer areas
9. Floridean starch
10. A – Mosses
    B – Lichens
11. Gemmae
12. Secondary protonema
13. Living pteridophytes
14. Seed habit
15. *Pinus*, *Cedrus*
16. Heterosporous
17. Free-living existence
18. A – Seeds
    B – Ovaries
19. A – Type of pigment
    B – Food stored
20. Gametophyte

Chapter-4 : Morphology of Flowering Plants

Sharpen Your Understanding

1. (1)
2. (3)
3. (3)
4. (4)
5. (2)
6. (2)
7. (1)
8. (3)
9. (2)
10. (4)
11. (3)
12. (3)
13. (3)
14. (1)
15. (1)
16. (3)
17. (4)
18. (4)
19. (2)
20. (3)

Thinking in Context

1. Shoot apical meristem, acropetal
2. *Opuntia*, *Euphorbia*
3. Tendril, pea
4. Cymose/Racemose, basipetal/acropetal
5. Zygomorphic
6. Hypogynous, mustard/china rose/brinjal
7. *Cassia*, gulmohur, imbricate
8. Staminode
9. Monoadelphous, china rose
10. Free central
11. *Salvia*, mustard
12. Monocarpellary superior
13. Endospermic, orchids, none-endospermic
14. Scutellum
15. Papilionoideae, Leguminosae
16. Lupin, sweet pea
17. Bicarpellary, syncarpous
18. Coconut
19. Monocot
20. Australian *Acacia*

Chapter-5 : Anatomy of Flowering Plants

Sharpen Your Understanding

1. (3) 2. (1)
3. (2) 4. (2)
5. (3) 6. (4)
7. (3) 8. (4)
9. (3) 10. (3)
11. (1) 12. (1)
13. (1) 14. (3)
15. (2) 16. (4)
17. (1) 18. (4)
19. (4) 20. (2)

Thinking in Context

1. Axillary buds
2. Intercalary meristem
3. Collenchyma
4. a. Tracheid, b. vessel
5. Ray parenchyma
6. a. Albuminous cells, b. sieve cells
7. Monocots
8. a. Chloroplast, b. opening, c. closing
9. a. Cuticle, b. Roots
10. Outerside
11. a. Parenchymatous, b. Conjunctive tissue
12. Stele
13. Monocot
14. Starch sheath
15. a. Thick, b. Bundle sheath cells
16. a. Primary, b. Secondary phloem
17. a. Thin, b. rectangular
18. Suberin
19. a. Periderm, b. Secondary phloem
20. Completely secondary

Chapter-6 : Cell : The Unit of Life

Sharpen Your Understanding

1. (3) 2. (4)
3. (3) 4. (4)
5. (4) 6. (4)
7. (3) 8. (4)
9. (3) 10. (2)
11. (3) 12. (4)
13. (1) 14. (2)
15. (3) 16. (4)
17. (4) 18. (4)
19. (2) 20. (2)

Thinking in Context

1. Nerve cells
2. Cell wall
3. Chromatophores
4. Polysome
5. A - 52%, B - 40%
6. Passive transport
7. Lipids
8. Acidic
9. Tonoplast
10. Fission
11. Carbohydrates
12. Double membrane bound
13. Axoneme
14. Chromatin
15. Sub-metacentric
16. Nucleoplasm
17. Phospholipids
18. Calcium pectate
19. Contractile vacuole
20. Aerobic respiration

Chapter-7 : Cell Cycle and Cell Division

Sharpen Your Understanding

1. (4)
2. (3)
3. (1)
4. (4)
5. (2)
6. (2)
7. (3)
8. (4)
9. (2)
10. (2)
11. (3)
12. (2)
13. (4)
14. (2)
15. (4)
16. (3)
17. (2)
18. (3)
19. (4)
20. (4)

Thinking in Context

1. 95%
2. a- resting phase
   b- cell growth
   c- DNA replication
3. DNA replication
4. Not distinct
5. Mitotic apparatus
6. Chromosome
7. Metaphase
8. Centromere
9. Anaphase
10. Telophase
11. Middle lamella
12. a-Synaptonemal complex
    b-Chiasmata
13. Vertebrates
14. a-Synapsis
    b-Zygotene
15. a-Haploid
    b-Gametogenesis
16. a-Two
    b-DNA replication
17. a-Telophase II
    b-Tetrad of cells
18. G_1
19. Equational division
20. Cytoplasmic

Chapter-8 : Transport in Plants

Sharpen Your Understanding

1. (4)
2. (1)
3. (2)
4. (4)
5. (3)
6. (4)
7. (1)
8. (3)
9. (3)
10. (4)
11. (3)
12. (1)
13. (2)
14. (4)
15. (2)
16. (1)
17. (4)
18. (3)
19. (2)
20. (3)

Thinking in Context

1. The lower (more negative)
2. Hypotonic
3. Apoplast
4. Thick and elastic
5. Dorsiventral leaf (often dicotyledonous)
6. Water loss
7. Apical and lateral meristem
8. Active and passive
9. 130 metres high
10. One percent
11. Pressure flow hypothesis
12. Transpiration pull
13. Water potential
14. Girdling experiment
15. Transpiration
16. Mycorrhizae
17. Cobalt chloride
18. Cytoplasmic streaming
19. Diffusion
20. Osmotic potential

Chapter-9 : Mineral Nutrition

Sharpen Your Understanding

1. (4)
2. (4)
3. (3)
4. (1)
5. (3)
6. (2)
7. (2)
8. (3)
9. (4)
10. (4)
11. (4)
12. (1)
13. (1)
14. (1)
15. (4)
16. (4)
17. (3)
18. (2)
19. (2)
20. (2)

Thinking in Context

1. Hydroponics
2. Selenium
3. Mg^{2+}
4. Potassium
5. Chemoautotrophs
6. Ammonification
7. Flux
8. Loss of chlorophyll
9. Calcium
10. N, S, Mo
11. Nitrogen
12. Boron
13. Chlorine
14. Glutamic acid
15. NH_4^+
16. Critical concentration
17. Ferric
18. Magnesium
19. Trace elements
20. Irons

Chapter-10 : Photosynthesis in Higher Plants

Sharpen Your Understanding

1. 3
2. 1
3. 2
4. 2
5. 3
6. 1
7. 4
8. 3
9. 1
10. 3
11. 2
12. 1
13. 2
14. 3
15. 1
16. 3
17. 3
18. 2
19. 1
20. 3

Thinking in Context

1. Surface area
2. CO_2 availability
3. Higher
4. Low light intensities
5. Decrease
6. Genetic predisposition
7. Photorespiration
8. A. RuBisCO,
   B. PEPcase
9. CO_2 molecule
10. One ATP
11. RuBisCO
12. Beyond 680 nm
13. PS-II
14. Chlorophyll-a
15. Sulphur or Sulphate
16. Physico-chemical
17. Chlorophyll-b
18. Accessory pigments
19. Photo-phosphorylation
20. Proton-gradient

Chapter-11 : Respiration in Plants

Sharpen Your Understanding

1. (3) 2. (1)
3. (2) 4. (4)
5. (1) 6. (2)
7. (3) 8. (4)
9. (3) 10. (1)
11. (2) 12. (4)
13. (3) 14. (1)
15. (4) 16. (1)
17. (2) 18. (3)
19. (2) 20. (3)

Thinking in Context

1. Diffusion
2. Cellular respiration
3. Respiratory quotient or respiratory ratio
4. Mitochondria
5. Terminal stage
6. ATP synthase (complex V)
7. Condensation
8. Anaerobic conditions
9. Hexokinase
10. Sucrose
11. EMP pathway
12. Lacked oxygen
13. Glycolysis
14. Anaerobic organisms
15. Facultative anaerobes
16. Respiratory substrates
17. Photosynthesis
18. Carbohydrates
19. A – $NADH+H^+$
    B – NAD^+
20. A – Cytoplasm
    B – Mitochondria

Chapter-12 : Plant Growth and Development

Sharpen Your Understanding

1. (3) 2. (2)
3. (1) 4. (3)
5. (2) 6. (3)
7. (2) 8. (1)
9. (1) 10. (3)
11. (1) 12. (3)
13. (2) 14. (4)
15. (1) 16. (3)
17. (2) 18. (4)
19. (1) 20. (2)

Thinking in Context

1. Unlimited growth
2. Phase of maturation
3. Differentiation
4. Growth and differentiation
5. Cytokinin
6. Ethylene
7. Abscisic acid
8. Day-neutral plants.
9. Ethylene
10. Plant growth regulators
11. Herring sperm DNA
12. Apical dominance
13. Removal of shoot tips (decapitation)
14. Cousins
15. Ethylene
16. Leaves
17. Vernalisation
18. Gibberellic acid and nitrates
19. Respiratory climactic
20. Phase of elongation

❑ ❑ ❑

Reproduction in Organisms

1 Chapter

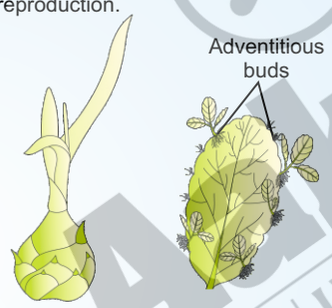
1 INTRODUCTION

- The period from birth to natural death of an organisms is called its life span. Life spans of organisms are not necessarily correlated with their sizes, the sizes of crows and parrots are not very different yet their life spans show a wide difference. Similarly, a mango tree has a much shorter life span as compared to a peepal tree. No organism is immortal except single celled organisms.
- Reproduction is defined as a biological process in which organism gives rise to young ones (offspring) similar to itself. Based on whether there is participation of one organism or two in the process of reproduction, it is of two types. When offspring is produced by a single parent with or without involvement of gamete formation, the reproduction is asexual. When two parents (opposite sex) participate in the reproductive process and also involve fusion of male and female gametes, it is called sexual reproduction.
- The organism's habitat, its internal physiology and several other factors are collectively responsible for how it reproduces.

2 ASEXUAL REPRODUCTION

- In this method, a single individual (parent) is capable of producing offspring (clones)
- The term clone is used to describe such morphologically and genetically similar individuals.
- Asexual reproduction is common among single celled organisms and in plants and animals with relatively simple organisations.
- In protists and monerans, cell division is itself a mode of reproduction.
- Organisms reproduce asexually by
  a. Binary fission : *Amoeba, Paramecium*
  b. Budding : Yeast
  c. Fragmentation : *Hydra*

  Asexual reproductive structures
  a. Zoospores : Fungi and Algae
  b. Conidia : *Penicillium*
  c. Buds : *Hydra*
  d. Gemmules : Sponge
  e. Bulbils : *Agave*



Vegetative propagules in angiosperms:
(a) Bulbil of *Agave*; (b) Leaf buds of *Bryophyllum*

- In plants, the term vegetative reproduction is frequently used for asexual reproduction. In plants, the units of vegetative propagation such as runner, rhizome, sucker, tuber, offset, bulb are all capable of giving rise to new offspring. These structures are called vegetative propagules.

- Water hyacinth also called terror of Bengal is one of the most invasive weeds found growing in standing water, propagating through offset.
  - It drains oxygen from the water, which leads to death of fishes.
  - This plant was introduced in India because of its beautiful flowers and shape of leaves. Since it can propagate vegetatively at a phenomenal rate and spread all over the water body in a short period of time, it is very difficult to get rid off them.

3 SEXUAL REPRODUCTION

- Sexual reproduction involves formation of male and female gametes, either by the same individual or by different individuals of the opposite sex. These gametes fuse to form the zygote which develops to form the new organism.
- It is an elaborate, 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. When it comes to sexual mode of reproduction, organisms share a similar pattern, though they differ greatly in external morphology, internal structure and physiology.
- All organisms have to reach a certain stage of growth and maturity in their life, before they can reproduce sexually. That period of growth is called the juvenile phase. It is known as vegetative phase in plants. This phase is of variable duration in different organisms.
- Plants-the annual and biennial types, show clear cut vegetative, reproductive and senescent phases, but in the perennial species it is very difficult to clearly define these phases.
- A few plants exhibit unusual flowering phenomenon, such as bamboo species flower only once in their life time, generally after 50-100 years, produce large number of fruits and die.
- *Strobilanthus kunthiana* flowers once in 12 years, this plant flowered last during September October 2006.
- In both plants and animals, hormones are responsible for the transitions between the three phases. Interaction between hormones and certain environmental factors regulate the reproductive processes and the associated behavioural expressions of organisms.

- Buds (eyes) of potato tuber, rhizome of banana and ginger give rise to new plants. The site of origin of the new plantlets in the plants are invariably the nodes present in the modified stems of these plants.
- Adventitious buds arise from the notches present at margins of leaves of *Bryophyllum*.

4 EVENTS IN SEXUAL REPRODUCTION

- The events in sexual reproduction follow a regular sequence. These sequential events may be grouped into three distinct stages namely the pre-fertilisation, fertilisation and the post-fertilisation events.

5 PRE-FERTILISATION EVENTS

- These include all the events of sexual reproduction prior to the fusion of gametes. The two main pre-fertilisation events are gametogenesis and gamete transfer.

Gametogenesis

- Gametogenesis refers to the process of formation of the two types of gametes – male and female. In some algae the gametes are homogametes (isogametes). However, in a majority of sexually reproducing organism the gametes are heterogametes. In such organisms the male gamete is called antherozoid or sperm and the female gametes is called the egg or ovum.

Name of organism	Meiocyte (2n)	Gamete (n)
Human beings	46	23
Fruit fly	8	4
Ophioglossum (a fern)	1260	630
Apple	34	17
Rice	24	12
Maize	20	10
Potato	48	24
Butterfly	380	190
Onion	16	8

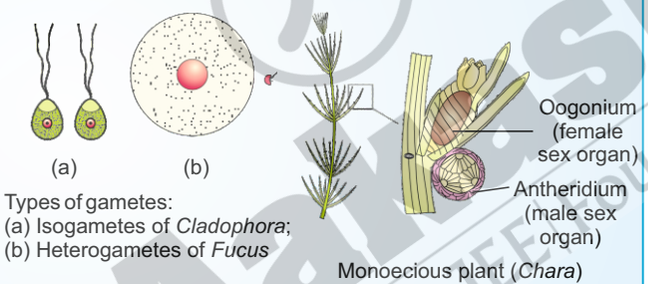
Chromosome numbers in meiocytes and gametes of some organisms.

Cell division during gamete formation :

- Gametes are haploid though the parent body may be haploid or diploid.
- A haploid parent produces gametes by mitotic division whereas a diploid parent produces gametes by meiosis in meiocytes (gamete mother cell). At the end of meiosis, only one set of chromosomes gets incorporated into each gamete.
- Monerans, fungi, algae and bryophytes possess haploid body.
- Pteridophytes, gymnosperms and angiosperms possess diploid body.

Sexuality in organisms

- Plants may have both male and female reproductive structures in the same plant (bisexual) or on different plants (unisexual). In several fungi and plants, terms such as homothallic and monoecious are used to denote the bisexual condition and heterothallic and dioecious are the terms used to describe unisexual condition.
- In flowering plants, the unisexual male flower is staminate, while the female is pistillate.
- Some examples of monoecious plants are cucurbits and coconut and of dioecious plants are papaya and date palm.



Gamete transfer

- In several simple plants like algae, bryophytes and pteridophytes, water is the medium through which 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 seed plants, pollen grains are the carriers of the male gametes. A specialised event called pollination facilitates transfer of pollen grains to the stigma.
- Successful transfer and coming together of gametes is essential for the most critical event in sexual reproduction, the fertilisation.

6 FERTILISATION

- Fusion of gametes is called syngamy or fertilisation, which results in formation of a diploid zygote.
- It is the most vital event of sexual reproduction.

Where does syngamy occur?

External fertilisation : (Requires great synchrony between sexes and release of large number of gametes) — Fertilisation outside the body of the organism. Eg. Majority of algae and fishes as well as amphibians.

Internal fertilisation : (Number of sperms produced is very large though there is significant reduction in number of eggs) — Synagamy occurs inside the body of the organism. Eg. Higher animals and majority of plants.

7 POST FERTILISATION EVENTS

Events in sexual reproduction after the formation of zygote are called post-fertilisation events.

The zygote

- Formed in all sexually reproducing organisms.
- Development of the zygote depends on the type of life cycle the organism has and the environment it is exposed to.
- Zygote is the vital link that ensures continuity of species between organisms of one generation and the next.

Embryogenesis

- Embryogenesis refers to the process of development of embryo from the zygote. During embryogenesis, zygote undergoes cell division and cell differentiation.
- In flowering plants, the zygote develops in the embryo, ovule into seed, ovary into fruit which has a thick wall called pericarp that is protective in function. After dispersal, seeds germinate to produce new plants.

- A major disadvantage of external fertilisation is that the offsprings are extremely vulnerable to predators threatening their survival upto adult hood.

Sharpen Your Understanding

1. Select the **odd** one w.r.t. life span [NCERT Pg. 3]
   (1) It is the period from birth to natural death of an organism
   (2) It should be necessarily correlated with the size of the organisms
   (3) Mango tree has a shorter life span as compared to a peepal tree
   (4) No individual is immortal, except single celled organisms
2. Asexual reproduction can not involve [NCERT Pg. 5]
   (1) Single parent
   (2) Gamete formation
   (3) Clone formation
   (4) Fusion of male and female gametes
3. A single cell divides into two halves and each rapidly grows into an adult in the process called [NCERT Pg. 6]
   (1) Binary fission
   (2) Budding
   (3) Fragmentation
   (4) Sporulation
4. Zoospores are [NCERT Pg. 7]
   (1) Motile (2) Non motile
   (3) Microscopic (4) Both (1) and (3)

NCERT Based MCQs

5. Select the **incorrect** one about 'water hyacinth'. [NCERT Pg. 8]
   (1) Most invasive weed
   (2) Also called terror of Bengal
   (3) Drains oxygen from water, leads to death of the fishes
   (4) Found in running water
6. Eyes of the potato tuber are [NCERT Pg. 8]
   (1) Leaves (2) Roots
   (3) Buds (4) Internodes
7. *Bryophyllum* reproduce vegetatively by [NCERT Pg. 8]
   (1) Root (2) Stem
   (3) Leaf buds (4) Flower
8. Which of the following is a Pre-fertilisation event? [NCERT Pg. 10]
   (1) Fusion of gametes
   (2) Gamete transfer
   (3) Formation of zygote
   (4) Embryogenesis
9. Homogametes are [NCERT Pg. 11]
   (1) Similar in appearance
   (2) Morphologically distinct types
   (3) Also called isogametes
   (4) Both (1) and (3)
10. If in the meiocyte of apple there are 34 chromosomes then how many chromsomes will be seen in gamete? [NCERT Pg. 13]
    (1) 16 (2) 17
    (3) 8 (4) 21
11. Pollination is [NCERT Pg. 14]
    (1) Germination of pollen grains
    (2) Movement of pollen grains
    (3) Transfer of pollen grains to stigma
    (4) Fusion of gametes
12. Organisms showing internal fertilization [NCERT Pg. 15]
    (1) Show fertilization in external medium
    (2) Produce egg inside the female body
    (3) Always have motile gametes
    (4) Must show synchrony between release of gametes
13. Zygote is always [NCERT Pg. 15]
    (1) Diploid (2) Haploid
    (3) Triploid (4) Pentaploid
14. After fertilization the zygote usually develops into [NCERT Pg. 16]
    (1) Seed
    (2) Embryo
    (3) Ovule
    (4) Pericarp

15. In which of the given plant group meiosis occur during gamete formation? [NCERT Pg. 11]
(1) Bryophytes (2) Fungi
(3) Most of the algae (4) Angiosperm

16. Monoecious plants are [NCERT Pg. 11]
(1) Cucurbits and papaya
(2) Date palm and papaya
(3) Coconuts and date palm
(4) Cucurbits and coconuts

17. *Hydra* reproduces by [NCERT Pg. 7]
(1) conidia (2) Zoospores
(3) Gemmules (4) Buds

18. Select the odd one w.r.t sexual reproduction [NCERT Pg. 8-9]
(1) Involves fusion of gametes
(2) It is an elaborate, complex and slow process
(3) Leads to variations in the offspring
(4) Offsprings are identical to parents

19. Gametes in all heterothallic fungi are of [NCERT Pg. 11]
(1) Three types (2) Two types
(3) Four types (4) Single type

20. In *Chara*, the female sex organ is called [NCERT Pg. 12]
(1) Antheridium
(2) Oogonium
(3) Stamen
(4) Anther

Thinking in Context

1. In _____ and _____, cell division is itself a mode of reproduction [NCERT Pg. 5]
2. *Strobilanthus kunthiana* flowers once in _____ years [NCERT Pg. 9]
3. When both male and female flowers are present on the same plant body, this is termed as _____. [NCERT Pg. 11]
4. _____ is the vital link that ensures continuity of species between organisms of one generation and the next [NCERT Pg. 15]
5. _____ is the process of development of embryo from the zygote. [NCERT Pg. 15]
6. Majority of plants show _____ fertilization [NCERT Pg. 15]
7. The _____ develops into the fruit which develops a thick wall called _____ [NCERT Pg. 16]
8. The most vital event of sexual reproduction is perhaps _____. [NCERT Pg. 14]
9. In diploid organisms, specialized cells called _____ undergo meiosis [NCERT Pg. 13]
10. In flowering plants, the unisexual male flower is called _____. [NCERT Pg. 11]
11. Several organisms belonging to monera, fungi, algae and bryophytes have _____ plant body. [NCERT Pg. 11]
12. During embryogenesis, zygote undergoes _____ and _____. [NCERT Pg. 15]
13. _____ refers to process of formation of gametes [NCERT Pg. 10]
14. Term monoecious is used to denote the _____ condition [NCERT Pg. 11]
15. At the end of meiosis, only _____ of chromosomes gets incorporated into each gamete [NCERT Pg. 13]
16. In a majority of organisms, the male gamete is _____ and the female gamete is _____. [NCERT Pg. 13]
17. In seed plants, the non motile male gametes are carried to female gamete by _____. [NCERT Pg. 15]
18. In organisms with _____ zygote divides by meiosis to form haploid spores that grow into haploid individuals. [NCERT Pg. 15]
19. Transfer of pollen grains to stigma is relatively easy in _____ than in papaya [NCERT Pg. 14]
20. A haploid parent produces gametes by _____. [NCERT Pg. 11]

❑ ❑ ❑

Sexual Reproduction in Flowering Plants

2 Chapter

1 INTRODUCTION

- All flowering plants show sexual reproduction.
- Flowers are objects of aesthetic, ornamental, social, religious and cultural value. They have always been used as symbols for conveying important human feelings such as love, affection, happiness, grief, mourning etc.
- Much before the actual flower is seen on a plant, the decision that the plant is going to flower has taken place. Several **hormonal and structural changes** differentiate & develop the floral primordium, which form inflorescences, bear floral buds and then the flowers.

2 PRE-FERTILISATION – STRUCTURES AND EVENTS

Stamen, Microsporangium and Pollen Grain

- Androecium, consists of a whorl of stamens, representing the male reproductive organ.

A typical **Stamen** has two parts

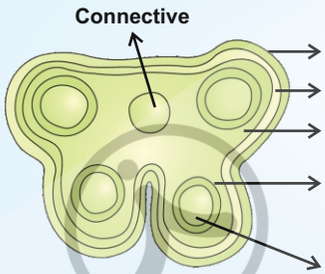
1. FILAMENT | **2. ANTHER**

- **FILAMENT**
  - It is long slender stalk.
  - The proximal end of the filament is attached to the thalamus or the petal of the flower.
  - The number & length of stamens are variable in flowers of different species.
- **ANTHER**
  - The terminal generally bilobed structure is anther.
  - Each lobe having two theca i.e., dithecous.
  - Often a longitudinal groove runs lengthwise separating the theca.
  - The anther is a four-sided **(tetragonal)** structure consisting of four **microsporangia** located at the corners, two in each lobe.
  - The **microsporangia** develop further & become pollen sacs. They extend longitudinally all through the length of an anther and are packed with pollen grains.

3 STRUCTURE OF MICROSPORANGIUM

In a T.S., a typical microsporangium appears near circular. It is generally surrounded by four wall layers.

FOUR ANTHER WALL LAYERS:



Transverse section of a young anther

The outer 3 wall layers perform the function of protection and help in dehiscence of anther to release the pollen.

Inner most wall layer. Nourishes the developing pollen grains. Cells of tapetum possess dense cytoplasm & have more than one nucleus

Compactly arranged homogenous cells; occupies the centre of each microsporangium.

4 MICROSPOROGENESIS

Microsporogenesis is a process of formation of microspores from PMC (Pollen Mother Cell).

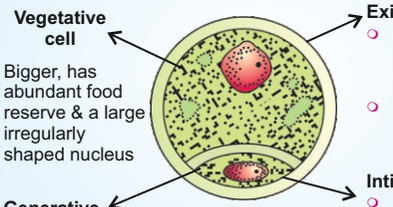
As the anther develops → Cells of the sporogenous tissue (PMC) → Undergoes MEIOSIS → to form microspore tetrad

- Each cell of the sporogenous tissue is a potential pollen or microspore mother cell.
- The microspores, as they are formed, are arranged in a cluster of four cells - the microspore tetrad.
- As the anthers mature and dehydrate, the microspores dissociate from each other & develop into pollen grains.

- **Sporopollenin** is one of most resistant organic material known. It can withstand high temperature, strong acids & alkali. No enzyme that can degrade it is known. Pollen grains are well preserved as fossil due to it.

5 POLLEN GRAIN

- Pollen grains represent the male gametophytes. A variety of architecture-sizes, shapes, colours, designs are seen on pollen grains from different species.
- It has prominent two layered wall-exine and intine.



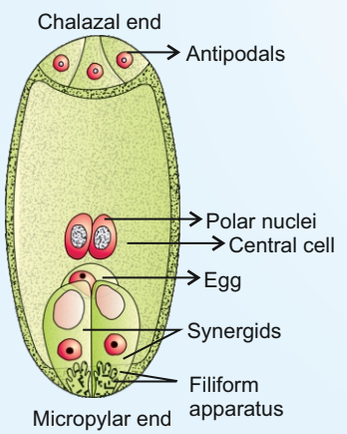
- Small, floats in the cytoplasm of vegetative cell; spindle shaped with dense cytoplasm and a nucleus

Pollen grains are generally spherical; measuring 25 - 50 micrometers in diameter

6

- In over 60% of angiosperms, pollen grains are shed at 2-celled stage, in the remaining species, generative cell divides mitotically to give rise to two male gametes before pollen grains are shed (3-celled stage).
- Pollen grains of many species cause severe allergies, chronic respiratory disorders, asthma, bronchitis etc. e.g., *Parthenium* (carrot grass) came to India as a contaminant with wheat, became ubiquitous in occurrence & causes pollen allergy.
- Pollen grains are rich in nutrients. Pollen tablets and syrups has been claimed to increase performance of athletes & race horses.
- **Pollen Viability:** Highly variable. Depends to some extent on prevailing temperature and humidity.
  - In some cereals like rice and wheat pollen grains lose viability within 30 minutes of release
  - In some members of Rosaceae, Leguminoseae and Solanaceae, viability can be for months.
- It is possible to store pollen of a large number of species for years in liquid nitrogen (–196°C) in pollen banks for crop breeding programmes.

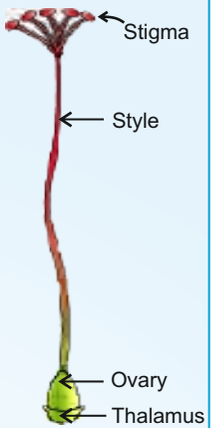
- In embryo sac 3 celled egg apparatus, at micropylar end (1 egg cell & two synergids with filiform apparatus, which guide pollen tube into the synergid.), 3 antipodals at chalazal end and a large central cell, with two polar nuclei remain present.
- Embryo sac formation from single megaspore is termed **monosporic** development.



Mature embryo sac

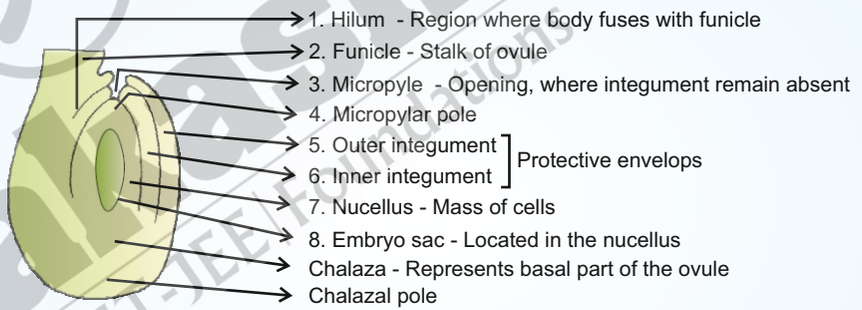
7 PISTIL, MEGASPORANGIUM (OVULE) AND EMBRYO SAC

- Gynoecium represents female reproductive part. Gynoecium may consist of single pistil (monocarpellary) or may have more than one pistil (multicarpellary). It may be free, (apocarpous) eg. *Michelia* or fused (syncarpous), eg. *Papaver*.
- Each pistil has three parts
  1. **Stigma:** Landing platform for pollen grains.
  2. **Style:** Elongated slender part below stigma
  3. **Ovary:** Basal bulged part of pistil, has **ovarian cavity** (locule). Placenta is located inside ovarian cavity. Megasporangia called ovules arise from placenta.
- One ovule in ovary – e.g. wheat, paddy, mangy
- Many ovule in ovary – e.g. papaya, watermelon, orchids.



- Pollen germination can be studied by dusting pollen on glass slide with 10% sugar solution.

Megasporangium (Ovule)



A typical anatropous ovule

Megasporogenesis

- Process of formation of megaspores from megaspore mother cells.
- Ovules generally differentiate a single megaspore mother cell (MMC) in micropylar region of nucellus.
- MMC $\xrightarrow{\text{Meiosis}}$ 4 megaspores.
  (2n) (n)

Female Gametophyte / Embryo sac

- In majority of flowering plants one megaspore remains functional and 3 degenerate.
- The functional megaspore develops the female gametophyte (embryo sac)
- The nucleus of functional megaspore undergoes free-nuclear mitotic divisions to form two nuclei which move to opposite pole. Two more sequential mitotic divisions result 8-nucleate stage, after that cell walls are laid down to form the typical 7-celled-8 nucleate female gametophyte or embryo sac.

8 POLLINATION

Transfer of pollen shed from anther to sigma of a pistil. Pollination can be divided into three types.

(1) AUTOGAMY

- Pollination is achieved within same flower, i.e., transfer of pollen from anther to the stigma of same flower.
- It requires synchrony in pollen release and stigma receptivity.
- Cleistogamous flowers (which do not open) are invariably autogamous, eg. *Viola* (common pansy), *Oxalis & Commelina* and provide assured seed set even in absence of pollinators.
- These species also produce chasmogamous flowers (with exposed anther and stigma) for cross-pollination.

(2) GEITONOGAMY

- Transfer of pollen grains from anther to stigma of another flower of the same plant.
- It is functionally cross pollination involving pollinating agents, genetically it is similar to autogamy, since the pollen grains come from the same plant.

(3) XENOGAMY

- Transfers of pollen grains from anther to the stigma of a different plant.
- This is the only type of pollination which brings genetically different types of pollen grains on the stigma.

9 AGENTS OF POLLINATION

1. ABIOTIC AGENTS

- Pollen coming in contact with stigma is a chance factor in both wind and water pollination. So flowers produce enormous amount of pollen when compared to number of ovules available for pollination. It is to compensate loss of pollen grains.

Wind pollination

- Requires light, non-stickly pollen so that they can be transported by wind currents. Well exposed stamens and large often-feathery stigma to trap air borne pollen, single ovule in each ovary and numerous flowers in an inflorescence. **Tassels in corn to trap pollen**.
- Quite common in grasses.
- Pollination by wind is more common among abiotic pollinations.

Water pollination

- Pollination by water is quite rare, limited to 30 genera, of monocotyledons e.g *Vallisneria, Hydrilla, Zostera* (sea grass).
- In majority of aquatic plants like water hyacinth and waterlily, flowers emerge above water & are pollinated by **insects or wind.**
- In *Vallisneria* pollination takes place on the surface of water (epihydrophily), in sea grasses it takes place below water (hypohydrophily)
- In most water-pollinated species, pollen grains are protected from wetting by a mucilaginous covering.

2. BIOTIC AGENTS

- Majority of flowering plants use a range of animals as pollinating agents-Bees, butterflies, flies, beetles, wasps, ants, moths, birds (sunbirds & humming birds) & bats.
- Among animals, insects particularly bees are dominant pollinating agents.
- Some primates (**lemurs**), arboreal (tree dwelling) rodents or even reptiles (**gecko lizard & garden lizard**) are also pollinators in some species.
- Insect-pollinating flowers are large, colourful, fragrant and rich in nectar. Small flowers are clustered in inflorescence to make them conspicuous.
- Animals are attracted to flowers by colour and/ or fragrance.
- Flowers pollinated by flies & beetles secrete foul odours to attract these animals.
- **Nectar & pollen grains** are usual floral rewards.
- In some species floral rewards are in providing safe places to lay eggs, eg, *Amorphophallus*; A species of moth and *Yucca* - cannot complete their life cycles without each other.

10 OUTBREEDING DEVICES

- Flowering plants have developed many devices to discourage self. pollination and to encourage cross pollination. For example –
  - Pollen release and stigma receptivity are not synchronised.
  - Anther and stigma are placed at different positions so that pollen cannot come in contact with stigma of the same flower.
  - **Self-incompatibility** is a genetic mechanism which prevents self-pollen from fertilizing the ovules by inhibiting pollen germination or pollen tube growth in the pistil.
  - Production of unisexual flowers.
- In castor & maize. (monoecious) autogamy is prevented but not geitonogamy. In papaya (dioecy), both autogamy and geitonogamy are prevented.

11 POLLEN-PISTIL INTERACTION

- The ability of pistil to recognise the pollen followed by its acceptance or rejection is the result of a continuous dialogue between pollen grain and the pistil. Its a dynamic process.
- This dialogue is mediated by chemical components of the pollen interacting with those of the pistil.
- Following compatible pollination, pollen tube grows through the tissues of the stigma and style, the contents of pollen grain move into pollen tube.
- The growing pollen tube carrying two non-motile male gametes, reaches the ovary, enters the ovule through micropyle & then enters one of the synergids through the filiform apparatus, which guides the entry of pollen tube.
- All these events - from pollen deposition on the stigma until pollen tubes enter the ovule - are together referred to as pollen - pistil interaction.

12 ARTIFICIAL HYBRIDISATION

- In such crossing, desired pollen are used for pollination & stigma is protected from contamination from unwanted pollen by **emasculation** and **bagging**.
- If female parent bears bisexual flowers emasculation is followed by bagging & rebagging after dusting mature pollen, for fruit development.
- If female flowers are unisexual there is no need of emasculation.

- Knowledge gained in pollen-pistil interactions can help plant breeders even in compatible pollination to get desired hybrids.
- Continued self-pollination result in inbreeding depressions.

13 DOUBLE FERTIFISATION

- Pollen tube releases the two male gametes into the cytoplasm of the synergid.
- One of the males gametes fuses with egg to form the diploid zygote (SYNGAMY). The other male gamete moves towards the polar nuclei of the central cell and fuses with them to produce **triploid** primary endosperm nucleus (PEN). It is TRIPLE FUSION.
- Syngamy & triple fusion are called **double fertilisation**, **an event unique to flowering plants**.

The central cell after triple fusion becomes primary endosperm cell (PEC) and develop ionto endosperm.

15 APOMIXIS AND POLYEMBRYONY

- Some species of Asteraceae & grasses have evolved a special mechanism to produce seeds without fertilisation called apomixis. A form of asexual reproduction that mimics sexual reproduction.
- In some species diploid egg cell formed without reduction division develops into embryo without fertilisation.
- In *Citrus* and mango nucellar cells protrude into embryo sac & develops into embryos, so each ovule contains many embryos-**polyembryony**.
- Hybrid seeds have to be produced every year as the progeny plants will segregate and will not be able to maintain hybrid characters. But if hybrid seeds are made into apomicts, there is no segregation of characters in hybrid progeny. So active research is going on to understand the genetics of apomixis & transfer apomictic genes into hybrid varieties.

14 POST-FERTILISATION: STRUCTURE AND EVENTS

(A) ENDOSPERM

- Endosperm development precedes embryo development.
- The cells of triploid endosperm are filled with reserve food materials and used by developing embryo.
- The most common type of endosperm, is nuclear type (PEN undergoes successive nuclear divisions to give free nuclei) eg. coconut water, and surrounding white kernel is cellular endosperm.

(B) EMBRYO

- Embryo develops at micropylar end of embryo sac where the zygote is situated.
- Most zygotes divide only after certain amount of endosperm is formed. This adaptation provides assured nutrition to the developing embryo.
- Early stages of embryo development (EMBRYOGENY) are similar in both monocotyledons and dicotyledons.
- In dicots the zygote forms → **proembryo** → **globular** → **heart-shaped** → **mature embryo.**
- A typical dicot embryo has embryonal axis & two cotyledons. Epicotyl terminates with plumule or stem tip; hypocotyl terminates at its lower tip in radical or root tip, covered by root cap.
- Embryos of monocot has only one cotyledon. In grass family it is called **scutellum** towards lateral side of the embryonal axis. Radicle or root cap enclosed with undifferentiated sheath called coleorhiza. Epicotyl has shoot apex & a few leaf primordia enclosed in foliar structure coleoptile.

(C) SEED

- In angiosperms, seed (fertilised ovule) is the final product of sexual reproduction, formed inside fruits. A seed typically consists of seed coats, cotyledon(s) & an embryo axis.
- Mature seeds may be **non-albuminous or ex-albuminous**, having no residual endosperm, which is consumed completely during embryo development (eg pea, groundnut). **Albuminous seeds** retain a part of endosperm (eg. **Wheat, maize, barley, castor**, coconut).
- In black pepper & beet, remnants of nucellus are also persistent, called **perisperm**.
- Wall of ovary develops into pericarp. **True fruits** develop from ovary.
- In apple, strawberry, cashew, etc, thalamus also contributes to form fruit called **false fruit**.
- Parthenocarpic fruit develop without fertilisation eg. Banana.
- Seeds form the basis of agriculture.
- *Lupinus arcticus* seed germinated and flowered after estimated record 10,000 yrs of dormancy. *Phoenix dactylifera* (date palm) seed remained viable for 2000 yrs.

Sharpen Your Understanding

1. The science of breeding, marketing, cultivation and arrangement of flowers is called: [NCERT Pg. 20]
   (1) Floriculture
   (2) Pollen germination
   (3) Agriculture
   (4) Silviculture
2. The proximal end of filament of a typical stamen is attached to which part of the flower? [NCERT Pg. 21]
   (1) Anther (2) Thalamus
   (3) Pollen sac (4) Microspores.
3. The inner-most wall layer of the micro-sporangium, which nourishes the developing pollen grains, generally having more than one nucleus is called [NCERT Pg. 21]
   (1) Exothecium (2) Endothecium
   (3) Epidermis (4) Tapetum
4. Pollen grains are well-preserved as fossils because of the presence of [NCERT Pg. 23]
   (1) Intine
   (2) Germpore
   (3) Sporopollenin
   (4) Pectin & cellulose
5. In over 60 percent of angiosperms, pollen grains are shed from the anther at: [NCERT Pg. 23]
   (1) 3-celled stage
   (2) 2-celled stage
   (3) Polyspory stage
   (4) Microspore tetrad stage
6. Which of the following species came into India as a contaminant with imported wheat, and has become ubiquitous in occurrence and cause pollen allergy? [NCERT Pg. 23]
   (1) *Citrus* (2) Strawberry
   (3) *Parthenium* (4) *Argemone*
7. The number of ovules in the ovary can be many in: [NCERT Pg. 25]
   (1) Water melon & orchids
   (2) Papaya & wheat
   (3) Paddy and Mango
   (4) Mango and wheat
8. The ovule is attached to the placenta by means of a stalk called the: [NCERT Pg. 25]
   (1) Hilum (2) Funicle
   (3) Micropyle (4) Nucellus
9. The special cellular thickenings called the filiform apparatus is present at the micropylar tip of: [NCERT Pg. 27]
   (1) Antipodals (2) Polar nuclei
   (3) Synergids (4) Egg cell

NCERT Based MCQs

10. The only type of pollination which brings genetically different types of pollen grains to the stigma during pollination is: [NCERT Pg. 28]
    (1) Autogamy (2) Cleistogamy
    (3) Geitonogamy (4) Xenogamy
11. Select the **correct** option for the pair of plants pollinated by water? [NCERT Pg. 29]
    (1) *Vallisneria & Hydrilla*
    (2) *Zostera* & water lily
    (3) Water lily and *Parthenium*
    (4) Water hyacinth & water lily.
12. Among animals, the dominant biotic pollinating agents are [NCERT Pg. 30]
    (1) Humming birds (2) Sun birds
    (3) Bees (4) Lemurs
13. The residual, persistent nucellus, occasionally, found in some seeds such as black pepper and beet, is known as- [NCERT Pg. 36]
    (1) Pericarp (2) Integument
    (3) Perisperm (4) Endosperm
14. In a few species such as apple, cashew etc, the thalamus also contributes to fruit formation, such fruits are called [NCERT Pg. 36]
    (1) Parthenocarpic (2) False fruits
    (3) True fruits (4) Eucarp

15. The oldest known viable seeds, have been reported from which of the following plants? [NCERT Pg. 38]

(1) *Phoenix dactylifera*

(2) *Nelumbium* species

(3) *Lupinus arcticus*

(4) *Cedrus deodara*

16. The special mechanism to produce seeds without fertilization evolved in some species of Asteraceae and grasses is called: [NCERT Pg. 38]

(1) Amphimixis

(2) Apomixis

(3) Amphidiploid

(4) Sexual reproduction

17. The Endosperm persists in the mature seed and is used up during the process of seed germination in which of the following pair of plants? [NCERT Pg. 35]

(1) Castor and coconut

(2) Pea and groundnut

(3) Beans and Pea

(4) Groundnut and castor

18. Removal of anthers from the flower bud of bisexual flowers, before the anther dehise, is referred to as: [NCERT Pg. 33]

(1) Bagging (2) Emasculation

(3) Rebagging (4) Debagging

19. Continued self-pollination in flowering plants results in: [NCERT Pg. 31]

(1) Increased variation

(2) Hybrid vigour

(3) Production of bisexual flowers

(4) Inbreeding depression.

20. Majority of insect-pollinated flowers have/are [NCERT Pg. 30]

(1) Light and non-sticky pollen

(2) Large, colourful, fragrant and rich in nectar

(3) Large feathery stigma to trap pollen

(4) Single ovule in each ovary.

Thinking in Context

1. Active research is going on in many laboratories around the world to understand the genetics of apomixis and to transfer apomictic genes into _____ [NCERT Pg. 39]

2. _____ is a form of asexual reproduction that mimics sexual reproduction. [NCERT Pg. 38]

3. A and B of mature seeds are crucial for storage, which can be used as food throughout the year and also to raise crop in the next season. [NCERT Pg. 38]

4. Fruits of orchids and parasitic plants such as *Orobanche* and *Striga* contain thousands of _____. [NCERT Pg. 38]

5. Parthenocarpy can be induced through the application of growth hormones and such fruits are _____. [NCERT Pg. 37]

6. The radical and the root cap in monocot seeds are enclosed in an undifferentiated sheath called the _____. [NCERT Pg. 36]

7. The PEN undergoes successive nuclear divisions to give rise to free nuclei. This stage of endosperm development is called _____. [NCERT Pg. 35]

8. If the female parent produces unisexual flowers, there is no need for _____ in artificial hybridization. [NCERT Pg. 33]

9. The genetic mechanism to prevent inbreeding is _____. [NCERT Pg. 31]

10. In some species of plants the floral rewards are in providing safe places to lay eggs, an example is that of the tallest flower of _____. [NCERT Pg. 30]

11. The flowers pollinated by flies and beetles secrete _____ to attract these animals. [NCERT Pg. 30]

12. To sustain animal visits, the flowers have to provide rewards to animal, for pollination. The usual floral rewards are _____. [NCERT Pg. 30]

13. Both wind and water pollinated flowers are not very colourful and do not produce _____. [NCERT Pg. 29]

14. In the corn cob the _____ we see are nothing but the stigma and style which wave in the wind to trap pollen grains. [NCERT Pg. 29]

15. It was believed, particularly for some bryophytes and pteridophytes that their distribution is limited because of the need for water for the transport of _____ and fertilization. [NCERT Pg. 29]

16. Geitonogamy is genetically similar to _____. [NCERT Pg. 28]

17. A typical angiosperm embryo sac, at maturity, though __A__ is __B__. [NCERT Pg. 27]

❑ ❑ ❑

18. Stored pollen can be used as pollen banks, similar to seed banks in _____. [NCERT Pg. 24]

19. The _____ is small, spindle shaped with dense cytoplasm and a nucleus and floats in the cytoplasm of the vegetative cell. [NCERT Pg. 23]

20. Though the seeds differ greatly, the early stages of _____ are similar in both monocotyledons and dicotyledons. [NCERT Pg. 35]

Principles of Inheritance and Variation

3 Chapter

1 INTRODUCTION

- Genetics deals with inheritance and variation of characters from parents to offsprings. Inheritance is the process by which characters are passed on from parent to progeny. Variation is the degree by which progeny differ from their parents.
- Humans knew that the causes of variation was hidden in sexual reproduction.

2 MENDEL'S LAWS OF INHERITANCE

- Gregor Mendel conducted hybridisation experiments on garden peas for seven years (1856-1863) and proposed the laws of inheritance.
- Mendel selected 14-true breeding pea plant varieties as pairs, which were similar except for one character with contrasting traits.

Contrasting traits studied by Mendel in Pea

S.No.	Characters	Contrasting Traits
1.	Stem height	Tall/Dwarf
2.	Flower colour	Violet/White
3.	Flower position	Axial/Terminal
4.	Pod shape	Inflated/Constricted
5.	Pod colour	Green/Yellow.
6.	Seed shape	Round/Wrinkled
7.	Seed colour	Yellow/Green

3 INHERITANCE OF ONE GENE

- Mendel found that F_1 always resembled either of the parents, but in F_2 (produced by selfing F_1) both traits appeared; $3/4^{th}$ showed the dominant trait and $1/4^{th}$ the recessive.
- Both traits were identical to their parental type and did not show any blending, i.e. none were of INTERMEDIATE type.
- Mendel got similar results for all traits.
- To determine the genotype of dominant trait at F_2, Mendel performed test cross.

3-A. BASED ON MONOHYBRID CROSS, MENDEL PROPOSED TWO GENERAL RULES

- **LAW OF DOMINANCE:** Explains the expression of only one parental character in F_1 of monohybrid cross and both F_2. It also explains the proportion of 3 : 1 obtained at the F_2.
- **LAW OF SEGREGATION:** The factors or alleles of a pair segregate from each other such that gametes receive only one of the two factors.

4 INCOMPLETE DOMINANCE

- F_1 did not resemble either of the parents and was in between the two. Seen in Dog flower (Snapdragon or *Antirrhinum* sp.)

  In this case:

  RR = has red flowers., rr = has white flowers.

  But Rr has pink flowers.
- Here Genotypic ratio at F_2 is like Mendelian monohybrid cross 1 : 2 : 1 but phenotypic ratio changed from 3 : 1 (to 1 : 2 : 1)

5 EXPLANATION OF CONCEPT OF DOMINANCE

In diploid organisms, there are two copies of each gene, i.e., a pair of alleles. One of them may be different, i.e., modified.

(i) The normal allele produces normal enzyme needed for transformation of substrate.

(ii) If, the modified allele produces normal/less efficient enzyme, which produces same phenotype/trait, it is dominant, but if it produces non-functional or no enzyme, the phenotype will be affected and recessive trait is seen.

'Factors' or genes are the units of inheritance. They contain information required to express a particular trait in an organism

British geneticist R.C Punnett developed a graphical representation call Punnett square to calculate possibility of all possible genotype of offsprings in a genetic cross

6 CO-DOMINANCE

- F_1 resembles both parents.
- ABO blood group in human being is controlled by Gene-I, having three alleles I^A, I^B and i. I^A and I^B produce slightly different form of sugar, while i does not produce any sugar.
- I^A and I^B are completely dominant over i, but when I^A & I^B are present together, they express their own sugars, because of Co-Dominance hence RBC have both sugars.
- There are six genotypes and four phenotypes in human ABO blood types.

7 PLEIOTROPY

A single gene can exhibit multiple phenotypic expression. It is the effect of a gene on metabolic pathways which contribute towards different phenotypes.

Example:

(a) Phenylketonuria (Single gene) → 1. Mental retardation; 2. Reduction in hair & skin pigmentation

(b) Starch Synthesis gene in pea-(B) → 1. Seed Shape **(Dominance)**; 2. Size of strach grain

(Incomplete dominance)

	Size	Shape
BB	Large grains	Round
Bb	Intermediate sized grains	Round
bb	Small grains	Wrinkled

8 MULTIPLE ALLELES

- More than two alleles governing the same character.
- ABO blood grouping is a very good example of multiple alleles. Since in an individual only two alleles are present, multiple alleles can be found only in population studies.

9 INHERITANCE OF TWO GENES

- Mendel also worked and crossed pea plants that differed into two characters and got a phenotypic ratio of 9 : 3 : 3 : 1 and genotype ratio of 1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1.
- Based on these DIHYBRID CROSSES Mendel proposed the:

LAW OF INDEPENDENT ASSORTMENT

The law states that when two pairs of traits are combined in a hybrid, segregation of one pair of characters is independent of the other pair of characters.

10 CHROMOSOMAL THEORY OF INHERITANCE

- **Walter Sutton & Theodore Boveri** noted that the behaviour of chromosomes was parallel to behaviour of genes and they used chromosome movement to explain Mendel's Laws.
- Sutton united the knowledge of chromosomal segregation with Mendelian principles and called it chromosomal theory of inheritance.
- Experimental verification was done by T.H. Morgan, who worked with fruit flies *Drosophila melanogaster*.

11 *DROSOPHILA MELANOGASTER* WERE SUITABLE FOR GENETIC STUDIES

- They could be grown on simple synthetic medium in laboratory.
- They complete their life cycle in about two weeks.
- A single mating could produce a large number of progeny flies
- There is a clear differentiation of sexes.
- Also, it has many types of hereditary variations that can be seen with low power microscopes.

12 LINKAGE AND RECOMBINATION

- Morgan carried out several dihybrid crosses in *Drosophila* to study genes that were sex-linked, similar to the dihybrid crosses of Mendel in peas.
- But the F_2 ratios deviated significantly from 9 : 3 : 3 : 1 (expected when the two genes are independent).
- When two genes in a dihybrid cross were situated on the same chromosome, the proportion of **parental gene combinations** were much higher than **non-parental type**. Morgan attributes it to physical association or linkage of two genes and used term recombination to describe non-parental gene combinations.
- Some genes were very-tightly linked **(Showed very low recombinations)**, while others were loosely linked **(Showed higher recombinations).**
- Morgan's student Alfred Sturtevant used frequency of recombination between genes on same chromosome as a measure of distance between genes and mapped their position on chromosomes.

  Today GENETIC MAPS are extensively used as a starting point in sequencing whole genomes as done in case of Human Genome Project.

13 POLYGENIC INHERITANCE

- Traits controlled by three or more genes are polygenic traits. It also takes into account influence of environment.
- The phenotype reflects the contribution of each allele, i.e., the effect of each allele is ADDITIVE.

E.g., Human Skin Colour

- AABBCC has darkest skin colour; aabbcc has lightest and AaBbCc intermediate colour. Other example is height in Humans.

14 SEX-DETERMINATION

GENETIC/CHROMOSOMAL BASIS

- Initial clue came from Insects. The X-body of Henking was in fact x-chromosome

TYPES

(a) XO-Type = Male heterogamety
e.g. = Grasshopper

(b) XY-Type = Male heterogamety
e.g. = Insects, Man

(c) ZW-Type = Female heterogamety
e.g. = Birds

SEX-DETERMINATION IN HUMANS

- Genetic make-up of SPERM determines sex of the child and in each pregnancy there is always 50% probability of a male or female child.
- It is unfortunate that in our society females are blamed for giving birth to female children.

SEX-DETERMINATION IN HONEY BEE

- Haplo-diploid sex-determination
- Unfertilised egg develops as male (drone) i.e. haploid; queen & worker bees (females) are diploid.

15 MUTATION

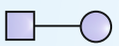
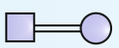
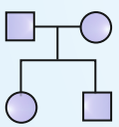
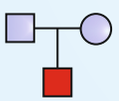
- Results in alteration of DNA sequences and consequently results in changes in the genotype and the phenotype of an organism.
- Loss (deletions) or gain (insertion/duplication) of a segment of DNA result in chromosome alteration.
- Alteration in chromosomes result in abnormalities or aberrations. Chromosomal aberrations are commonly observed in cancer cells.
- Mutations also arise due to change in a single base pair of DNA, known as point mutation; eg: Sickle-cell anemia.
- Deletions and insertions of base pairs of DNA causes frame-shift mutations.
- Chemical and physical factors that induce mutations are called mutagens.

  E.g UV radiations can cause mutations in organisms

16 GENETIC DISORDERS

PEDIGREE ANALYSIS

- Controlled crosses are not possible in case of human beings. Study of family history about inheritance of a particular trait provides an alternative. Such analysis in several generations of a family is called pedigree-analysis.

SYMBOLS USED IN THE HUMAN PEDIGREE ANALYSIS	
	Male
	female
	sex unspecified
	affected indviduals
	mating
	mating between relatives (consanguineous mating)
	parents above and children below
	parents with male child affected with diseases
	five unaffected offspring

MENDELIAN DISORDERS

- Mainly determined by alteration or mutation in a single gene.
- It may be dominant or recessive. Autosomal or Sex-linked.

Examples:

(1) **Colour-blindness**
- Sex-linked recessive.
- Due to defect in either red or green cone of eye due to mutation in certain genes present on X-Chromosome
- **8% of males & only about 0.4% of females affected.**

(2) **Haemophilia**
- X-linked recessive
- A single protein that is part of cascade of proteins involved in blood clotting is affected.

(3) **Sickle-Cell anaemia**
- Autosome linked recessive
- Controlled by single pair of allele Hb^A and Hb^S.

(4) **Phenylketonuria**
- Inborn error in metabolism. Autosomal recessive. Affected individual lack enzyme which converts phenylalanine to tyrosine. Results in mental retardation.

(5) **Thalassemia**
- Autosomal recessive, could be due to mutation or deletion.
- **α-thalassemia:** Controlled by two closely linked genes HBA1 and HBA2 on Chr-16.
- **β-Thalassemia:** controlled by single gene HBB on Chr-11.

CHROMOSOMAL DISORDERS

- Caused due to absence or excess or abnormal arrangement of one or more chromosomes.
- Failure of segregation of chromatids during cell-division cycle resulting in gain or loss of a chromosome(s), is called ANEUPLOIDY.
- Failure of Cytokinesis after telophase stage of cell division results in an increase in a whole set of chromosomes in an organism, this is called POLYPLOIDY, **often seen in plants.**
- TRISOMY or MONOSOMY leads to very serious consequences in the individual.

Common examples of chromosomal disorders.

(I) **Down's Syndrome:** Trisomy of 21; was first described by Langdon Down (1866).

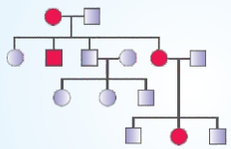
Symptoms:
i) Short Statured
ii) Small round head.
iii) Furrowed tongue
iv) Partially open mouth.
v) Palm is broad with palm crease
vi) Physical, psychomotor & mental development is retarded.

(ii) **Klinefelter's Syndrome:** Karyotype = 47 xxy, overall masculine development, however GYNAECOMASTIA is also expressed. Such individuals are sterile.

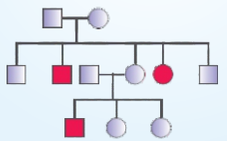
(iii) **Turner's Syndrome:** Due to absence of one of the X-chromosomes, i.e., 45 with XO. Such females are sterile as ovaries are rudimentary besides lack of other secondary sexual characters.

Pedigree analysis of
(a) Autosomal dominant trait (e.g., Myotonic dystrophy)
(b) Autosomal recessive trait (e.g., sickle-cell anaemia)

(a)



(b)



- T.H. Morgan found that in *Drosophila* the genes for yellow body and white eye were very tightly linked and showed only 1.3% recombination, while white eye and miniature wing showed 37.2% recombination.
- In Honeybee, males produce sperms by mitosis, they do not have father and thus cannot have sons, but have grand-fathers and can have grandsons.
- Cystic fibrosis is autosomal recessive disorder.
- Chromosomal disorders can be easily studied by the analysis of KARYOTYPES.
- Inheritable mutations can be studied by generating a pedigree of a family.
- The family pedigree of Queen Victoria shows a number of haemophilic descendents as she was a carrier of the disease.
- Thalassemia differs from sickle-cell anaemia in that the former is a quantitative problem of synthesising too few globin molecules while the latter is a qualitative problem of synthesising an incorrectly functioning globin.

Sharpen Your Understanding

1. The degree by which progeny differ from their parents is called: [NCERT Pg. 69]
   (1) Heredity (2) Inheritance
   (3) Siblings (4) Variation
2. The process by which characters are passed on from parent to progeny is called: [NCERT Pg. 69]
   (1) Inheritance (2) Variation
   (3) Offspring (4) Character
3. Gregor Mendel, conducted hybridisation experiments on garden peas for seven years between [NCERT Pg. 70]
   (1) 1900 – 1907 (2) 1956 – 1963
   (3) 1856 – 1863 (4) 1756 – 1763
4. Mendel selected how many true – breeding pea plant varieties, as pairs which were similar except for one character with contrasting traits: [NCERT Pg. 70]
   (1) 7 varieties (2) 14 varieties
   (3) 12 varieties (4) 10 varieties
5. Slightly different forms of the same gene is called: [NCERT Pg. 72]
   (1) Factors
   (2) Homozygous
   (3) Heterozygous
   (4) Alleles
6. To determine the genotype of a tall plant of F_2, Mendel crossed it with a dwarf plant. This is called a: [NCERT Pg. 74]
   (1) Test cross
   (2) Monohybrid cross
   (3) Self cross
   (4) Out cross
7. In a true breeding pea variety the allelic pair of genes are: [NCERT Pg. 72]
   (1) Heterozygous (2) Homozygous
   (3) Monohybrid (4) Non-identical
8. The inheritance of flower colour in the dog flower/snapdragon or *Antirrhinum* is a good example of: [NCERT Pg. 76]
   (1) Incomplete dominance
   (2) Dominance
   (3) Co-Dominance
   (4) Qualitative inheritance
9. The human ABO blood types, show a total of: [NCERT Pg. 77]
   (1) 4 different genotypes & 6 phenotypes
   (2) 6 different genotypes & 6 phenotypes
   (3) 4 different genotypes & 4 phenotypes
   (4) 6 different genotypes & 4 phenotypes
10. Experimental verification of the chromosomal theory of inheritance was done by: [NCERT Pg. 83]
    (1) Thomas Hunt Morgan
    (2) Walter Sutton
    (3) Theodor Boveri
    (4) Gregor Mendel

NCERT Based MCQs

11. Instances where a single gene can exhibit multiple phenotypic expression, is called: [NCERT Pg. 85]
    (1) Pleiotropy
    (2) Incomplete dominance
    (3) Complete dominance
    (4) Co-dominance
12. XO-type of sex-determination is seen in: [NCERT Pg. 86]
    (1) Birds (2) Human beings
    (3) Grasshopper (4) *Drosophila*
13. In haplodiploid sex-determination system as seen in honey bee: [NCERT Pg. 87]
    (1) Males produce sperms by meiosis
    (2) Males do have father and thus can have sons.
    (3) Unfertilised egg develops as a male (drone) by means of parthenogenesis
    (4) Females are mostly haploid
14. Chromosomal aberrations are commonly observed in: [NCERT Pg. 88]
    (1) Cancer cells
    (2) Only autosomes
    (3) Only sex-chromosomes
    (4) Only germ cells

15. Select the **odd** one out w.r.t. example of Mendelian disorder? [NCERT Pg. 89]

(1) Cystic fibrosis

(2) Sickle-cell anaemia

(3) Haemophilia

(4) Down's syndrome

16. Which of the following statement is **incorrect** w.r.t. sickle-cell anaemia? [NCERT Pg. 90-91]

(1) Substitution of amino acid in the globin protein results due to single base substitution at the sixth codon of the beta globin gene from GAG to GUG.

(2) The defect is caused by the substitution of valine (val) by glutamic acid (Glu).

(3) The mutant haemoglobin molecule undergoes polymerization under low oxygen tension.

(4) Shape of RBC change from biconcave disc to elongated sickle like structure.

17. α-thalassemia is controlled by: [NCERT Pg. 91]

(1) two closely linked genes HBA1 and HBA2.

(2) a single gene HBB.

(3) genes present on Chr-11

(4) glutamic acid

18. Failure of segregation of chromatids during cell-division cycle results in the gain or loss of chromosome called: [NCERT Pg. 91]

(1) Polyploidy (2) Aneuploidy

(3) Point mutation (4) Recombination

19. Females are sterile as ovaries are rudimentary besides lack of other secondary sexual characters in: [NCERT 92]

(1) Down's syndrome

(2) Klinefelter's syndrome

(3) Turner's syndrome

(4) Cystic fibrosis

20. Overall masculine development, with gynaecomastia is seen in the case of: [NCERT Pg. 92]

(1) Turner's syndrome

(2) Thalassemia

(3) Klinefelter's syndrome

(4) Haemophilia

Thinking in Context

1. Humans knew from as early as 8000-1000 B.C. that one of the causes of variation was hidden in _____. [NCERT Pg. 69]
2. A true-breeding line is one that, having undergone continuous self-pollination shows _____ and expression for several generations. [NCERT Pg. 70]
3. During Mendel's investigations into inheritance patterns it was for the first time that _____ were applied to problems in Biology. [NCERT Pg. 70]
4. TT and tt are called the __A__ of the plant while, descriptive terms tall and dwarf are the __B__. [NCERT Pg. 72]
5. The production of gametes by the parents, the formation of the zygotes, the F_1 and F_2 plants can be understood from a diagram called _____. [NCERT Pg. 73]
6. Tt plant is heterozygous for genes controlling one character (height), it is a _____. [NCERT Pg. 73]
7. In case of _____ the F_1 generation resembles both parents. [NCERT Pg. 77]
8. Since in an individual only two alleles can be present, multiple alleles can be found only when _____ studies are made. [NCERT Pg. 78]
9. In 1900, three scientists _____, _____& _____ independently rediscovered Mendel's results on the inheritance of characters. [NCERT Pg. 81]

10. _____ united the knowledge of chromosomal segregation with Mendelian principles and called it the chromosomal theory of inheritance. [NCERT Pg. 83]

11. Today _____ are extensively used as a starting point in the sequencing of whole genomes. [NCERT Pg. 83-84]

12. Phenylalanine is accumulated and converted into phenylpyruvic acid and other derivatives. Accumulation of these in brain results in mental retardation in case of the autosomal recessive trait called _____. [NCERT Pg. 91]

13. Besides the involvement of multiple genes polygenic inheritance also takes into account the _____. [NCERT Pg. 85]

14. 'X-body' of Henking was in fact a chromosome and that is why it was given the name _____. [NCERT Pg. 85-86]

15. The sex determination in honeybee is based on _____ of chromosomes an individual receives. [NCERT Pg. 87]

16. _____ cause mutations in organisms as it is a mutagen. [NCERT Pg. 88]

17. Mutations arise due to change in a single base pair of DNA. This is known as _____. [NCERT Pg. 88]

❑ ❑ ❑

18. Colour blindness is due to mutation in certain genes present in the _____. [NCERT Pg. 89]

19. The family of queen Victoria shows a number of haemophilic descendants as she was a _____ of the disease. [NCERT Pg. 90]

20. Thalassemia differs from sickle-cell anaemia in that the former is a __A__ problem of synthesizing too few globin molecules while the latter is a __B__ problem of synthesizing an incorrectly functioning globin. [NCERT Pg. 91]

Molecular Basis of Inheritance

4 Chapter

1 INTRODUCTION

- Deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) are two types of nucleic acid found in living systems. DNA acts as the genetic material in most of the organisms. RNA though it acts as a genetic material in some viruses, like TMV, QB-bacteriophage but mostly functions as a messenger, adaptor, structural and catalytic molecule.

2 THE DNA

- DNA is a long polymer of deoxyribonucleotides. The length of DNA usually defined as number of nucleotides, is also characteristic of an organism.

ORGANISM	DNA CONTENT
1. Bacteriophage $\phi \times 174$	5386 Nucleotides
2. Bacteriophage lambda	48502 base pairs
3. *Escherichia coli*	4.6×10^6 base pairs
4. Haploid content of human DNA	3.3×10^9 base pairs

Structure of Polynucleotide Chain

- The basic unit of a polynucleotide (DNA or RNA) is NUCLEOTIDE – which has 3 components.
  - (i) A Nitrogenous base — PURINES = A (Adenine) and G (Guanine); PYRIMIDINES = C (Cytosine), T (Thymine) and U (Uracil)
  - (ii) A Pentose sugar — RIBOSE (In RNA); 2-DEOXYRIBOSE (in DNA)
  - (iii) A Phosphate group
- Purines are same in DNA and RNA, cytosine is common to both DNA and RNA, Uracil is present in RNA, Thymine (5-methyl uracil) in DNA
- A nitrogenous base is linked to the OH of 1′C pentose sugar through a N-glycosidic linkage to form a **NUCLEOSIDE**
- When a phosphate group is linked to OH of 5′C of a nucleoside through phosphoester linkage, a corresponding NUCLEOTIDE is formed.
- Two nucleotides are linked through 3′-5′ phosphodiester linkage to form a DINUCLEOTIDE. More nucleotides in such a manner form polynucleotide.
- A polymer thus formed has at one end a free phosphate moiety at -5′- end of sugar and at the other end of polymer the sugar has a free OH of 3′ C group

3 DNA-DOUBLE HELIX

- DNA as an acidic substance present in nucleus was first identified by Friedrich Miescher in 1969, named it as "Nuclein'.
- Based on the X-ray diffraction data produced by Maurice Wilkins and Rosalind Franklin, James Watson and Francis Crick proposed a very simple but famous double helix model of DNA in 1953.
- One hallmark of the helix is base pairing between the two strands. Based on the observation of Erwin Chargaff that for a double stranded DNA, the ratios between A and T and G and C are constant and equals one. The base-pairing confers COMPLEMENTARITY, a unique property to the polynucleotide chain.
- So, if each strand of parental DNA, acts as a template for synthesis of a new strand, the two double stranded daughter DNA produced would be identical to the parental DNA molecule.

Salient Features of Double-helix of DNA

- Made of two polypeptide chains, where the backbone is constituted by sugar - phosphate and bases project inside.
- Two chains have anti-parallel polarity, one chain 5′ → 3′, the other 3′ → 5′
- Bases in two strands are paired through hydrogen bonds, forming base pairs. (A = T and C ≡ G). This generates approximately uniform distance between the two strands.
- The two chains are coiled in a right handed fashion.
- Pitch of the helix = 3.4 nm. Roughly 10 bp in each turn. So, distance between a bp in a helix is approx. 0.34 nm. (0.34×10^{-9} m)
- The plane of one base pair stacks over the other in double-helix. This in addition to H-bonds, confers stability to the helical structure.

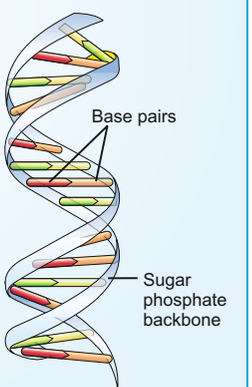


Fig. : DNA double helix.

4 CENTRAL DOGMA OF MOLECULAR BIOLOGY : Proposed by FRANCIS CRICK.

- States flow of genetic information as DNA → RNA → Protein

DNA (Replication) —TRANSCRIPTION→ mRNA —TRANSLATION→ Protein

In some viruses the flow of information is in reverse direction, i.e. from RNA to DNA. It is called reverse of central dogma.

5 PACKAGING OF DNA HELIX

- DNA double helix in a typical mammalian cell is 6.6×10^9 bp, the length is approx 2.2 m (6.6×10^9 bp $\times$ 0.34×10^{-9} m/bp), far greater than the dimension of a typical nucleus (approx 10^{-6}m)
- In prokaryote (*E. coli*), the DNA being negatively charged is held with some proteins that have positive charges in the 'NUCLEOID'. The DNA in nucleoid is organised in large loops held by proteins.

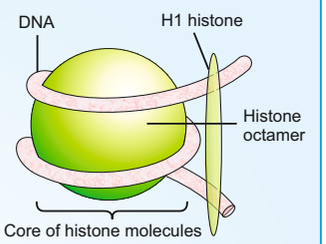


Fig.: Nucleosome

- In eukaryotes, it is much more complex.
  (i) The positively charged set of basic proteins, HISTONES (rich in lysine and arginine) are organised to form a unit of eight molecules, called **HISTONE OCTAMER**
  (ii) The negatively charged DNA is wrapped around positively charged histone octamer to form a nucleosome. A typical nucleosome contains 200 bp of DNA helix.
- Nucleosomes constitute the repeating unit of a structure in nucleus called CHROMATIN, thread like stained bodies seen in nucleus. The nucleosomes in chromatin are seen as 'beads - on - string' structure under electron microscope. It is packaged to form chromatin fibers that are further coiled and condensed at metaphase stage to form chromosomes.
- Packaging of chromatin at higher level needs non-histone chromosomal (NHC) proteins.

In a typical NUCLEUS (regions of chromatin)

EUCHROMATIN	HETEROCHROMATIN
1. Loosely packed.	1. More densely packed
2. Stains light	2. Stains dark
3. Transcriptionally active	3. Transcriptionally inactive

6 THE SEARCH FOR GENETIC MATERIAL

Transforming Principle

- In 1928, Frederick Griffith, in a series of experiments with *Streptococcus pneumoniae*, witnessed a miraculous transformation in Bacteria.
- Some of these bacteria produce smooth shiny colonies (S) while others rough colonies (R). S-strain kills mice (virulent) while R-strain do not develop pneumonia. But heat killed S-strain are also non-virulent. When heat killed S and live R bacteria were injected in mice, the mice died and S-strain living bacteria were found in dead mice. Griffith concluded that R-strain was somehow transformed by heat-killed S - strain. It must be due to the transfer of genetic material (transforming principle). But the biochemical nature was not defined.

Biochemical Nature of Transforming Principle

- Oswald Avery, Colin MacLeod and Maclyn McCarty (1933-44) discovered that DNA of S bacteria caused R bacteria to become transformed. As proteases and RNAses did not affect transformation, but DNAse inhibit transformation. They concluded that DNA is the hereditary material. But not all biologists were convinced.

The Genetic Material is DNA

- The UNEQUIVOCAL proof that DNA is the genetic material came from the experiments of Alfred Hershey and Martha Chase (1952), on bacteriophages, using radioactive phosphorus ^{32}P and sulphur ^{35}S in separate medium, with *E. coli*.

7 PROPERTIES OF GENETIC MATERIAL (DNA VERSUS RNA)

A molecule that can act as a genetic material must fulfill the following criteria:
(i) Should be able to generate its replica (Replication)
(ii) Should be stable chemically and structurally
(iii) Should provide the scope for slow mutation required for evolution.
(iv) Should be able to express in the form of Mendelian characters.

- Both DNA and RNA can direct their duplications.
- The DNA has two complementary strands, if separted by heating can again come together when appropriate conditions are provided.
- 2′-OH group present at every nucleotide in RNA is reactive and makes it easily degradable.
- RNA is also catalytic, hence reactive. Among the two nucleic acids, DNA is a better genetic material.
- Presence of thymine at the place of uracil also confers additional stability to DNA
- Both DNA and RNA are able to mutate. Being unstable RNA mutate at a faster rate.
- RNA can directly code for the synthesis of proteins and can easily express the characters. DNA, however is dependent on RNA for synthesis of proteins.
- DNA being more stable is preferred for storage of genetic information. For transmission of genetic information RNA is better.

8 RNA WORLD

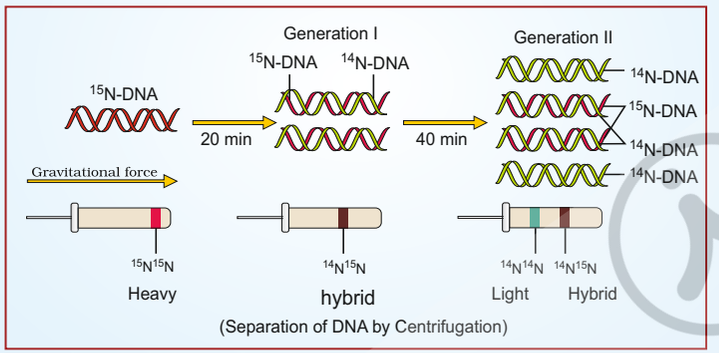
RNA was the first genetic material. The essential life processes like metabolism, translation, splicing evolved around RNA. RNA used to act as a genetic material as well as a catalyst, so was reactive and hence unstable. Therefore, DNA has evolved from RNA with chemical modifications that make it more stable.

9 REPLICATION

Watson and Crick had immediately proposed a scheme for replication of DNA while proposing the double helix structure of DNA, i.e., the two strands would separate and act as a template for the synthesis of new complementary strands. After completion of replication each DNA molecule would have one parental and one newly synthesised strand, termed as semi-conservative DNA replication

10 EXPERIMENTAL PROOF

- Semiconservative DNA replication was shown first in *Escherichia coli*, then in higher organisms like plants and human cells.
- Matthew Meselson and Franklin Stahl, performed the experiment (1958) using normal ^{14}N and non-radioactive ^{15}N isotope of Nitrogen as source of NH_4Cl, and centrifugation in a cesium chloride (CsCl) density gradient. The various samples were separated independently on CsCl gradients to measure the densities of DNA. (*E. coli* divides every 20 minutes)



- Taylor and colleagues (1958) used radioactive thymidine and *Vicia faba* (Faba beans), to prove that DNA in chromosomes also replicate semi-conservatively.

11 THE MACHINERY AND THE ENZYMES

- *E. coli* completes replication in 18 minutes. The average rate of polymerisation is 2000 bp/sec.
- Energetically replication is a very expensive process.

Deoxyribo nucleoside triphosphates — Serve — (1) Act as substrate; Dual purpose — (2) Provide energy for polymerisation

- Replication occur within a small opening of DNA helix called replication fork.

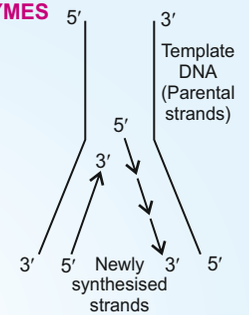


Fig: Replicating Fork

- DNA-dependent DNA polymerase (main enzyme) catalyses the polymerisation process in 5′ → 3′ direction, so on one strand (template with polarity 3′ → 5′) replication is continuous, while on other (template with polarity 5′ → 3′) it is dis-continuous.
- Discontinuously synthesised fragments are later joined by DNA ligase.
- There is a definite region in *E. coli* DNA where replication originates is termed ori-site (origin of replication).
- During recombinant DNA procedures, requires a vector, which provide origin of replication.
- In eukaryotes, replication of DNA takes place at S-phase of the cell-cycle. Replication of DNA and cell-division cycle should be highly co-ordinated. A failure in cell-division after DNA replication results in POLYPLOIDY (Chromosomal anomaly)

12 TRANSCRIPTION

- It is process of copying genetic information from one strand of DNA into RNA.
- Principle of complementarity governs transcription (except, adenosine forms pair with uracil instead of thymine). In transcription only a segment of DNA and only one of the two strands is copied into RNA. Otherwise, one segment of DNA would be coding for two different proteins. Also, the two RNA molecules if produced simultaneously would be complementary to each other, hence would form a double stranded RNA. This would prevent translation.

TRANSCRIPTION UNIT : A transcription unit in DNA primarily has three regions

(i) A promoter
(ii) The structural gene
(iii) A terminator

- The DNA-dependent RNA polymerase catalyses polymerisation in only one direction 5′ → 3′. The strand that has polarity 3′ → 5′ act as a template. The other strand with polarity 5′ → 3′ and the sequence same as RNA (except thymine at place of uracil), is referred to as coding strand.

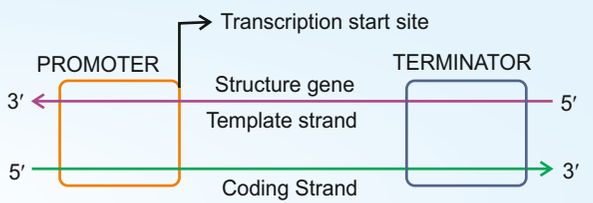


Fig: A transcription Unit

- Promoter is located towards 5′-end (upstream) of structural gene (in reference to coding strand). It provides binding site for RNA polymerase.
- Terminator is located towards 3′-end (downstream) of coding strands and defines end of transcription.

13 TRANSCRIPTION UNIT AND THE GENE

- Genes are located on the DNA which is functional unit of inheritance. DNA sequence coding for tRNA or rRNA also define a gene.
- Cistron is defined as a segment of DNA coding for polypeptide.
- The structural gene is monocistronic (mostly in Eukaryotes) or polycistronic (mostly in bacteria or prokaryotes). In Eukaryote genes are split between coding sequences or EXONS, which appear in mature RNA and INTRONS or intervening sequence. The split gene arrangement further complicates the definition of a gene in terms of a DNA segment. Regulatory sequences are defined as regulatory genes, even though they do not code for any RNA or protein.

TYPES OF RNA AND THE PROCESS OF TRANSCRIPTION

- A single DNA dependent RNA polymerase catalyses transcription of all three types of RNA (mRNA, tRNA, rRNA) in bacteria.
- RNA polymerase binds to promoter and initiates transcription. It uses nucleoside triphosphates as substrate and polymerises in a template depended fashion following the rule of complementarity. It somehow also facilitates opening of the helix and continues elongation.
- Only a short stretch of RNA remains bound to the enzyme. Once the polymerase reaches the terminator region, the nascent RNA and RNA polymerase falls off. This results in termination of transcription.
- RNA polymerase is only capable of catalysing the elongation process. It associates transiently with initiation factor (σ) and termination factor (ρ) to initiate and terminate the transcription respectively.
- In bacteria, mRNA does not require any processing, so transcription and translation are coupled. In Eukaryotes, there are two additional complexities.

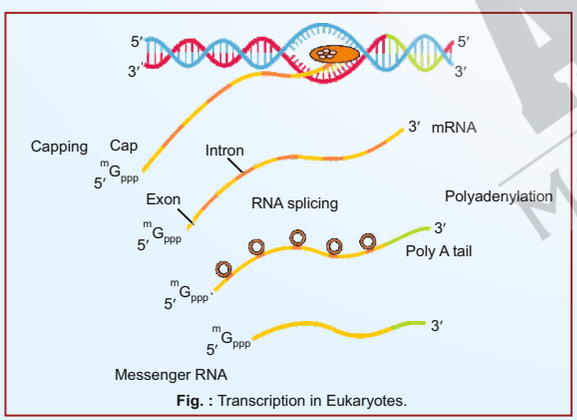


Fig. : Transcription in Eukaryotes.

- There are at least three RNA polymerase in the nucleus (in addition to RNA polymerase found in organelles) and a clear cut division of labour.

ENZYME	FUNCTIONS
1. RNA pol-I	Transcribes 28S, 5.8S and 18S rRNA
2. RNA pol-II	Transcribes mRNA precursor i.e. hn-RNA
3. RNA pol-III	Transcribes 5S rRNA, tRNA and Sn RNAs

- The primary transcript (hn RNA) is subjected to SPLICING, where INTRONS are removed and EXONS are joined in a defined order. hn-RNA undergoes additional processing called capping and tailing to form mRNA. In CAPPING an unusual nucleotide (methyl guanosine triphosphate) is added to 5′ -end of hn RNA. In TAILING, adenylate residues (200-300) are added to 3′-end in a template independent manner. Fully processed hn-RNA is called m-RNA that is transported out of the nucleus for TRANSLATION. The split-gene arrangement represent probably an ancient feature of the genome. The presence of introns is reminiscent of antiquity, and the process of splicing represents the dominance of RNA-world.

14 GENETIC CODE

- George Gamow, suggested, that the genetic code should be triplet.
- Chemical method developed by Har Gobind Khorana was instrumental in synthesising RNA molecules with defined combinations of bases. Marshall Nirenberg's cell-free system for protein synthesis finally helped the code to be deciphered. Severo Ochoa enzyme (Polynucleotide phosphorylase) was helpful in polymerising RNA with defined sequences in a template independent manner (enzymatic synthesis of RNA)

Salient Features of Genetic Code :

- The codon is Triplet. 61 codons code for amino acids and 3 codons are stop codons.
- The code is DEGENERATE, i.e., some amino acids are coded by more than one codon.
- The codon is read on mRNA in contiguous fashion i.e., there are no punctuations.
- The code is nearly universal. (eg : UUU codes for phenylalanine from bacteria to humans). Exception = some variations have been found in mitochondrial codons and in some protozoans.
- AUG has dual function. It codes for methionine and act as initiator codon.
- UAA, UAG and UGA are stop terminator codons.

15 MUTATIONS AND GENETIC CODE

- Insertion or deletion of one or two bases changes the reading frame from the point of insertion or deletion and called frame shift mutations.
- Insertion or deletion of three or its multiple base, insert or delete in one or multiple codon hence one or multiple amino acids, and reading frame remains unaltered from that point onwards.

tRNA- the Adapter Molecule

- Francis Crick postulated the presence of an adapter molecule, that would read the code and bind to specific amino acid. The tRNA, then called sRNA (soluble RNA) was known before genetic code was postulated. tRNA has an anti-codon loop that has bases complementary to the code, and it also has an amino acid acceptor end to which it binds to amino acids. tRNAs are specific for each amino acid. For initiation, there is another specific tRNA that is called **initiator tRNA**. There are no tRNAs for stop codons.
- Secondary structure of tRNA looks like a cloverleaf, though the actual structure is a compact molecule which looks like inverted L.

16 TRANSLATION

- Translation refers to the process of polymerisation of amino-acids to form a polypeptide. The order and sequence of amino-acids are defined by the sequence of bases in the mRNA.
- In the first phase amino acids are activated in the presence of ATP and linked to their cognate tRNA by a process called **charging of tRNA,** or **aminoacylation of tRNA**. Protein synthesis takes place on the ribosomes.
- Ribosomes consist of structural RNAs and about 80 different proteins. It has two sub-units. When the small sub unit encounters an mRNA, the process of translation begins. There are two sites in the large subunit, for subsequent amino acids to bind and thus, be close enough to each other for the formation of a peptide bond by the catalyst (23 S rRNA in bacteria is the enzyme- ribozyme). Presence of catalyst would enhance the rate of peptide bond formation.
- A translational unit in mRNA is flanked by a start condon (AUG) and the stop codon. The untranslated additional sequence on mRNA are called untranslated regions, (UTRs), present at both 5′-end (before start codon) and at 3′- end (after stop codons). UTRs are required for efficient translation.
- The ribosome moves from codon to codon along the mRNA. Amino acids are added one by one and translated into polypeptide sequences. At the end, a release factor binds to the stop codon, terminating translation and releasing the complete polypeptide from the ribosome.

17 REGULATION OF GENE EXPRESSION

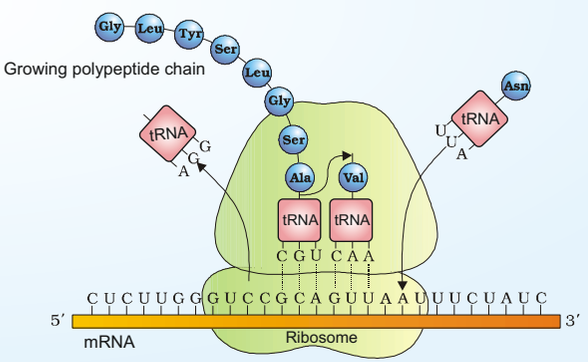
Gene expression results in formation of a polypeptide. It can be regulated at several levels. In Eukaryotes, the regulation could be exerted at

(i) Transcriptional level (Formation of primary transcript)
(ii) Processing level (Regulation of Splicing)
(iii) Transport of mRNA from nucleus to cytoplasm.
(iv) Translational level

- Metabolic, physiological or environmental conditions regulate expression of genes.
- Development and differentiation of embryo into adult organisms are also a result of the coordinated regulation of expression of several set of genes.
- In prokaryotes, control of the rate of transcriptional initiation is the predominant site for control of gene expression.

18 THE *Lac* OPERON

- Francois Jacob and Jacque Monod were the first to elucidate a transcriptionally regulated system, the *lac* operon (*lac* refers to lactose), a polycistronic structural gene regulated by a common promoter and regulatory gene, called operon.
- Lac operon consists of one regulatroy gene (i) and three structural genes (z, y and a). i gene (i refers inhibitor) codes for repressor, z-for β-galactosidase (β-gal), y-for permease and gene a codes for transacetylase. All three gene products in lac operon are needed for metabolism of lactose.
- Lactose is the substrate of β-galactosidase and it regulates switching on/off of operon, so called INDUCER. Regulation of *lac* operon is regulation of enzyme synthesis by its substrate.
- Regulation of *lac* operon by repressor is negative regulation however *lac* operon is under control of positive regulation as well.
- Regulatory proteins can act both positively (activators) and negatively (repressors).
- Each operon has its specific operator and specific repressor.



19 HUMAN GENOME PROJECT - (HGP)

- Launched in 1990, a 13 year project was co-ordinated by U.S. department of energy and National Institute of Health, Wellcome trust (UK), Japan, France, Germany, China participated. It was completed in 2003.
- Human genome has approx. 3×10^9 bp and the cost of sequencing in the beginning was US$3 per bp, i.e. 9 billion US dollars. HGP lead to the rapid development of a new area in biology called bioinformatics.
- Many non-human model organisms like bacteria, Yeast, *Caenorhabditis elegans*, *Drosophila,* plant (rice and *Arabidopsis*) have also been sequenced.

METHODOLOGIES :

- **Expressed sequence tags (ESTs):** Focused on identifying all genes that expressed as RNA.
- **Sequence annotation:** Blind approach of sequencing the whole genome containing coding and non coding sequences; needing vectors like BAC (Bacterial artificial chromosomes) and YAC (Yeast Artificial Chromosomes).

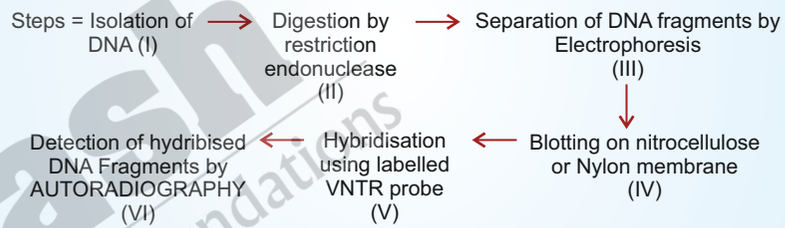
SALIENT FEATURES OF HUMAN GENOME :

- Human genome contains 3164.7 million bp. Average gene consist of 3000 bases.
- Largest gene DYSTROPHIN of 2.4 million bases. Total genes estimated at 30,000.
- Almost 99.9% nucleotide bases exactly same in all people. Functions unknown for 50% discovered genes. Less than 2% genome codes for protein. Chromosome 1 has most genes (2968) and Y-chromosome has the fewest (231).
- At 1.4 million locations single base DNA differences (SNPs - single nucleotide polymorphism, snips) occur. SNPs can help in tracing human history.

- The fragments were sequenced using automated DNA sequencer that worked on the principle of a method developed by Frederick Sanger.
- The sequence of chromosome-1 was completed only in May 2006. This was the last of the 24 human chromosomes (22 autosomes and X and Y) to be sequenced.

20 DNA FINGERPRINTING

- 99.9% base sequence among humans is same. 0.1% differences in sequence of DNA make every individual unique in their phenotype. DNA fingerprinting involves identifying difference in **repetitive DNA**, a small stretch of DNA repeated many times, called satellite DNA. Depending on base composition (A:T or G:C rich), length of segment and number of repetitive units, the satellite DNA is classified into micro-statellites and mini-satellites. They do not code for any proteins. They form large portion of human genome and show high degree of polymorphism and form the basis of DNA fingerprinting. Since DNA from every tissue (blood, hair-follicle, skin, bone, saliva, sperm), show same degree of polymorphism, they have forensic application.
- Polymorphisms are inheritable from parent to child so DNA finger printing solves paternity disputes.
- The technique of DNA finger printing was initially developed by Alec Jeffreys.



Significance

- VNTR are called min-statellite, a small DNA sequence arranged tandemly in many copies. The size of VNTR varies from 0.1 to 20 kb. So after hybridisation with VNTR probe, the autoradiogram gives many bands of differing sizes. These bands give a characteristic pattern for an individual DNA. It differs from individual to individual in a population except in MONOZYGOTIC twins.
- The sensitivity of the technique has been increased by use of polymerase chain reaction (PCR).

21

- The repressor of operon is synthesised (all the time-constitutively from the 'i' gene)
- A very low level of expression of *lac* operon has to be present in the cell all the time otherwise lactose cannot enter the cells. Lactose or allolactose is the inducer of lac operon. Glucose or galactose cannot act as inducers for lac operon.
- Allelic sequence variation has traditionally been described as a DNA polymorphism, if more than one variant (allele) at a locus occurs in human population with a frequency greater than 0.01.
- DNA fingerprinting has much wider application in determining population and genetic diversities. Currently, many different probes are used to generate DNA fingerprints.
- The hallmark of double-stranded helical structure of DNA is the hydrogen bonding between the bases from opposite strands.

Sharpen Your Understanding

1. What is the haploid content of DNA in a typical human cell? [NCERT Pg. 96]
   (1) 6.6×10^9 bp (2) 3.3×10^9 bp
   (3) 48502 bp (4) 4.6×10^6 bp
2. DNA as an acidic substance present in nucleus was first identified and named as 'Nuclein' by [NCERT Pg. 97]
   (1) Maurice Wilkins
   (2) Francis Crick
   (3) Friedrich Miescher
   (4) Rosalind Franklin
3. Who first observed that for a double stranded DNA, the ratios between Adenine and Thymine and Guanine and Cytosine are constant and equals one? [NCERT Pg. 97]
   (1) Erwin Chargaff (2) James Watson
   (3) Rosalind Franklin (4) Frederick Griffith
4. The distance between a base pair in a helix of DNA is approximately : [NCERT Pg. 97-98]
   (1) 3.4 nm (2) 0.34 nm
   (3) 34 nm (4) 20 nm
5. Who proposed the Central Dogma in molecular biology, which states that the genetic information flows from DNA → RNA → Protein? [NCERT Pg. 98]
   (1) James Watson (2) Maurice Wilkins
   (3) Francis Crick (4) Erwin Chargaff
6. Histones are rich is basic amino acid residues like [NCERT Pg. 99]
   (1) Cystine and arginine
   (2) Lysine and arginine
   (3) Alanine and Lysine
   (4) Serine and Lysine
7. In a typical nucleus, the Euchromatin is said to be [NCERT Pg. 100]
   (1) Densely packed
   (2) Transcriptionally inactive
   (3) Transcriptionally active
   (4) Darkly stained
8. Which of the following enzymes, inhibit transformation during the work of Oswald Avery; Colin MacLeod and Maclyn McCarty on the biochemical characterization of transforming principle? [NCERT Pg. 101]
   (1) Proteases (2) DNases
   (3) RNases (4) Lipases
9. The unequivocal proof that DNA is the genetic material came from the experiments of : [NCERT Pg. 101]
   (1) Alfred Hershey and Martha Chase
   (2) Frederick Griffith
   (3) Oswald Avery
   (4) MacLeod and McCarty

NCERT Based MCQs

10. Presence of which of the following nitrogenous bases, at the place of Uracil of RNA confers additional stability to DNA? [NCERT Pg. 103]
    (1) Cytosine (2) Thymine
    (3) Adenine (4) Guanine
11. Taylor and colleagues proved that the DNA in chromosomes of *Vicia faba* also replicate semi-conservatively using. [NCERT Pg. 106]
    (1) ^{15}N radio-isotope
    (2) P^{32} and S^{35} isotopes
    (3) CsCl gradients
    (4) Radioactive thymidine
12. The structural gene in a transcription unit in bacteria or prokaryotes is mostly [NCERT Pg. 109]
    (1) Monocistronic
    (2) Polycistronic
    (3) Intervening sequence
    (4) Exons and Introns
13. The precursor of mRNA, in the eukaryotes is transcribed by [NCERT Pg. 111]
    (1) DNA polymerase
    (2) RNA polymerase-I
    (3) RNA polymerase-II
    (4) RNA polymerase-III

14. Some amino acids are coded by more than one codon, hence the codon is said to be [NCERT Pg. 112]
(1) Universal (2) Triplet
(3) Non degenerate (4) Degenerate

15. A change of single base pair in the gene for beta globin chain that results in the change of amino acid residue glutamate to valine. It results into a diseased condition called as [NCERT Pg. 113]
(1) Sickle cell anemia (2) α-thalassemia
(3) β-thalassemia (4) Haemophilia

16. The secondary structure of tRNA looks like [NCERT Pg. 114]
(1) Inverted L
(2) A clover leaf
(3) A double helix
(4) Straight polypeptide chain

17. Which of the following is a ribozyme in bacteria for the formation of peptide bond? [NCERT Pg. 115]
(1) 28 S rRNA
(2) 5.8 S rRNA
(3) 23 S rRNA
(4) 16 S rRNA

18. Which of the following enzyme is primarily responsible for the hydrolysis of the disaccharide, lactose into its monomeric units galactose and glucose in the ***Lac* operon**? [NCERT Pg. 116]
(1) Beta-galactosidase
(2) Permease
(3) Transacetylase
(4) Tyrosinase

19. The blind approach of simply sequencing the whole set of genome that contained all the coding and non-coding sequence, and later assigning different regions in the sequence with functions is termed as [NCERT Pg. 119]
(1) Bioinformatics
(2) Sequence annotation
(3) EST approach
(4) Transcriptome method

20. Polymorphism, i.e., variation at the genetic level arises due to [NCERT Pg. 121]
(1) Repetitive DNA
(2) Satellite DNA
(3) Mutations
(4) Asexual reproduction

Thinking in Context

1. _____ is the basis of genetic mapping of human genome as well as of DNA fingerprinting. [NCERT Pg. 121]

2. The probability of polymorphism to be observed in non-coding DNA sequence would be _____ as mutations in these sequences may not have any immediate effect/impact in an individual's reproductive ability [NCERT Pg. 122]

3. The VNTR belongs to a class of Satellite DNA referred to as ____. [NCERT Pg. 122]

4. _____ is credited for developing method for determination of amino acid sequences in proteins. [NCERT Pg. 119]

5. HGP was closely associated with the rapid development of a new area in biology called _____ [NCERT Pg. 118]

6. The repressor of the Lac operon is synthesised all the time, i.e., _____ from the *i*-gene. [NCERT Pg. 117]

7. In prokaryotes, control of the rate of _____ is the predominant site for control of gene expression [NCERT Pg. 116]

8. In the first phase of translation itself amino acids are activated in the presence of ATP and linked to their cognate tRNA-a process commonly called as charging of tRNA or _____ to be more specific. [NCERT Pg. 114]

9. For initiation of translation, the ribosome binds to the mRNA at the start codon (AUG) that is recognized only by the _____ [NCERT Pg. 115]

10. _____ postulated the presence of an adapter molecule that would on one hand read the code and on other hand would bind to specific amino-acids. [NCERT Pg. 114]

11. Severo Ochoa enzyme _____ was helpful in polymerizing RNA with defined sequences in a template independent manner. [NCERT Pg. 112]

12. _____ had dual functions, it codes for Methionine, and it also act as initiator codon. [NCERT Pg. 112]

13. In _____, adenylate residues (200-300) are added at 3′ - end in a template independent manner. [NCERT Pg. 111]

14. Exons are said to be those sequence that appear in mature or _____. [NCERT Pg. 109]

15. It is because of the requirement of the _____ that a piece of DNA if needed to be propagated during recombinant DNA procedures, requires a vector. [NCERT Pg. 107]

16. The principle of _____ governs the process of transcription, except the adenosine complements now forms base pair with uracil instead of thymine. [NCERT Pg. 107]

❑ ❑ ❑

17. The heavy DNA molecule could be distinguished from the normal DNA by the centrifugation in a _____ density gradient. [NCERT Pg. 105]

18. DNA being more stable is preferred for _A_ of genetic information. For the _B_ of genetic information, RNA is better. [NCERT Pg. 104]

19. DNA being double stranded and having _____ further resists changes by evolving a process of repair. [NCERT Pg. 104]

20. Stability as one of the properties of genetic material was very evident in Griffiths, 'transforming principle' itself that heat, which killed the bacteria, at least did not destroy some of the properties of _____ [NCERT Pg. 103]

Strategies for Enhancement in Food Production

5 Chapter

1 INTRODUCTION

With ever-increasing population of the world, enhancement of food production is a major necessity. Biological principles as applied to animal husbandry and plant breeding have a major role in our efforts to increase food production. Several new techniques such as embryo transfer and tissue culture play vital role in enhancing food production.

2 PLANT BREEDING

- Green revolution was dependent to a large extent on plant breeding techniques for development of high yielding and disease resistant varieties in wheat, rice, maize etc.

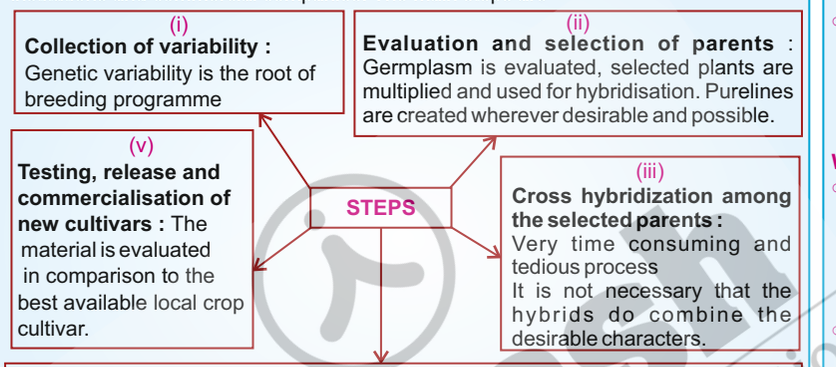
What is plant breeding?

- Plant breeding is the purposeful manipulation of plant species in order to create desired plant types that are better suited for cultivation, give better yields and are disease resistant.
- Today, all our major food crops are derived from domesticated varieties.
- Classical plant breeding involves crossing or hybridization of pure lines, followed by artificial selection to produce plants with desirable traits of higher yields, nutrition and resistant to diseases. With advancement in genetics, molecular biology and tissue culture, plant breeding is now increasingly being carried out by using molecular genetic tools.

Characters that breeders want to incorporate into the crops plants are increased crop yield, improved quality, increased tolerance to environmental stresses like salinity, drought, extreme temperature, resistance to pathogens and increased tolerance to insect pests.

3

Plant breeding programmes are carried out in systematic way worldwide in government institutions and commercial companies. The main steps are



The entire collection of plants/seeds having all the diverse alleles for all genes in a given crops is called germplasm collection.

5 PLANT BREEDING FOR DISEASE RESISTANCE

- Cultivars resistant to disease, enhance food production and also helps to reduce the dependence on use of fungicides and bacteriocides.
- **Method of breeding for disease resistance :** Breeding is carried out by the conventional breeding techniques or by mutation breeding.

Crop	Variety	Resistance to Disease
Wheat	Himgiri	Leaf and stripe rust, hill bunt
Brassica	Pusa Swarnim (Karan rai)	White rust
Cauliflower	Pusa Shubhra, Pusa Snowball K-1	Black rot and Curl blight black rot
Cowpea	Pusa Komal	Bacterial blight
Chilli	Pusa Sadabahar	Chilly mosaic virus, Tobacco mosaic virus and Leaf curl

Resistance of the host plant is the ability to prevent the pathogen from causing disease and is determined by the genetic constitution of the host plant

4

- Agriculture accounts for approximately 33 percent of India's GDP.
- The development of several high yielding varieties of wheat and rice in the mid 1960s, as a result of various plant breeding techniques led to dramatic increase in food production in our country. This phase is often referred to as the **Green Revolution**.

Wheat and Rice :

- During the period 1960 to 2000, wheat production increased from 11 million tonnes to 75 million tonnes while rice production went up from 35 million tonnes to 89.5 million tonnes. This was due to the development of semi-dwarf varieties of wheat and rice.
- Nobel laureate Norman E. Borlaug, at International Centre for Wheat and Maize Improvement in Mexico, developed semi-dwarf wheat.
- In 1963, several varieties such as Sonalika and Kalyan Sona, which were high yielding and disease resistant, were introduced all over the wheat-growing belt of India.
- Semi-dwarf rice varieties were derived from IR-8, (developed at International Rice Research Institute (IRRI), Philippines) and Taichung Native-1 (from Taiwan). The derivatives were introduced in 1966. Later better-yielding semidwarf rice varieties Jaya and Ratna were developed in India.

Sugarcane:

- *Saccharum barberi* was originally grown in north India, but had poor sugar content and yield. Tropical canes grown in south India *Saccharum officinarum* had thicker stems and higher sugar content but did not grow well in north India. These two species were success-fully crossed to get sugar cane varieties combining the desirable qualities of high yield, thick stems, high sugar content and ability to grow in the sugar cane areas of north India.

Millets:

- Hybrid maize, jowar and bajra have been successfully developed in India. Hybrid breeding have led to the development of several high yielding varieties resistant to water stress.

6

- Conventional breeding is often constrained by the availability of limited number of disease resistance genes that are present and identified in various crop varieties or wild relatives.
- Inducing mutations in plants through diverse means and then screening the plant materials for resistance sometimes leads to desirable genes being identified.
- It is possible to induce mutations artificially through use of chemicals or radiations and selecting and using the plants that have the desirable character as a source in breeding, this process is called mutation breeding.

In mung bean, resistance to yellow mosaic virus and powdery mildew were induced by mutations whereas in Bhindi (*Abelmoschus esculantus*) resistance to yellow mosaic virus was transferred from a wild species and resulted in a new variety of *Abelmoschus esculentus* called **Parbhani Kranti**.

7 PLANT BREEDING FOR DEVELOPING RESISTANCE TO INSECT PESTS

- Another major cause for large scale destruction of crop plant and crop produce is insect and pest infestation.
- Insect resistance in host crop plants may be due to morphological, biochemical or physiological characteristics.
- Source of resistance genes may be cultivated varieties, germplasm collections of the crop or wild relatives.

Crop	Resistance to insect/pest	Reason of resistance	Type of resistance
Wheat	Stem saw fly	Solid stem	Morphological
Wheat	Leaf beetle	Hairly leaves	Morphological
Cotton	Jassids	Hairly leaves	Morphological
Cotton	Bollworms	Smooth leaves and absence of nectar	Morphological and Biochemical
Maize	Stem borers	Low nitrogen, sugar and high aspartic acid	Biochemical

Some released crop varieties bred by hybridisation and selection for insect pest resistance are given below:

Crop	Variety	Insect Peststt
Brassica (rapeseed mustard)	Pusa Gaurav	Aphids
Flat bean	Pusa Sem 2, Pusa Sem 3	Jassids, aphids and fruit borer
Okra (Bhindi)	Pusa Sawani Pusa A-4	Shoot and Fruit borer

9 SINGLE CELL PROTEINS (SCP)

- More than 25 per cent of human population is suffering from hunger and malnutrition. One of the alternate sources of proteins for animal and human nutrition is single cell protein (SCP)
- Organisms / Microbes grown as a source of good protein are *Spirulina*, *Methylophilus methylotrophus*, mushrooms and some fungi.
- Microbes like *Spirulina* can be grown easily on waste water from potato processing plants, such utilisation reduces environmental pollution.

8 PLANT BREEDING FOR IMPROVED FOOD QUALITY

- More than 840 million people in the world do not have adequate food to meet their daily food and nutritional requirements. They suffer from hidden hunger .

Biofortification : Breeding crops with higher levels of vitamins and minerals, or higher protein and healthier fats – It is the most practical means to improved public health.

Biofortification is done with the objectives of improving

1. Proteins content and quality
2. Oil content and quality
3. Vitamin content and
4. Micronutrient and mineral content

- In 2000, maize hybrids that had twice the amount of the amino acids, lysine and tryptophan were developed. Wheat variety, Atlas 66 having a high protein content, has been used as a donor for improving cultivated wheat.
- IARI (Indian Agricultural Research Institute, New Delhi) has developed/released several vegetable crops that are rich in vitamins and minerals and proteins. e.g.

Vitamin A enriched carrots, spinach, pumpkin, vitamin C enriched bitter gourd, bathua, mustard, tomato. Iron and calcium enriched spinach and bathua and protein enriched beans (Broad, lablab and french) and garden peas.

10 TISSUE CULTURE

- As traditional breeding techniques failed to keep pace with demand and to provide sufficiently fast and efficient systems for crop improvement, another technology called tissue culture got developed.
- **Explant :** Any plant part taken out and grown in a test tube under sterile conditions in special nutrient media.
- The capacity to generate whole plant from explant is called **totipotency**.
- It is possible to achieve propagation of a large number of plants through tissue culture called micropropagation.
- Each of these plants will be genetically identical to the original plant from which they grown i.e. they are somaclones.
- Many important plants like tomato, banana, apple etc. have been produced on commercial scale by using this method.
- Another important application of the method is the recovery of healthy plants from diseased plants. Even if the plants is infected with the virus, the meristem is free of virus.
- Scientists have even isolated single cells from plants and after digesting their cell walls have been able to isolate naked protoplasts.
- Isolated protoplasts from two different varieties of plants can be fused to get hybrid protoplasts which can be further grown to form a new plant. These hybrids are called **somatic hybrids** while the process is called **somatic hybridization**.
- Protoplast hybrid of potato and tomato called pomato was created but unfortunately this plant did not have all the desired combination of characteristics for its commercial utilization.

One can remove the meristem and grow it *in vitro* to obtain virus free plants.

Sharpen Your Understanding

1. Classical plant breeding involves [NCERT Pg. 170]
   (1) Mutation breeding
   (2) Hybridisation or crossing of pure lines
   (3) Genetic engineering
   (4) Both (2) and (3)
2. All of the following are environmental stresses to plants, **except** [NCERT Pg. 170]
   (1) Salinity
   (2) Higher productivity
   (3) Extreme temperature
   (4) Drought
3. Which of the following is very time consuming and tedious process? [NCERT Pg. 171]
   (1) Evaluation and selection of parents
   (2) Cross hybridization among the selected parents
   (3) Testing of superior recombinants
   (4) Release and commercialization of new cultivars
4. Plants are self pollinated for several generations till they reach a state of uniformity (homozygosity) so that [NCERT Pg. 171]
   (1) Plants become resistant to all fungal diseases
   (2) All recessive alleles can be expressed
   (3) Alleles/characters can segregate from each other
   (4) The characters will not segregate in the progeny
5. The use of certain chemicals and radiations to change the base sequences of genes of plants is called [NCERT Pg. 174]
   (1) Classical breeding
   (2) Conventional breeding
   (3) Transgenic breeding
   (4) Mutation breeding
6. Breeding of crops for improved nutritional quality is called [NCERT Pg. 176]
   (1) Bioremediation
   (2) Biofortification
   (3) Eutrophication
   (4) Biomagnification
7. Term 'Totipotency' in plants refers to the capacity of a [NCERT Pg. 177]
   (1) Cell to generate whole plant
   (2) Axillary bud to generate only roots of plant
   (3) Cell to increase in size
   (4) Cell to remain dormant

NCERT Based MCQs

8. An explant during tissue culture can be [NCERT Pg. 177]
   (1) Only old part of the plant
   (2) Any part of the plant
   (3) Any dead part of the plant
   (4) Meristematic tissue only
9. 33% of India's GDP comes from [NCERT Pg. 172]
   (1) Fishery (2) Apiculture
   (3) Agriculture (4) Horticulture
10. Germplasm collection is the collection of [NCERT Pg. 171]
   (1) Plants/seeds with all the diverse alleles for all genes
   (2) Germ cells only
   (3) Protoplasm of differentiated cells only
   (4) Dormant seeds only
11. Jaya and Ratna are the semi-dwarf varieties of [NCERT Pg. 173]
   (1) Wheat (2) Rice
   (3) Cowpea (4) Mustard
12. Select the **incorrect** match. [NCERT Pg. 173]
   (1) Black rot of crucifers – Bacteria
   (2) Late blight of potato – Bacteria
   (3) Brown rust of wheat – Fungi
   (4) Red rot of sugarcane – Fungi

13. Pusa Sadabahar is a variety of [NCERT Pg. 174]
(1) Chilli (2) Potato
(3) Cowpea (4) Mustard

14. 'Parbhani-Kranti' is resistant to yellow mosaic virus. It is a variety of [NCERT Pg. 174]
(1) Bhindi (2) Mustard
(3) Chilli (4) Rice

15. Resistance to Jassids in cotton plants and to cereal leaf beetle in wheat plant is due to [NCERT Pg. 175]
(1) Biochemical characters
(2) Morphological characters
(3) Physiological characters
(4) Anatomical characters

16. Sonalika and Kalyan Sona are varieties of [NCERT Pg. 173]
(1) Wheat
(2) Tobacco
(3) Millets
(4) Bajra

17. Select the **incorrect** about *Saccharum barberi* [NCERT Pg. 173]
(1) Was originally grown in North India
(2) Had higher sugar content
(3) Had poor yield
(4) Is a variety of sugarcane

18. All of the following are millets, **except** [NCERT Pg. 173]
(1) Hybrid maize (2) Jowar
(3) Bajra (4) Rice

19. Select the **incorrect** one for SCP? [NCERT Pg. 176]
(1) Prokaryotes can be source of SCP
(2) BGA can be grown easily on materials like waste water
(3) Only single celled organisms are used
(4) BGA, when grown on sewage reduces environmental pollution

20. Atlas 66, having a high protein content is a variety of [NCERT Pg. 176]
(1) Rice
(2) Wheat
(3) Cowpea
(4) Chilli

Thinking in Context

1. Semi-dwarf rice varieties were derived from _____ developed at IRRI and _____ from Taiwan. [NCERT Pg. 173]

2. Himgiri is a variety of wheat crop and it is resistant to _____ [NCERT Pg. 174]

3. In 2000, maize hybrids that had twice the amount of _____ and _____ compared to existing maize hybrids were developed. [NCERT Pg. 176]

4. Scientists have isolated single cells from plants and after digesting their cell walls have been able to isolate naked _____ [NCERT Pg. 177]

5. IARI released variety of carrots that are _____ enriched [NCERT Pg. 176]

6. Method of producing thousands of plants through tissue culture is called _____ [NCERT Pg. 177]

7. Plants developed in tissue culture are genetically identical to each other and are called _____ [NCERT Pg. 177]

8. Somatic hybridization between tomato and potato results in formation of _____ [NCERT Pg. 177]

9. Although the plant is infected with a virus, the _____ is free of virus. [NCERT Pg. 177]

10. During tissue culture the plant growth regulators like _____ are used [NCERT Pg. 177]

11. Turnip mosaic disease is caused by _____ [NCERT Pg. 173]

12. Black rust of wheat is caused by _____ [NCERT Pg. 173]

13. _____ is the root of any breeding programme. [NCERT Pg.171]

14. Pusa Komal is a variety of _____ [NCERT Pg. 174]

15. Pusa Swarnim is _____ a variety of *Brassica*. [NCERT Pg. 174]

16. In mung bean resistance to yellow mosaic virus and powdery mildew were induced by _____ [NCERT Pg. 174]

17. Method of recovery of healthy plants from diseased plant is _____ [NCERT Pg. 177]

18. High aspartic acid, low nitrogen and sugar content in maize leads to resistance to _____ [NCERT Pg. 175]

19. _____ is the most practical means to improve public health. [NCERT Pg. 176]

20. P1542 is a variety of _____ [NCERT Pg. 172]

❑ ❑ ❑

Microbes in Human Welfare

6 Chapter

1 INTRODUCTION

- Microbes are the major components of biological systems on this earth. They are present everywhere-in soil, water, air, inside our bodies and that of other animals and plants.
- They are present even at sites where no other life-form could possibly exist-like deep inside the geysers (thermal vents) where the temperature is 100°C, deep in the soil, under the layers of snow several metres thick and in highly acidic environments.
- Microbes are diverse-protozoa, bacteria, fungi and microscopic animal & plant viruses, viroids and also prions.
- Microbes like bacteria and many fungi can be grown on nutritive media to form colonies, that can be seen with naked eyes. Such cultures are useful in studies on micro-organisms.
- Microbes can be harmful and disease causing but many are useful to man in diverse ways.

2 MICROBES IN HOUSEHOLD PRODUCTS

- *Lactobacillus* & others (LAB) grow in milk & convert it to curd. LAB produce acids that coagulate & partially digest milk proteins, at suitable temperatures. It also improves its nutritional quality by increasing vit-B_{12}.

  In our stomach too, LAB play beneficial role in checking pathogenic microbes.
- The dough used for **dosa**, **idli** is fermented by bacteria.
- Dough which of used for making bread, is fermented using baker's yeast (*Saccharomyces cerevisiae*).
- **Toddy** is fermented sap from palms.
- Microbes are used to ferment fish, soyabean & bamboo shoots to make foods.
- The characteristic texture, flavour, taste and specificity of cheese is due to the microbes:
  a. **Swiss cheese:** Large holes are due to large amount of CO_2 produced by the bacterium. *Propionibacterium sharmanii*.
  b. **Roquefort cheese:** Ripened by a specific fungi, which gives the specific flavour.

3 MICROBES IN INDUSTRIAL PRODUCTS

Requires growing microbes in fermentors

Fermented Beverages

- *Saccharomyces cerevisiae*, is used for beverages production and called brewer's yeast. It is also used for fermenting malted cereals & fruit juices to produce ethanol.
- Wine & beer are produced without distillation, whereas whisky, brandy & rum are produced by distillation of fermented broth.

Antibiotics (Anti = against, bio = life)

- Penicillin-first antibiotic was a chance discovery, by Alexander Fleming, while working on *Staphylococci* bacteria, when he observed that they didn't grew due to the growth of mould *Penicillium notatum*. Its full potential was discovered by Chain & Florey. Fleming, Chain & Florey were awarded Nobel prize in 1945.

Chemicals, Enzymes & other Bioactive Molecules

- *Aspergillus niger* (a fungus) – Citric acid
- *Acetobacter aceti* (a bacterium) – Acetic acid
- *Clostridium butylicum* (a bacterium) – Butyric acid
- *Lactobacillus* (a bacterium) – Lactic acid
- *Saccharomyces cerevisiae* – Ethanol
- Lipases – Used in detergent formulations.
- Streptokinase produced by bacterium *Streptococcus* & modified by genetic engineering is used as a 'clot buster' for removing clots from blood vessels of myocardial infarction patients.
- Cyclosporin-A, used as immunosuppressive agent in organ-transplant patients, is produced from *Trichoderma polysporum* (a fungus).
- Statins produced by yeast *Monascus purpureus* is a blood-cholesterol lowering agent.

4 MICROBES IN SEWAGE TREATMENT

- The municipal waste water is called sewage. A major component of this waste water is human excreta. It contains large amounts of organic matter & microbes.
- Before disposal into natural water bodies like rivers and streams, it is treated in sewage treatment plants (STPs) to make it less polluting.
- Treatment of waste water is done by the heterotrophic microbes naturally present in the sewage.

Treatment is carried in two stages

Primary Treatment (Physical treatment)

- Involves physical removal of particles-large & small from the sewage through filtration and sedimentation
- Floating debris is removed by sequential filtration
- Grit (soil & small pebbles) removed by sedimentation
- Solids that settle form the primary sludge & the supernatant forms the effluent.
- The effluent is taken for secondary treatment.

In anaerobic sludge digester anaerobic bacteria digest bacteria & fungi in the sludge. Produce a mixture of CH_4, H_2S, CO_2 (Biogas)

↑

A small part of the activated sludge is pumped back into aeration tank to serve as inoculum. Rest is pumped into anaerobic sludge digesters

↑

Effluent passed into settling tank, where bacterial 'flocs' sediment, called Activated sludge and then effluent from secondary treatment plant can be released into natural water bodies.

Secondary Treatment (Biological treatment)

Primary effluent is passed into large aeration tanks

↓

Constantly agitated and air is pumped into it

↓

Allows vigorous growth of useful aerobic microbes into flocs. **(Bacteria + fungal filaments to form mesh like structures)**

↓

Microbes grow & consume the major part of organic matter, significantly reducing the BOD.

5 MICROBES IN PRODUCTION OF BIOGAS

1. Biogas is a mixture of gases (predominantly methane) produced by microbial activity.
2. Methanogens, like *Methanobacterium*, grow anaerobically on cellulosic material to produce large amount of CH_4 along with CO_2 and H_2.
3. These bacteria are commonly found in anaerobic sludge during sewage treatment, rumen of cattle.
4. In rumen, these bacteria help in the breakdown of cellulose & play an important role in nutrition of cattle. The excreta of cattle (dung), commonly called Gobar is rich in these bacteria.
5. Dung can be used for generation of biogas, so commonly called Gobar gas.

7 MICROBES AS BIOCONTROL AGENTS

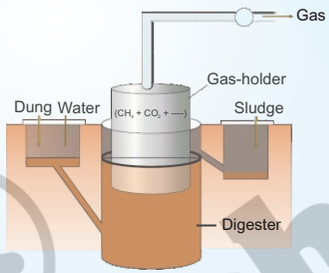
- Biocontrol refers to the use of biological methods for controlling plant diseases and pests.
- As use of insecticides and pesticides are harmful and polluting, our soil is also polluted by weedicides.

Biological control of pests & diseases

- It relies on natural predation.
- The process does not eradicate pests, instead keeps it at manageable levels by a complex system of checks and balances.
- Chemical methods kill both useful and harmful life forms indiscriminately.
  - Beetle with red & black markings-the ladybird & dragon-flies are useful to get rid of aphids and mosquitoes respectively.
  - Butterfly caterpillars are controlled by bacteria *Bacillus thuringiensis* (Bt) on plants such as brassicas & fruit trees.
  - Bt toxin genes is introduced to produce Bt-cotton.
  - Fungus *Trichoderma*, common in the root ecosystems, effective against several plant pathogens.
  - Baculoviruses attack insects and other arthropods. Majority of Baculoviruses are in the genus *Nucleopolyhedrovirus*, they are species-specific, narrow spectrum insecticidal applications.

6 BIOGAS PLANT

- Consist of a concrete tank (10-15 feet deep) in which bio-wastes are collected and a slurry of dung is fed.
- A floating cover is placed over the slurry, which rises when gas is produced due to microbial activity.
- It has outlet to transfer biogas.
- Slurry is removed and may be used as fertiliser.
- Biogas can be used for cooking and lighting.
- The technology of biogas production was developed in India mainly due to the efforts of Indian Agricultural Research Institute (IARI) & Khadi & Village Industries Commission (KVIC).



8 MICROBES AS BIOFERTILISERS

- Organic farming uses biofertilizers.
- Biofertilizers are organisms that enrich the nutrient quality of the soil.
- Main sources of biofertilizers are bacteria, fungi and cyanobacteria.
- Root nodules in leguminous plants is formed by symbiotic association of *Rhizobium*, to fix atmospheric nitrogen into organic forms.
- Free-living N_2-fixers like *Azospirillum* and *Azotobacter* enrich the soil.
- Fungi-plant root, symbiotic association is called mycorrhiza. *Glomus* form mycorrhiza. Fungi-absorb phosphorus from soil & passes to the plant. Plants also show resistance to root-borne pathogens, tolerance to salinity and drought and overall increase in growth and development.
- Cyanobacteria like *Anabaena, Nostoc, Oscillatoria* etc. fix atmospheric N_2, in paddy fields.
- BGA (blue green algae) also add organic matter to the soil and increase its fertility.

9

- The puffed-up appearance of dough is due to CO_2 gas.
- Toddy is a traditional drink of some parts of Southern India.
- Antibiotics mean against life, in the context of disease causing organisms, but in context to human life they are 'pro life'.
- Bottled juices are clarified by use of pectinases and proteases.
- Statins act by competitively inhibiting the enzyme responsible for synthesis of cholesterol.
- BOD **(Biochemical Oxygen Demand)** is the amount of oxygen consumed if all the organic matter in one liter of water were oxidised by bacteria.
- BOD test measures the rate of uptake of oxygen by micro-organisms in a sample of water. BOD is a measure of the organic matter present in the water.
- In our country, a number of biofertilisers are available commercially in the market and farmers use these regularly to replenish soil nutrients and reduce dependence on chemical fertilizers.
- Microbes are a very important component of life on earth. Not all microbes are pathogenic. Many are very useful.
- Microbes play a major role in treating millions of gallons of waste water everyday across the globe. Till date, no man-made technology has been able to rival the microbial treatment of sewage.
- The ministry of Environment and Forests has initiated Ganga Action Plan & Yamuna Action Plan to save these major rivers of our country from pollution.
- The biocontrol measures help us to avoid heavy use of toxic pesticides for controlling pests.
- It is clear from the diverse uses human beings have put microbes to that they are important for our survival.

Sharpen Your Understanding

NCERT Based MCQs

1. During the process of making curd, a inoculum is added to fresh milk to initiate the process. The term inoculum actually means a starter [NCERT Pg.181]
   (1) Rich in vitamin B_2 and B_{12}
   (2) Having pathogenic microbes
   (3) Producing large amount of CO_2
   (4) Rich in millions of LAB

2. The puffed-up appearance of dough is due to [NCERT Pg.181]
   (1) Specific bacteria
   (2) Fermented fish
   (3) Production of CO_2
   (4) A particular flavour

3. The 'Roquefort cheese' gets a particular flavour as they are ripened by [NCERT Pg.181]
   (1) Lactic acid bacteria
   (2) *Saccharomyces*
   (3) A specific fungi
   (4) *Aspergillus*

4. Which of the following alcoholic drinks are produced without distillation? [NCERT Pg.182]
   (1) Wine and beer (2) Wine and rum
   (3) Rum and whisky (4) Brandy and wine

5. The first antibiotic to be discovered, which was extensively used to treat American soldiers wounded in world war-II was [NCERT Pg.182]
   (1) Streptomycin (2) Penicillin
   (3) Tetracyclin (4) Bacitracin

6. "Toddy", a traditional drink of some parts of Southern India is made by fermenting [NCERT Pg.181]
   (1) Fresh bamboo shoots
   (2) Soyabean
   (3) Cereals
   (4) Sap from palms

7. Which of the following microbes is used for the commercial production of ethanol? [NCERT Pg.183]
   (1) *Aspergillus niger*
   (2) *Saccharomyces cerevisiae*
   (3) *Acetobacter aceti*
   (4) *Lactobacillus*

8. Cyclosporin-A is used as an immunosuppressive agent in organ-transplant patients, is produced by the fungus [NCERT Pg.183]
   (1) *Aspergillus niger*
   (2) *Penicillium notatum*
   (3) *Trichoderma polysporum*
   (4) *Saccharomyces*

9. Which of the following bio-active molecule has been commercialised as blood-cholesterol lowering agent? [NCERT Pg.183]
   (1) Statins (2) Cyclosporin-A
   (3) Penicillin (4) Lipase

10. Which of the following chemical produced by the bacterium *Streptococcus* and modified by genetic engineering can be used to remove clots from blood vessels of myocardial infarction patients? [NCERT Pg.183]
   (1) Statins (2) Streptokinase
   (3) Thiokinase
   (4) Pyruvate kinase

11. During the process of primary treatment in the STP, floating debris is removed by: [NCERT Pg.184]
   (1) Aeration
   (2) Sedimentation
   (3) Sequential filtration
   (4) Effluent treatment

12. During secondary treatment of sewage, the bacterial 'flocs' are allowed to sediment. This sediment is called [NCERT Pg.184]
   (1) Activated sludge (2) Primary sludge
   (3) Slurry (4) Supernatant

13. The bacteria commonly found in the anaerobic sludge during sewage treatment is [NCERT Pg.185]

(1) *Streptococcus*

(2) *Staphylococci*

(3) *Methanobacterium*

(4) *Acetobacter*

14. The organisms that enrich the nutrient quality of the soil are known as [NCERT Pg.188]

(1) Natural manure (2) Organic manure

(3) Biocontrol agents (4) Biofertilizers

15. Which of the following group of organisms serve as an important biofertilizer in paddy fields? [NCERT Pg.188]

(1) Methanogens (2) Cyanobacteria

(3) Archaebacteria (4) Protozoans

16. Many members of which of the following genus of fungi form the mycorrhiza? [NCERT Pg.188]

(1) *Glomus*

(2) *Aspergillus*

(3) *Monascus*

(4) *Saccharomyces*

17. The dragonflies are useful to get rid of [NCERT Pg.187]

(1) Aphids (2) Mosquitoes

(3) *Parthenium* (4) Methanogens

18. Industrial production of butyric acid is done by using the bacterium [NCERT Pg.183]

(1) *Lactobacillus*

(2) *Clostridium butylicum*

(3) *Acetobacter aceti*

(4) *Staphylococci*

19. Baculoviruses are pathogens that attack [NCERT Pg.187]

(1) Insects & other arthropods

(2) Prions & viroids

(3) Prions & virusoids

(4) Butterfly caterpillars

20. Which of the following group of gases form the biogas and can be used as source of energy as it is inflammable? [NCERT Pg.185]

(1) CO_2, H_2S, H_2

(2) CO, CO_2, H_2

(3) CH_4, H_2S, CO_2

(4) CO, H_2, C_2H_6

Thinking in Context

1. Microbes are present even at sites where no other life form could possibly exist even at sites such as _____ where the temperature may be as high as 100°C. [NCERT Pg. 179]

2. In our stomach, the LAB plays very beneficial role in checking _____. [NCERT Pg. 181]

3. The dough, used for making foods such as dosa and idli is fermented by _____ [NCERT Pg. 181]

4. Whisky, brandy and rum are produced by _____ of the fermented broth. [NCERT Pg. 182]

5. In the context of disease causing organisms, anti-biotics mean _____[NCERT Pg. 182]

6. For the discovery of _____ Fleming, Chain and Florey were awarded the Nobel prize in 1945. [NCERT Pg. 182]

7. _____ acts by competitively inhibiting the enzyme responsible for synthesis of cholesterol. [NCERT Pg. 183]

8. The _____ measures the rate of uptake of oxygen by micro-organisms in a sample of water and thus, indirectly, BOD is a measure of the organic matter present in the water. [NCERT Pg. 184]

9. The effluent from the _____ is generally released into natural water bodies like rivers and streams. [NCERT Pg. 184]

10. _____ are commonly found in the rumen of cattle. [NCERT Pg. 185]

11. The technology of _____ was developed in India mainly due to the efforts of IARI and KVIC. [NCERT Pg. 186]

12. _____ refers to the use of biological methods of controlling plant diseases and pests. [NCERT Pg. 186]

13. In agriculture there is a method of controlling pests that relies on _____ rather than introduced chemicals. [NCERT Pg. 186]

14. The use of biocontrol methods and measures will greatly reduce our dependence on _____. [NCERT Pg. 187]

15. An example of microbial biocontrol agents that can be introduced to control butterfly caterpillars is the bacterium _____. [NCERT Pg. 187]

16. _____ species are free-living fungi that are very common in the root ecosystems. [NCERT Pg. 187]

17. The majority of baculoviruses used as biological control agents are in the genus _____. [NCERT Pg. 187]

18. Nodules on the roots of leguminous plants are formed by the symbiotic association of _____. [NCERT Pg. 188]

19. The main source of _____ are bacteria, fungi and cyanobacteria. [NCERT Pg. 188]

20. _____ produce methane (biogas) while degrading plant waste. [NCERT Pg. 189]

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Organisms and Populations

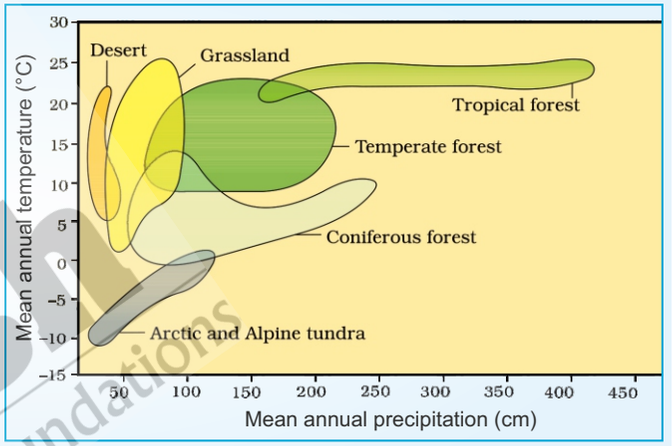
7 Chapter

1 INTRODUCTION

- Living world is fascinatingly diverse and amazingly complex. Complexity can be investigated at various levels of biological organisation-macromolecules, cells, tissues, organs, individual organisms, population, communities, ecosystems and biomes.
- Ecology studies interactions among organisms and between organism and its physical (abiotic) environment. Ecology is basically concerned with four levels of biological organisation-**organisms, populations, communities and biomes**. The chapter explores ecology at organismic and population levels.

2 ORGANISMS AND ITS ENVIRONMENT

- Ecology at the organismic level is essentially physiological ecology which tries to understand how different organisms are adapted to their environments in terms of survival and reproduction.
- The rotation of our planet around the sun and the tilt of its axis cause annual variations in the intensity and duration of temperature, resulting in distinct seasons. These variations together with annual variation in precipitation (both rain and snow) account for formation of major biomes such as desert, rain forest and tundra.
- Regional and local variations within each biome lead to the formation of a wide variety of habitats. Temperature, water, light and soil affect the habitat.
- The **habitat** of an organism is characterised by physico-chemical (abiotic) components and biotic components like-pathogens, parasites, predators and competitors - of the organism with which they interact constantly.
- Over a period of time, the organism evolved to optimise its survival and reproduction in its habitat through natural selection.
- Niche of an organism has an invariably defined range of conditions that it can tolerate, diversity in the resources it utilises and a distinct functional role in the ecological system.



3 MAJOR ABIOTIC FACTORS

(1) TEMPERATURE

- Ecologically most important factor
- Affects enzyme kinetics, metabolic activity & physiology
- Eurythermals tolerate wide temperature fluctuations.
- Stenothermals restricted to narrow range.
- Thermal tolerance determines geographical distribution.

(2) WATER

- Life originated in water
- Productivity and distribution of plants is dependent on water.
- SALINITY measured in ppt is:-
  1) < 5 in inland water.
  2) 30-35 in sea
  3) >100 in some hypersaline lagoons
- Osmotic problems affect living organisms.

(3) LIGHT

- Plants need light for photo-synthesis and photoperiod for flowering.
- Animals also need light for foraging, reproduction & migration.
- UV light is harmful.
- Red algae are found in deepest water.

(4) SOIL

- Nature of soil depends on climate, weathering and transportation.
- Composition, grain size, pH, minerals and topography determine vegetation which dictates the type of animals supported.

4 RESPONSE TO ABIOTIC FACTORS

Abiotic conditions of many habitats vary drastically in time and organisms living in such habitats need to evolve strategies to survive or manage with the stressful conditions.

5 ORGANISMIC RESPONSE TO ABIOTIC STRESS

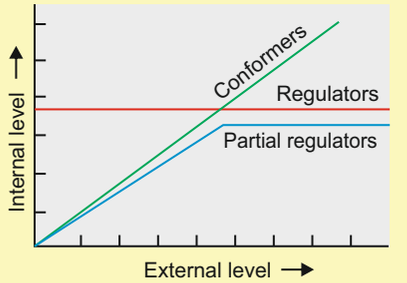
REGULATE
- Maintain homeostasis by physiological (or behavioural) means.
- Which ensures constant body temperature and osmotic concentration.
- All birds, mammals and very few lower vertebrates and invertebrates are capable of this.

CONFORM
- 99% animals & nearly all plants.
- Their body temperature changes with the ambient temperature.

MIGRATE
- Temporarily move away to escape the condition and return when the period is over e.g. siberian cranes visit Bharatpur every winter.

SUSPEND
- Thick walled SPORE in bacteria, fungi & lower plants.
- Dormancy in higher plants.
- Hibernation in bears and Aestivation in snails and fish
- Diapause, or suspended development in zooplanktons.

- Success of mammals is largely due to their ability to maintain constant body temperature and thrive in antarctica or in Sahara desert.



Diagrammatic representation of organismic response

6 ADAPTATIONS- TO COPE WITH EXTREME ENVIRONMENT

(1) GENETICALLY FIXED
- Kangaroo rat in North American deserts.
  - internal fat-oxidation for water
  - ability to concentrate urine
- CAM plants like *Opuntia*.
- **Allen's Rule**- Shorter extremities of mammals in cold climate to reduce heat loss.
- Thick blubber in seal.

(2) PHYSIOLOGICAL
- Altitude sickness, Symptoms-Nausea, fatigue & heart palpitations.
- Gradually the body compensates low oxygen by increasing RBC production, decreasing the binding affinity of haemoglobin and increasing the breathing rate.

(3) BEHAVIOURAL
- Desert lizards-bask in the sun & absorb heat when their body temperature drops below comfort zone, but move away into shade when ambient temperature starts increasing.
- Some species hide in burrow to escape from the above-ground heat.

- Organisms living in extreme environments like **hot springs, deep sea hydrothermal vents, antarctic fishes in freezing conditions or at > 100 times normal atmospheric pressure** - show biochemical adaptations.

7 POPULATION

POPULATION ATTRIBUTES:
- **Birth rates and Death Rates:** refer to per capita births and deaths.
- **Sex-ratio**: e.g. 60 percent of the population are females & 40 percent males.
- **Age-pyramids** : Shows percent individuals of a given age or age group. For human population age pyramids generally show age distribution of males and females in a diagram. The shape of the pyramids reflects the growth status of the population.

- Evolutionary changes through natural selection takes place at population level.

- If N is the population density at time t, then its density at time $t + 1$ is $N_{t+1} = N_t + [(B + I) - (D + E)]$
  - If births plus immigration (B + I) is more than Deaths plus emigration (D + E) population density will increase.
  - Under normal conditions births & deaths are most important factors influencing population density.
  - If a new habitat is just being colonised, immigration is more significant to population growth than birth rates.

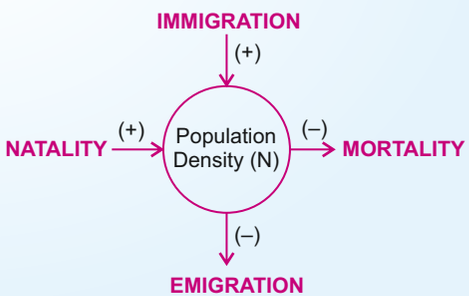
8 POPULATION GROWTH

(1) Population for any species is not a static parameter.

(2) Food availability, predation pressure and adverse weather are the factors which affect population.

(3) **Population density**, in a given habitat during a given period, fluctuates due to changes in FOUR basic processes, two of which (natality, immigration) increase density and two (mortality, emigration) decrease it.

Tiger census in our national parks & tiger reserves is often based on **pug marks and fecal pellets**.



9 GROWTH-MODELS

EXPONENTIAL GROWTH

- When resources in the habitat are unlimited.
- Then population grows in an exponential or geometric fashion.
- Integral form of the exponential growth equation

$N_t = N_0 e^{rt}$

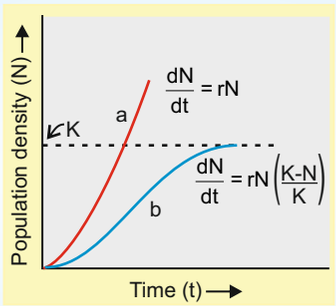
Where =

N_t = Population density at time 't'

N_0 = Population density at time zero.

r = intrinsic rate of natural increase

e = base of natural logarithms (2.71828).



(a) Exponential plot
(b) Logistic plot
(k) Is carrying capacity.

LOGISTIC GROWTH

- In nature resources are limited.
- This leads to competition.
- The fittest survive and reproduce.
- So, it shows, lag, acceleration, deceleration and finally asymptote.
- It gives **Verhulst-Pearl logistic curve.**
- Logistic model is realistic.
- Asymptote : When population density reaches the carrying capacity

10 LIFE HISTORY VAIRATION

- Populations evolve to maximise their reproductive fitness, also called Darwinian fitness (high 'r' value), in the habitat in which they live and evolve towards the most effective reproductive strategy.

REPRODUCTIVE STRATEGIES IN ORGANISMS

(1) Breed only once in their life time.
e.g., Pacific salmon fish Bamboo.
(2) Some produce large number of small-sized offsprings
e.g., Oysters, Pelagic fishes

(1) Breed many times during lifetime.
e.g., Most birds & Mammals.
(2) Others produce a small number of large-sized offsprings.
e.g., Birds & Mammals

11 POPULATION INTERACTIONS

No organism in nature (animals, plants and microbes) can live in isolation but interact in various ways to form a biological community. These interactions can be beneficial (+); detrimental (–) or neutral (0)

(1) PREDATION (+;-)

- Predators act as conduits for energy transfer across trophic levels.
- Keep prey population under control.
- Used as biological control method for pest-control.
- Maintain species diversity by reducing competition among prey eg. *Pisaster* & 10 species of invertebrates.
- Predators in nature are prudent.
- Prey species evolved defences:-
  (a) Camouflage - insects & frogs
  (b) Monarch butterfly- Chemical defence
  (c) Thorns - Cactus, *Acacia*
- Many plants produce and store chemicals that make herbivore sick when they are eaten, e.g., *Calotropis* produces **cardiac glycosides**

(2) COMPETITION (–;–)

- Darwin said interspecific competition is a potent force in organic evolution.
- Totally unrelated species can compete for same resources.
- The fitness ('r' the intrinsic rate of increase) of one species is significantly lower in presence of another species.
- **Competitive release** - The distributional range increase dramatically when the superior species is removed.
  eg. *Balanus* & *Chathamalus*
- Gause's competitive exclusion principle= eg. Abingdon tortoise and Goats in galapagos island.
- Co-Existence by resource partitioning eg 5 closely related species of warblers.

(3) PARASITISM (+;–)

- Free lodging and meals.
- Parasites are host specific, i.e., **co-evolve.**
- Parasitic adaptations = loss of sense organs, presence of adhesive organs or suckers, loss of digestive system & high capacity of reproduction.
- Human liver fluke depends on a snail and a fish to complete life cycle.
- Parasites reduce survival, growth and reproduction of host. Make them weak.
- **Brood parasitism** in birds eg. Cuckoo and crow. The eggs of parasitic bird had evolved to resemble host's egg in colour and size.
- Ectoparasites on surface and Endoparasites inside host.
- Life cycles of Endoparasites are more complex because of their extreme specialisation. Their morphological and anatomical features are simple but reproductive potential is very high.

(4) COMMENSALISM (+;0)

- An orchid growing as an *epiphyte* on a mango branch.
- Barnacles growing on back of a whale.
- Cattle egret and grazing cattle.
- Sea anemone that has stinging tentacles and clown fish that lives among them.

In **Amensalism** one species is harmed whereas the other is unaffected.

(5) MUTUALISM (+;+)

- Lichens, *Mycorrhizae*,
- Plant - animal relationships- for pollination.
- Plants offer rewards or fees like pollen, nectar for pollinators and fruits for seed dispersers.
- And safeguards against cheaters.
- It also shows *co-evolution* and one to one relationship like fig and partner wasp.

Mediterranean orchid ***Ophrys*** employs **'sexual deceit'** to get pollination done by a species of bee, by **pseudo copulation.**

Sharpen Your Understanding

NCERT Based MCQs

1. Ecology at which of the following levels is essentially physiological ecology, which tries to understand how different organisms are adapted to their environment in terms of survival and reproduction? [NCERT Pg. 220]

(1) Organismic (2) Population

(3) Community (4) Biome

2. The most important ecologically relevant environmental factor is: [NCERT Pg. 221]

(1) Light (2) Soil type

(3) Temperature (4) Water

3. A vast majority of organisms are restricted to a narrow range of temperatures, such organisms are called: [NCERT Pg. 222]

(1) Eurythermal

(2) Stenothermal

(3) Halophiles

(4) Stenohaline

4. The salt concentration measured as salinity in ppt, is less than 5 in [NCERT Pg. 222]

(1) Hypersaline lagoons

(2) Sea

(3) Inland waters

(4) Salt lakes

5. Among the algae that inhabit the sea, which is likely to be found in the deepest waters? [NCERT Pg. 223]

(1) Red algae

(2) Brown algae

(3) Green algae

(4) Golden-brown algae

6. An overwhelming majority of animals and nearly all plants cannot maintain a constant internal environment. They are [NCERT Pg. 224]

(1) Regulators

(2) Conformers

(3) Partial regulators

(4) Suspenders.

7. The main reason why very small animals are rarely found in polar regions is: [NCERT Pg. 224]

(1) Heat loss or heat gain is a function of surface area.

(2) Small animals have a small surface area.

(3) Thermoregulation is energetically inexpensive.

(4) They gain heat fast when it is cold outside.

8. Which of the following organisms show behavioural responses to cope up with variations in their environment? [NCERT Pg. 226]

(1) Archaebacteria in hydrothermal vents.

(2) Fishes thriving in freezing Antarctic waters

(3) Desert lizards

(4) Kangaroo rat.

9. The body solves the problem of altitude sickness by: [NCERT Pg. 226]

(1) Increasing RBC production

(2) Increasing binding affinity of hemoglobin

(3) Decreasing the breathing rate.

(4) Decreasing RBC production

10. Select the odd one out w.r.t the attributes characteristic of a population? [NCERT Pg. 227]

(1) Sex-ratio (2) Birth rates

(3) Death rates (4) Gender

11. If a new habitat is just being colonised, which of the following may contribute more significantly to population growth than birth rates? [NCERT Pg. 229]

(1) Mortality (2) Morbidity

(3) Immigration (4) Emigration

12. The integral form of the exponential growth equation is: [NCERT Pg. 230]

(1) $\frac{dN}{dt} = N$

(2) $\frac{dN}{dt} = rN$

(3) $N_t = N_0 e^{rt}$

(4) $N_0 = N_t r^{et}$

13. In the logistic growth curve, which of the following phases is seen, when the population density reaches the carrying capacity? [NCERT Pg. 231]

(1) Lag phase

(2) Acceleration

(3) Deceleration

(4) Asymptote

14. The population interaction in which one species is harmed whereas the other is unaffected is: [NCERT Pg. 233]

(1) Commensalism

(2) Amensalism

(3) Mutualism

(4) Parasitism

15. Species facing competition might evolve mechanisms that promote co-existence. One such mechanism is: [NCERT Pg. 234-235]

(1) Competitive release

(2) Competitive exclusion

(3) Resource partitioning

(4) Intrinsic rate of increase

16. Brood parasitism in birds is a fascinating example of parasitism in which: [NCERT Pg. 236]

(1) Parasitic bird incubate the egg.

(2) The host bird lays its egg in nest of parasitic bird.

(3) The crow lays its eggs in the nest of Koel

(4) Eggs of parasitic bird have evolved to resemble the host's egg in size and colour.

17. The interaction in which one species benefits and the other is neither harmed nor benefitted is seen in: [NCERT Pg. 236-237]

(1) Mycorrhizae associations between fungi and roots of higher plants.

(2) Sea anemone and clown fish

(3) Abingdon tortoise and goats in Galapagos island

(4) *Cuscuta* on hedge plants

18. The Mediterranean orchid *Ophrys* employs which of the following strategies to get pollination done by a species of bee? [NCERT Pg. 238]

(1) Sexual deceit

(2) Commensalism

(3) Amensalism

(4) Neutral interaction

19. A species whose distribution is restricted to a small geographical area because of the presence of a competitively superior species, is found to expand its distributional range dramatically when the competing species is experimentally removed. This phenomenon is called: [NCERT 234-235]

(1) Co-existence

(2) Resource partitioning

(3) Competitive release

(4) Cryptic colouration

20. The morphological, physiological or behavioural attribute of an organism that enables it to survive and reproduce in its habitat is called: [NCERT Pg. 225]

(1) Niche (2) Adaptation

(3) Hibernation (4) Morbidity

Thinking in Context

1. Regional and local variations within each biome lead to the formation of a wide variety of _____. [NCERT Pg. 220]
2. Each organism has an invariably defined range of conditions that it can tolerate, diversity in the resources it utilises and a distinct functional role in the ecological system, all these together comprise its _____. [NCERT Pg. 221]
3. A few organisms can tolerate and thrive in a wide range of temperatures, they are called _____. [NCERT Pg. 222]
4. For aquatic organisms the quality _____, and _____ of water becomes important. [NCERT Pg. 222]
5. Many plants are dependent on sunlight to meet their photoperiodic requirement for _____. [NCERT Pg. 222]
6. Evolutionary biologist believe that the 'success' of mammals is largely due to their ability to maintain a _____ and thrive whether they live in Antarctica or in the Sahara desert. [NCERT Pg. 224]
7. Some snails and fish go into _____ to avoid summer-related problems of heat and desiccation. [NCERT Pg. 225]
8. Under unfavourable conditions many zooplankton species in lakes and ponds are known to enter _____, a stage of suspended development. [NCERT Pg. 225]
9. Mammals from colder climates generally have shorter ears and limbs to minimize heat loss. This is called the _____. [NCERT Pg. 226]
10. _____ is the number of individuals of the same species that have come into the habitat from elsewhere during the period under consideration. [NCERT Pg. 228]
11. Under normal conditions _____ are the most important factors influencing population density. [NCERT Pg. 229]
12. _____ availability is obviously essential for the unimpeded growth of a population. [NCERT Pg. 229]
13. No population of any species in nature has at its disposal unlimited resources to permit _____. [NCERT Pg. 231]
14. Prickly pear *Cactus* introduced into Australia in early 1920's caused havoc by spreading rapidly into millions of hectares. It was brought under control only after a _____ from its natural habitat was introduced into the country. [NCERT Pg. 223]
15. Some species of insects and frogs are _____ to avoid being detected easily by the predator. [NCERT Pg. 233]
16. If the predator is too efficient and over exploits its prey then the prey might become extinct and then the predator will also become extinct for lack of food, that's why predators in nature are _____. [NCERT Pg. 233]
17. Nearly 25 percent of all insects are known to be _____. (feeding on plant sap and other parts of plants) [NCERT Pg. 234]
18. A wide variety of chemical substances that we extract from plants on a commercial scale like nicotine, caffeine, quinine, strychnine, opium, etc are produced by them actually as defences against _____. [NCERT Pg. 234]
19. Mac Arthur showed that five closely related species of warblers living on the same tree were able to avoid _____ due to behavioural differences in their foraging activities. [NCERT Pg. 235]
20. One petal of flower of Mediterranean orchid *Ophrys* bears an uncanny resemblance to the female of bee in _____, the male bee is attracted to what is perceives as a female 'pseudo copulates' with the flower and dusts pollen from flower. [NCERT Pg. 238]

❑ ❑ ❑

Ecosystem

8 Chapter

1 INTRODUCTION

- Ecosystem is a functional unit of nature, where living organisms interact among themselves and the surrounding physical environment, e.g., a small pond, a large forest or a sea.
- Entire biosphere is a global ecosystem, composite of all local ecosystems on Earth.
- Forest, grassland and desert are terrestrial ecosystems; pond, lake, wetland, river and estuary are aquatic and crop fields and an aquarium are man-made ecosystems.
- Input (productivity), transfer of energy (food chain/web, nutrient cycling) and the output (degradation and energy loss) are the major functions of ecosystem.

2 ECOSYSTEM – STRUCTURE AND FUNCTION

- Interaction of biotic and abiotic components result in a physical structure.
- Vertical distribution of different species occupying different levels is called stratification, like trees at top vertical strata, shrubs second and herbs and grasses occupy bottom layers.

3 ECOSYSTEM COMPONENTS FUNCTION AS A UNIT IN THE FOLLOWING ASPECTS

PRODUCTIVITY | DECOMPOSITION | ENERGY FLOW | NUTRIENT CYCLING

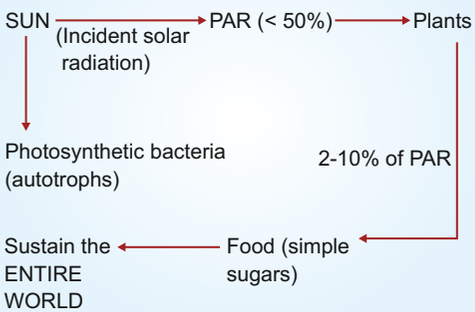
PRODUCTIVITY

- Amount of biomass or organic matter produced per unit area over a time period by plants during photosynthesis is primary production, expressed in terms of weight (gm^{-2}) or energy ($K\ cal\ m^{-2}$).
- Rate of biomass production is productivity, expressed as $gm^{-2}\ yr^{-1}$ or $(K\ cal\ m^{-2})\ yr^{-1}$. It can be divided into:
  - (i) Gross primary productivity (GPP), is the rate of production of organic matter during photosynthesis.
  - (ii) Net primary productivity (NPP), is the available biomass for the consumption to heterotrophs (herbivores and decomposers)

  GPP – R (respiratory loss) = NPP.
- Primary productivity depends on the plant species inhabiting a particular area. It also depends on environmental factors, availability of nutrients and photosynthetic capacity of plants. It varies in different ecosystems.
  - Annual net primary productivity of whole biosphere is approximately = 170 billion tons (dry wt.) of organic matter.
  - Productivity of oceans (70% of surface) = 55 billion tons, rest is on land
- Secondary productivity is the rate of formation of new organic matter by consumers.

5 ENERGY FLOW

- Unidirectional from sun to producers and then to consumers.



4 DECOMPOSITION

- Breakdown of complex organic matter into inorganic substances like CO_2, water and nutrients is decomposition.
- Detritus, *i.e.* dead plant remains like leaves, bark, flowers and dead remains of animals, including fecal matter, is the raw material for decomposition.
- Largly oxygen requiring process

DECOMPOSITION (Important steps)

FRAGMENTATION	LEACHING	CATABOLISM	HUMIFICATION	MINERALISATION
Break down of detritus into smaller particles by detritivores (*eg.*, earthworm)	Water soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts	Bacterial and fungal enzymes degrade detritus into simpler inorganic substances	Accumulation of dark, amorphous HUMUS which is highly resistant to microbial action. Colloidal reservoir of nutrients Humus undergoes decomposition at an extremely slow rate in soil	Humus is further degraded by microbes to release inorganic nutrients

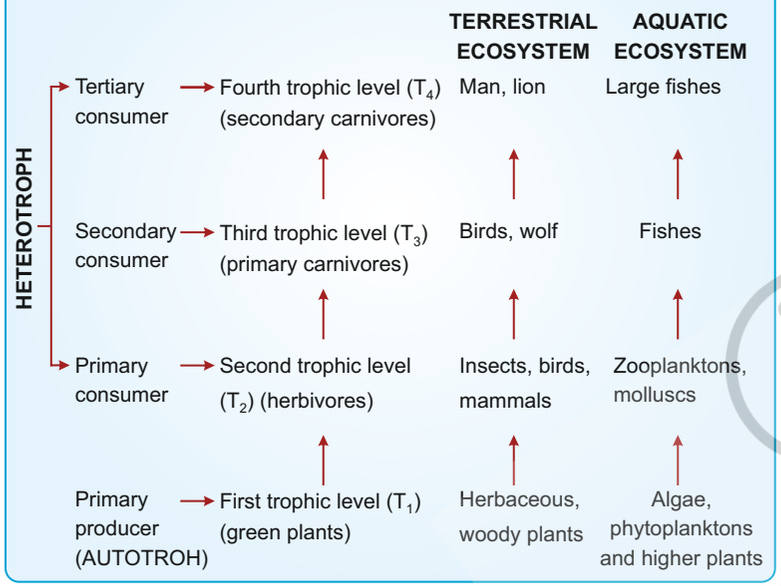
- Fragmentation, leaching and catabolism operate simultaneously on the detritus.

RATE OF DECOMPOSITION	COMPOSITION OF DETRITUS	CLIMATIC FACTORS
SLOWER	Rich in lignin and chitin	Low temperature and anaerobiosis
QUICKER	Rich in nitrogen and water soluble substances like sugar	Warm and moist environment. Oxygen requiring process

- Temperature and soil moisture are most important climatic factors that regulate decomposition.

6 TROPHIC LEVELS IN AN ECOSYSTEM

- Amount of energy decreases at successive trophic levels.
- Only 10% of the energy is transferred to each trophic level from the lower trophic level (10% Law).



7 DETRITUS FOOD CHAIN (DFC)

- Begins with dead organic matter.
- Made up of decomposers which are heterotrophic organisms, mainly fungi and bacteria. They meet their energy and nutrient requirements by degrading dead organic matter or detritus. Known as Saprotrophs.
- In a terrestrial ecosystem, a much larger fraction of energy flows through the DFC than through the GFC.

GRAZING FOOD CHAIN (GFC)

- Sun is the source of energy.
- Autotrophs assimilate food using simple inorganic materials and radiant solar energy.
- The energy flows from autotrophs to heterotrophs as per the law of thermodynamics.
- In an aquatic ecosystem, GFC is the major conduit for energy flow.

8 STANDING CROP

- Each trophic level has a certain mass of living material at a particular time called as the standing crop.
- Standing crop is measured as the mass of living organisms (Biomass) or the number in a unit area.
- Measurement of biomass in terms of dry weight is more accurate.

STANDING STATE

- Organisms need a constant supply of nutrients to grow, reproduce and regulate various body functions.
- The amount of nutrients such as carbon, nitrogen, phosphorus, calcium etc., present in the soil at any given time, is called standing state.
- It varies in different kinds of ecosystems and also on a seasonal basis.

9 ECOLOGICAL PYRAMIDS

- Food or energy relationship between organisms at different trophic levels, is expressed in terms of number, biomass or energy.
- The base of each pyramid represents the producers or the first trophic level while the apex represents tertiary or top level consumer.
- The trophic level represents a functional level, not a species as such. A given species may occupy more than one trophic level in the same ecosystem at the same time. *eg.* A sparrow is a primary consumer when it eat seeds, fruits, peas, and a secondary consumer when it eats insects and worms.
- Three types of ecological pyramids are usually studied – (a) pyramid of number; (b) pyramid of biomass and (c) pyramid of energy.

LIMITATIONS OF ECOLOGICAL PYRAMIDS

- It does not take into account the same species belonging to two or more trophic levels.
- It assumes a simple food chain, that never exists in nature. It does not accommodate a food web.
- Saprophytes are not given any place in ecological pyramids even though they play a vital role in the ecosystem

PYRAMID OF NUMBER	PYRAMID OF BIOMASS	PYRAMID OF ENERGY
Upright in most ecosystems A big tree ecosystem is inverted or spindle shaped	Upright in most ecosystems. In sea, it is generally inverted	Always upright and can never be inverted When energy flows from a particular trophic level to next trophic level some energy is always lost as heat

10 ECOLOGICAL SUCCESSION

- The composition and structure of all communities constantly change in response to the changing environmental conditions, which is orderly and sequential, parallel with changes in the physical environment, leading finally to a community that is in near equilibrium to the environment and is called **climax community**.
- This gradual and fairly predictable change in the species composition of a given area is called ecological succession.
- The entire sequence of communities that sucessively change in a given area are called **SERE(s)** and individual transitional communities are termed **seral stages** or **seral communities**.
- In the successive seral stages change in diversity of species of organisms, increase in the number of species and organisms as well as an increase in total biomass is seen.
- Actually succession and evolution would have been parallel processes.
- Primary succession starts in an area where no living organisms ever existed, like on bare rock, newly cooled lava, newly created pond or reservoir, so it is slow and can take several hundred to thousand years.
- Primary succession is very slow process.
- Secondary succession takes place in areas that somehow, lost all the living organisms that existed there, like abandoned farm lands, burned or cut forests, lands that have been flooded. Since some soil or sediment is present, succession is faster than primary succession.
- In secondary succession, since soil is already there, the rate of succession is much faster and hence, climax is also reached more quickly.
- As succession proceeds, the numbers and types of animals and decomposers also change.
- The species that invade a bare area are called **pioneer species**.
- After several more stages ultimately a stable climax forest community is formed.

14

- In ecosystem there is unidirectional movement of energy towards higher trophic levels and its dissipation and loss as heat to the environment.
- Some organisms of DFC are prey of the GFC animals.
- Some animals like cockroaches, crows etc. are omnivores.
- Both hydrarch and xerarch lead to medium water conditions (MESIC).
- Environmental factors, e.g., soil, moisture, pH, temperature, etc., regulate the rate of release of nutrients into the atmosphere.
- The climax community remains stable as long as the environment remains unchanged.
- Products of ecosystem processes are named as ECOSYSTEM SERVICES, e.g., purification of air and water by forests.

11 SUCCESSION OF PLANTS

HYDRARCH (In wet areas)	XERARCH (Xeric/dry conditions)
Phytoplankton (pioneer) species → Submerged plant stage → Submerged free floating stage → Reed-swamp stage → Marsh-meadow stage → Scrub stage → Forest (climax) MESIC	Lichens (pioneer) species → Bryophytes → Higher plants → MESIC (climax) Forest

12 NUTRIENT CYCLING

- Nutrients which are never lost from the ecosystems, they are recycled time and again indefinitely. It is called biogeochemical cycles (bio-living organism, geo-rocks, air, water).
- Nutrient cycles are of two types:
  (a) Gaseous (*eg.* nitrogen, carbon cycle)
  (b) Sedimentary (*eg.* sulphur, phosphorus cycle)

CARBON-CYCLE

- Natural reservoir is atmosphere.
- Carbon constitutes 49% of dry weight of organisms and is next only to water.
- 71% of global carbon is dissolved in oceans, which regulates amount of CO_2 in atmosphere.
- Fossil fuel represent a reservoir of carbon.
- 4×10^{13} kg of carbon is fixed annually in biosphere through photosynthesis.
- Respiratory activities of producers and consumers return a lot of CO_2 to the atmosphere. Decomposers contribute substantially to CO_2 pool
- Burning of wood, forest fire, fossil fuel, volcanic activity, deforestation etc. also contribute to the atmospheric CO_2.

PHOSPHORUS-CYCLE

- Phosphorus is major constituent of biological membranes, nucleic acids and cellular energy transfer system.
- Needed to make shells, bones and teeth.
- Natural reservoir is rock.
- Herbivores and other animals get it from plants.
- There is no respiratory release of phosphorus into atmosphere.
- Atmospheric inputs of phosphorus through rain fail are much smaller than carbon inputs and secondly gaseous exchanges of phosphorus between organism and environment are negligible.

13 ECOSYSTEM SERVICES

- Healthy forest ecosystem purify air and water, mitigate droughts and foods, cycle nutrients, generate fertile soils, provide wildlife habitat, maintain biodiversity, pollinate crops, provide storage site for carbon and also provide aesthetic, cultural and spiritual values.
- Robert Constanza tried to put price tags of average US $ 33 trillion a year for these ecosystem services, which is largely taken for granted, because they are free. This is nearly twice the value of global GNP of US $ 18 trillion.
- Out of the total cost soil formation accounts for about 50%, recreation and nutrient cycling less than 10% each and climate regulation and habitat for wildlife 6% each.

Sharpen Your Understanding

1. Which of the following may be considered as man-made ecosystems? [NCERT Pg. 241]
   (1) Forest and grasslands
   (2) Desert and grasslands
   (3) Crop fields and an aquarium
   (4) Pond and lakes
2. Vertical distribution of different species occupying different levels is called [NCERT Pg. 242]
   (1) Stratification (2) Scarification
   (3) Organisms (4) Populations
3. Select the **odd** one out w.r.t. decomposers especially abundant in the bottom of the pond? [NCERT Pg. 242]
   (1) Fungi
   (2) Bacteria
   (3) Flagellates
   (4) Phytoplanktons
4. The rate of formation of new organic matter by consumer is known as [NCERT Pg. 243]
   (1) Primary productivity
   (2) Secondary productivity
   (3) Gross primary productivity
   (4) Net primary productivity

NCERT Based MCQs

5. The annual net primary productivity of the whole biosphere in dry weight is approximately [NCERT Pg. 243]
   (1) 55 billion tons of organic matter
   (2) 70 billion tons of organic matter
   (3) 170 billion tons of organic matter
   (4) 115 billion tons of organic matter
6. The process by which, water soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts is called [NCERT Pg. 243]
   (1) Fragmentation
   (2) Leaching
   (3) Catabolism
   (4) Humification
7. Which of the following conditions inhibit decomposition resulting in buildup of organic materials? [NCERT Pg. 244]
   (1) Low temperature and anaerobiosis
   (2) Warm and moist environment
   (3) Oxygen rich condition
   (4) Nitrogen and sugar rich detritus
8. The major conduit for energy flow in an aquatic ecosystem is [NCERT Pg. 246]
   (1) Grazing food chain
   (2) Detritus food chain
   (3) Parasitic food chain
   (4) Dead organic matter
9. The mass of living material present at each trophic level at a particular time is called as [NCERT Pg. 247]
   (1) Standing state
   (2) Standing crop
   (3) Detritus
   (4) Detritivores
10. The ecological pyramid of energy [NCERT Pg. 249]
    (1) Can be inverted
    (2) Can be spindle shaped
    (3) Is never upright
    (4) Can never be inverted
11. Secondary succession begins in areas where the natural biotic communities have been destroyed such as [NCERT Pg. 251]
    (1) Newly cooled lava
    (2) Abandoned farm lands
    (3) Newly created reservoir
    (4) Freshly dug pond
12. The pioneer species that invade a bare rock to start the process of succession are [NCERT Pg. 251]
    (1) Usually lichens
    (2) Bryophytes
    (3) Phytoplanktons
    (4) Higher plants

13. All succession whether taking place in water or on land, proceeds to a similar climax community, called the [NCERT Pg. 252]
(1) Xeric (2) Hydric
(3) Mesic (4) Seral

14. In primary succession in water, the pioneers are the [NCERT Pg. 251]
(1) Small phytoplanktons
(2) Reed-swamp stage
(3) Submerged plant stage
(4) Submerged free floating stage

15. The entire sequence of communities that successively change in a given area are called [NCERT Pg. 250]
(1) Seres (2) Seral
(3) Pioneer (4) Climax

16. Out of the total cost of various ecosystem services, the soil formation account for about [NCERT Pg. 255]
(1) 50 percent (2) 10 percent
(3) 6 percent (4) 40 percent

17. What is the average price tag put forward by researchers on the fundamental ecosystem services, which are largely taken for granted as they are free? [NCERT Pg. 255]
(1) US $ 33 trillion per day
(2) US $ 18 trillion per year
(3) US $ 33 trillion a year
(4) US $ 33 billion a year

18. Select the **odd** one out w.r.t. gaseous nutrient cycle? [NCERT Pg. 253]
(1) Nitrogen cycle (2) Carbon cycle
(3) Oxygen cycle (4) Sulphur cycle

19. Select the **incorrect** statement w.r.t. ecological pyramids? [NCERT Pg. 250]
(1) It assumes a simple food chain
(2) It does not accommodate a food web
(3) Saprophytes are given a prominent place, as they play a vital role in ecosystem
(4) It does not take into account same species belonging to two or more trophic levels

20. Primary consumers are called [NCERT Pg. 245]
(1) Autotrophs
(2) Herbivores
(3) Top carnivores
(4) Primary carnivore

Thinking in Context

1. _____ is the available biomass for the consumption to heterotrophs (herbivores and decomposers). [NCERT Pg. 243]

2. The humus is further degraded by some microbes and release of inorganic nutrients occur by the process known as _____ [NCERT Pg. 244]

3. _____ secrete digestive enzymes that breakdown dead and waste materials into simple, inorganic materials which are subsequently absorbed by them [NCERT Pg. 246]

4. Based on the source of their nutrition or food, organisms occupy a specific place in the food chain that is known as their _____ [NCERT Pg. 246]

5. The number of trophic levels in the grazing food chain is restricted as the transfer of energy follow _____ [NCERT Pg. 247]

6. When any organism dies it is converted to _____ or dead biomass that serves as an energy source for decomposers. [NCERT Pg. 247]

7. Trophic level represents a _____, not a species as such. [NCERT Pg. 249]

8. The pyramid of biomass in sea is generally _____ because the biomass of fishes far exceeds that of phytoplankton. [NCERT Pg. 249]

9. A community that is in near equilibrium with the environment is called a _____ [NCERT Pg. 250]

10. Primary succession is a _____, taking may be thousands of years for the climax to be reached. [NCERT Pg. 251-252]

11. The amount of nutrients, such as carbon, nitrogen, phosphorus, calcium, etc., present in the soil at any given time is referred to as the _____. [NCERT Pg. 253]

12. Nutrients are never lost from the ecosystems, rather they are _____ time and again indefinitely. [NCERT Pg. 253]

13. For the sedimentary cycle, *e.g.*, sulphur and phosphorus cycles, the reservoir is located in _____. [NCERT Pg. 253]

14. _____ helps to meet the deficit of nutrient which occurs due to imbalance in the rate of influx and efflux. [NCERT Pg. 253-254]

15. According to one estimate _____ of carbon is fixed annually in the biosphere through photosynthesis. [NCERT Pg. 254]

16. Some amount of the fixed carbon is lost to _____ and removed from circulation. [NCERT Pg. 254]

❑ ❑ ❑

17. The natural reservoir of phosphorus is rock, which contains phosphorus in the form of _____ [NCERT Pg. 254]

18. Unlike carbon cycle, there is no respiratory release of _____ into atmosphere. [NCERT Pg. 254]

19. _____ and his colleagues have very recently tried to put price tags on nature's life-support services. [NCERT Pg. 255]

20. Succession begins with _____ of a bare lifeless area by pioneers which later pave the way for successors and ultimately a stable climax community is formed. [NCERT Pg. 256]

Biodiversity and Conservation

Chapter 9

1 INTRODUCTION

- The rich variety of living organisms with which we share this planet never ceases to astonish and fascinate us.
- There are more than 20,000 species of ants, 3,00,000 species of beetles, 28,000 species of fishes and nearly 20,000 species of orchids.

2 BIODIVERSITY

- Immense diversity (or heterogeneity) exists not only at the species level but at all levels of biological organisation ranging from macromolecules within cells to biomes.
- The term 'Biodiversity' was popularised by the socio biologist Edward Wilson. The most important of them are

GENETIC DIVERSITY

- A single species might show high diversity at genetic level over its distributional range.
- *E.g.,* Genetic variation shown by *Rauwolfia vomitoria* in different Himalayan ranges in potency and concentration of reserpine

SPECIES DIVERSITY

- Diversity at the species level
- *E.g.,* Western ghats have a greater amphibian species diversity than Eastern ghats.

ECOLOGICAL DIVERSITY

- At the ecosystem level
- *E.g.,* India with its deserts, rain forests, mangroves, coral reefs, wetlands, estuaries and alpine meadows has a greater ecosystem diversity than a Scandinavian country like Norway.

* India has more than 50,000 genetically different strains of rice, and 1,000 varieties of mango.

3 HOW MANY SPECIES ARE THERE ON EARTH AND HOW MANY IN INDIA?

- According to IUCN (2004), the total number of plant and animal species described so far is slightly more than 1.5 million.
- For many taxonomic groups, species inventories are more complete in temperate than in tropical countries.
- Some extreme estimates range from 20 to 50 million, but a more conservative and scientifically sound estimate made by Robert May places the global species diversity at about 7 million.

Interesting Aspects of Earth's Biodiversity:

a. More than 70% of all species recorded are animals, while plants (including algae, fungi, bryophytes, gymnosperms and angiosperms) comprise no more than 22% of the total.
b. Among animals, insects make more than 70% of total, i.e., out of every 10 animals on this planet, 7 are insects.
c. Number of fungi species is more than fishes, amphibians, reptiles and mammals combined.

- Biologists are not sure about how many prokaryotic species there might be, as conventional taxonomic methods are not suitable for identifying microbial species and many are not culturable under laboratory conditions. Their diversity alone might run into millions.
- Although, India has only 2.4% of world's land area; its share of the global species diversity is an impressive 8.1 percent.
- India is one of the 12 mega diversity countries of the world. Nearly 45,000 species of plants and twice as many of animals have been recorded from India.
- If we accept May's global estimates, only 22 percent of the total species have been recorded so far, then, India has more than 1,00,000 plant species and 3,00,000 animal species yet to be discovered.

4 PATTERNS OF BIODIVERSITY

A. LATITUDINAL GRADIENTS

- Species diversity decreases as we move from equator towards the poles.
- Tropics (23.5° N to 23.5°S) harbour more species than temperate or polar areas.

Eg., Colombia	Newyork	Greenland	India
Near Equator	41° N temperate	71°N poles	Tropics
1,400 bird species	105 bird species	56 bird species	1,200 bird species

- A forest in a tropical region like Equador has upto 10 times more vascular plants, as a forest of equal area in temperate midwest of USA.
- Scientists estimate that in the Amazon rain forests, there might be at least two million insect species waiting to be discovered and named.

LARGELY TROPICAL AMAZON RAIN FOREST IN SOUTH AMERICA- has greatest biodiveristy on Earth.

- 40,000 species of plants
- 3,000 of fishes
- 1,300 of birds
- 427 of mammals.
- 427 of amphibians
- 378 of reptiles
- More than 1,25,000 invertebrates

Ecologists and Evolutionary biologists have proposed various hypotheses to explain greater biological diversity at the tropics.

a. Unlike temperate regions subjected to frequent glaciations in the past, tropical latitudes remained undisturbed, having long evolutionary time for species diversification.
b. Constant, less seasonal tropical environments promote niche specialisation and lead to greater species diversity.
c. More solar energy in tropics contributes to higher productivity and might contribute indirectly to greater diversity.

B. SPECIES-AREA RELATIONSHIPS (by German naturalist Alexander Von Humboldt)

- Species richness within a region increased with increasing explored area, but only up to a limit.
- The relation between species richness and area for a wide variety of taxa (angiosperms, birds, bats, freshwater fishes) is a rectangular hyperbola. On a logarithmic scale, it is a straight line, described by the equation

$$\log S = \log C + Z \log A$$

where S = species richness; A = Area; Z = Slope of the line (regression coefficient); C = Y intercept.

- The value of Z lies in the range of 0.1 to 0.2 regardless of region or taxa.
- But, the slope of the line is much steeper in very large areas like the entire continents. *e.g.,* for frugivorous birds and mammals in tropical forests the slope is 1.15.

5 IMPORTANCE OF SPECIES DIVERSITY TO THE ECOSYSTEM

- Communities with more species, tend to be more stable than those with less species. A stable community should not show too much variation in productivity from year to year; it must be resistant or resilient to occasional disturbances (natural or man-made), and it must also be resistant to invasions by alien species.
- David Tilman's long-term ecosystem experiments using outdoor plots show that plots with more species showed less year-to-year variation in total biomass and increased diversity contributed to higher productivity.
- Rich biodiversity is essential for ecosystem health and imperative for the very survival of human race on this planet.
- The 'rivet popper hypothesis' of Stanford ecologist **Paul Ehrlich**, puts the importance of a species in proper perspective.

AIR PLANE	ECOSYSTEM
Rivets	Species
Rivet on the wings	Key species.

(i) Popping a rivet (causing a species to become extinct) may not affect flight safety (proper functioning of ecosystem) initially, but if more rivets are removed the plane will become dangerously weak.

(ii) Loss of rivets on the wings (Key species, that drive major ecosystem functions) will be serious. So each species is important for the ecosystem

6 LOSS OF BIODIVERSITY

- The colonisation of tropical pacific islands by humans led to extinction of more than 2,000 species of native birds. The IUCN red list (2004) documents extinction of 784 species (including 338 vertebrates, 359 invertebrates and 87 plants) in the last 500 yrs.
- The last 20 years alone witnessed disappearance of 27 species.
- Amphibians appear more vulnerable to extinction.
- 15,500 species world-wide are facing threat of extinction.
- There were five episodes of mass extinction of species in the past, before humans appeared.
- The 'Sixth Extinction' presently in progress is 100 to 1000 times faster than pre-human times and our activities are responsible for the faster rates.
- If the present trends continue, nearly half of all species on earth might be wiped out within the next 100 years.
- Loss of biodiversity in a region may lead to (a) decline in plant production, (b) lowered resistance to environmental perturbations like drought, and (c) Increased variability in plant productivity, water use and pest and disease cycles.

Recent Extinctions

1.	Dodo	– Mauritius
2.	Quagga	– Africa
3.	Thylacine	– Australia
4.	Steller's sea cow	– Russia
5.	Three sub-species of tiger	– Bali, Javan & Caspian

Species Facing Threat of Extinction in World

12% Birds
23% Mammals
32% Amphibians
31% Gymnosperms

7 CAUSES OF BIODIVERSITY LOSSES: THE EVIL QUARTET-FOUR MAJOR CAUSES

Habitat Loss and Fragmentation

- Most important cause.
- Tropical rain forests once covered more than 14% of earth's land, now it is just 6%.
- Amazon rain forest (lungs of the planet), being cut for soyabeans cultivation and grasslands for raising beef cattle.
- Mammals and birds requiring large territories and animals with migratory habits are badly affected, leading to population declines.

Over-Exploitation

- When need turns to greed, there is over-exploitation.
- In the last 500 years steller's sea cow, passenger pigeon became extinct due to over-exploitation.
- Marine fish populations are over harvested, endangering commercially important species.

Alien Species invasions

- Nile perch introduced in Lake Victoria in East-Africa led to the extinction of 200 sps of Cichlid fish in the lake.
- Carrot grass *(Parthenium), Lantana* and water hyacinth *(Eichhornia)* are invasive weeds.
- African catfish *Clarias gariepinus* are posing threat to indigenous cat fishes.

Co-Extinctions

- Seen in obligatory associations.
- When a host species becomes extinct, its parasites meets the same fate.
- Co- evolved plant-pollinator mutualism is another example

8 BIODIVERSITY CONSERVATION

Why should we conserve biodiversity?

Narrowly Utilitarian Arguments

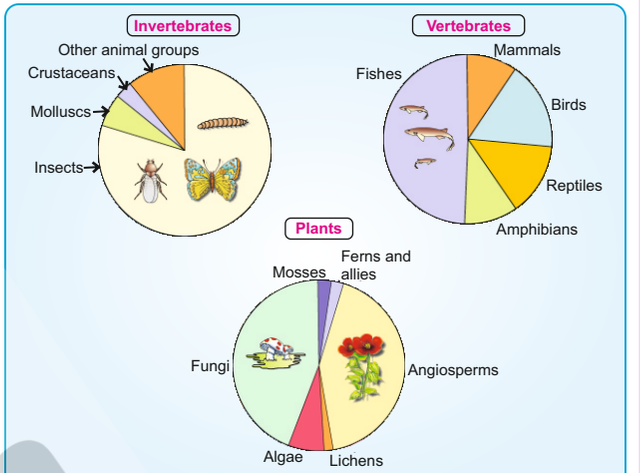
- Humans derive countless direct economic benefits from nature – food, firewood, fibre, construction material, industrial products and medicinal products.
- More than 25% drugs are derived from 25,000 sp. of plants.
- Nations endowed with rich biodiversity can reap enormous benefits by 'bioprospecting' - exploring molecular, genetic and species level diversity for products of economic importance.

Broadly Utilitarian Arguments

- Biodiversity plays a major role in many ecosystem services that nature provides.
- Amazon rain forest produce approx 20% of total oxygen of Earth's atmosphere by photosynthesis.
- Pollination by bees, bumble-bees, birds and bats.
- Aesthetic pleasures of walking through woods, watching spring flowers bloom, waking upto a bulbul's song etc.

Ethical Arguments

- Philosophically or spiritually we have to understand that each species has a intrinsic value.
- We have a moral duty to care for their well-being.
- We need to pass on our biological legacy in good order to future generations.



Representing global biodiversity

9 HOW DO WE CONSERVE BIODIVERSITY?

When we conserve and protect whole ecosystem, i.e., saving the entire forest to save the tiger it is called *in-situ* (on site) conservation. And organisms facing a very high risk of extinction in the wild, in near future, needs urgent measures to save it from extinction, then *ex-situ* (offsite) conservation is desirable.

In-situ Conservation

- **Biodiversity Hot Spots:** Regions with very high levels of species richness and high degree of endemism (species confined to a particular region & not found anywhere else).
  Total number are 25 (initially) +9 (added later) = 34.
  Three of these – western ghats and Sri Lanka, Indo-Burma & Himalaya – Cover our country's regions.
  They (all 34) cover less than 2% of Earth's land area and their strict protection could reduce the ongoing mass extinctions by 30%.
- 14 biosphere reserves, 90 National Parks and 448 wild life sanctuaries provide legal protection in India.
- **Sacred groves** in Khasi and Jaintia Hills of Meghalaya, Aravalli Hills (Rajasthan), Western Ghats, Sarguja, Chanda and Bastar regions (Madhya Pradesh) are the last refuges of rare and threatened plants.

Ex-situ Conservation

- Zoological Parks, Botanical gardens and wild-life Safari parks serve this purpose.
- Many animals have become extinct in the wild but are maintained in zoological parks.
- Cryopreservation- to protect and preserve gametes of threatened species in viable and fertile condition.
- Plants can be propagated using tissue culture methods.
- Seeds of different genetic strains, of commercially important plants can be kept for long periods in seed banks.

- The historic Convention on Biological diversity (The Earth Summit) was held in Rio de Janeiro (1992) for biodiversity conservation and sustainable utilisation of benefits.
- World summit on sustainable development (WSSD) held in 2002 in Johannesburg pledged for significant reduction in current rate of biodiversity loss at global, regional and local levels by 2010.
- If the present trend of species extinction continues nearly half of all species on Earth might be wiped out within the next 100 years.
- More than 1.5 m species have been recorded in the world, but there might still be nearly 6 million species on earth waiting to be discovered and named.
- The group fungi has more species than all the vertebrate species combined.
- Earth's fossil history reveals incidence of five mass extinctions in the past, but the present rates of extinction, largely attributed to human activities, are 100 to 1000 times higher.
- Earth's rich biodiversity is vital for the survival of mankind.
- Nearly 700 species have become extinct in recent times and more than 15,500 species (of which >650 are from India) currently face the threat of extinction.
- In many cultures, tracts of forests were set aside, and all the trees and wildlife within were venerated and given total protection, they are sacred groves.
- Biodiversity hot spots are the regions of accelerated habitat loss.

Sharpen Your Understanding

1. The variation shown by the medicinal plant *Rauwolfia vomitoria* growing in different Himalayan ranges might be in terms of potency and concentration of the active chemical (reserpine) that the plant produces, it denotes [NCERT Pg. 259]
   (1) Ecological diversity
   (2) Species diversity
   (3) Genetic diversity
   (4) Ecosystem diversity
2. The more conservative and scientifically sound estimate made by Robert May has placed the global species diversity at about [NCERT Pg. 259]
   (1) 1.5 million
   (2) 20 to 50 million
   (3) 2.5 million
   (4) 7 million
3. Among animals, the most species-rich taxonomic group, making up more than 70 percent of the total are: [NCERT Pg. 260]
   (1) Insects (2) Mammals
   (3) Amphibians (4) Reptiles
4. Although India has only 2.4 percent of the world's land area, its share of the global species diversity is an impressive [NCERT Pg. 261]
   (1) 12% (2) 7%
   (3) 8.1% (4) 16%
5. With much of its land area in the tropical latitudes, the number of species of birds in India is more than [NCERT Pg. 261]
   (1) 1400 (2) 1200
   (3) 105 (4) 56
6. What might account for greater biological diversity at the tropics? [NCERT Pg. 261-262]
   (1) Frequent glaciations in the past and disturbed conditions
   (2) More seasonal and unpredictable environment
   (3) More solar energy available in tropics contributes to higher productivity and indirectly greater diversity
   (4) Unpredictable environment did not allow niche specialisation
7. The 'rivet popper hypothesis' to explain the importance of every single species in the ecosystem, was used by Stanford ecologist: [NCERT Pg. 263]
   (1) Paul Ehrlich
   (2) David Tilman
   (3) Alexander von Humboldt
   (4) Edward Wilson
8. The most important cause driving animals and plants to extinction is: [NCERT Pg. 264]
   (1) Alien species invasions
   (2) Habitat loss and fragmentation
   (3) Over-exploitation
   (4) Co-extinctions
9. Extinctions of Steller's sea cow and Passenger pigeons were due to [NCERT Pg. 265]
   (1) Habitat loss
   (2) Ethical reasons
   (3) Over exploitation by humans
   (4) Co-Evolution
10. The 'Sixth Extinction' presently in progress is different from the previous episodes in which aspect? [NCERT Pg. 264]
    (1) Human activities are not responsible
    (2) Being much slower and less harmful
    (3) 100 to 1000 times faster than in pre-human times
    (4) There is no biodiversity losses
11. Exploring molecular, genetic and species-level diversity for products of economic importance is called: [NCERT Pg. 265]
    (1) Biomagnification (2) Biodiversity
    (3) Biofortification (4) Bioprospecting
12. The Ethical argument for conserving biodiversity relates to : [NCERT Pg. 266]
    (1) Ecosystem services
    (2) Philosophical or spiritual values
    (3) Aesthetic pleasures
    (4) Endemism

NCERT Based MCQs

13. Strict protection of biodiversity hotspots could reduce the ongoing mass extinctions by almost: [NCERT Pg. 267]
(1) 2 percent
(2) 30 percent
(3) 50 percent
(4) 15 percent

14. In Meghalaya, the last refuges for a large number of rare and threatened plants, are the [NCERT Pg. 267]
(1) Sanctuaries
(2) Biospheres
(3) Sacred groves
(4) Seed banks

15. Gametes of threatened species can be preserved in viable and fertile conditions for long periods by [NCERT Pg. 267]
(1) Tissue culture methods
(2) Cryopreservation techniques
(3) Seed banks
(4) Zoological parks

16. 190 countries pledged their commitment to achieve by 2010, a significant reduction in the current rate of biodiversity loss at global, regional and local levels at [NCERT Pg. 267]
(1) The Earth summit, 1992
(2) World summit on sustainable development, 2002
(3) Convention on biological diversity
(4) Conference of parties

17. Threatened animals and plants are taken out from their natural habitat and placed in special setting where they can be protected and given special care in [NCERT Pg. 267]
(1) *Ex-situ* conservation
(2) *In-situ* conservation
(3) On site conservation
(4) Sacred groves

18. The aesthetic pleasures of walking through thick woods, watching spring flowers in full bloom or waking up to a bulbul's song in the morning, comes under which approach for conserving biodiversity? [NCERT Pg. 266]
(1) Narrowly utilitarian
(2) Broadly utilitarian
(3) Ethical argument
(4) Direct Economic Benefit

19. When a host fish species becomes extinct, its unique assemblage of parasites also meets the same fate. This can be explained as an example of [NCERT Pg. 265]
(1) Alien species invasion
(2) Mutualism
(3) Co-extinction
(4) Endemism

20. The whole ecosystem and its biodiversity at all levels is protected by establishing a [NCERT Pg. 266-267]
(1) Wildlife safari
(2) Seed bank
(3) Botanical garden
(4) Biosphere reserve

Thinking in Context

1. Seeds of different genetic strains of commercially important plants can be kept for long periods in _____ [NCERT Pg. 267]

2. The recent illegal introduction of the African catfish _____ for aquaculture purposes is posing a threat to the indigenous catfishes in our rivers. [NCERT Pg. 265]

3. The _____ introduced into Lake Victoria in east Africa led eventually to the extinction of an ecologically unique assemblage of more than 200 species of cichlid fish in the lake. [NCERT Pg. 265]

4. During the long period (>3billion years) since the origin and diversification of life on earth there were _____ of mass extinction of species. [NCERT Pg. 264]

5. The colonisation of tropical pacific islands by humans is said to have led to the extinction of more than _____ of native birds [NCERT Pg. 263]

6. _____ found that plots with more species showed less year-to-year variation in total biomass. [NCERT Pg. 263]

7. For many decades, ecologists believed that communities with more species, generally, tend to be _____ than those with less species. [NCERT Pg. 262]

8. If we analyse the species-area relationships among very large areas like the entire continents, we find the slope of the line to be _____. [NCERT Pg. 262]

9. Tropical environments unlike temperate ones, are _____, relatively more constant and predictable. [NCERT Pg. 262]

10. Scientists estimate that in the rain forests there might be at least two million _____ waiting to be discovered and named. [NCERT Pg. 261]

11. Adding to the grim scenario of extinctions is the fact that more than _____ world-wide are facing the threat of extinction [NCERT Pg. 264]

12. Besides total loss, the degradation of many habitats by _____ also threatens the survival of many species. [NCERT Pg. 264]

13. Presently many marine fish populations around the world are _____, endangering the continued existence of some commercially important species. [NCERT Pg. 265]

14. In general, species diversity _____as we move away from the equator towards the poles. [NCERT Pg. 261]

15. If we accept Robert May's global estimates, only _____ of the total species have been recorded so far. [NCERT Pg. 261]

16. Conventional taxonomic methods are not suitable for identifying _____ and many species are simply not culturable under laboratory conditions. [NCERT Pg. 260]

17. Applying May's proportion to India's diversity figures, there are probably more than A plant species and more than B animal species yet to be discovered and described. [NCERT Pg. 261]

18. Biodiversity is the term popularised by the socibiologist _____ to describe the combined diversity at all the levels of biological organisation [NCERT Pg. 258-259]

19. India has more than A genetically different strains of rice, and B varieties of mango. [NCERT Pg. 259]

20. Western Ghats have a greater _____ species diversity than the Eastern Ghats [NCERT Pg. 259]

❑ ❑ ❑

Environmental Issues

10 Chapter

1 INTRODUCTION

- Pollution is any undesirable change in physical, chemical or biological characteristics of air, land, water or soil.
- Agents that bring about such undesirable change are called pollutants.
- The government of India passed the **Environment (protection) Act, 1986** to protect and improve the quality of our environment.

2 AIR POLLUTION AND ITS CONTROL

- We are dependent on air for our respiratory needs.
- Air pollutants cause injury to all living organisms as they reduce the yield of crops and also deleteriously affect the respiratory system of humans and animals.
- Harmful effects depends on concentration of pollutants, duration of exposure and the organism.
- Smoke stacks of thermal power plants, smelters and other industries release particulate and gaseous air pollutants. These pollutants must be separated/filtered out before releasing the harmless gases into the atmosphere.
- According to **CPCB**, particulate size 2.5 mm or less in diameter **(PM2.5)**, can be inhaled deep into the lungs, causing respiratory symptoms, irritation, lungs damage and premature death.

Control Strategies

- **Electrostatic Precipitator** can remove 99% particulate matter present in exhaust from a thermal power plant.
- **Scrubber** can remove gases like SO_2.
- **Catalytic Converter** with platinum, palladium and rhodium-as catalysts, in automobiles, convert unburnt hydrocarbons into CO_2 and H_2O, and carbon monoxide and nitric oxide to CO_2 and nitrogen gas. **But they need unleaded petrol as lead inactivates the catalyst.**

Noise as an Air Pollutant

- The **Air (Prevention and control of pollution) Act 1981**, was amended in **1987, to include NOISE as an air-pollutant**.
- **Noise** is undesired high level of sound.
- A brief exposure of extremely high sound level **150 dB or more** generated by jet plane or rocket can damage ear drums and can cause permanent loss of hearing ability.
- Chronic exposure of lower noise level may permanently damage hearing abilities.
- Noise also causes sleeplessness, increased heart beat, altered breathing pattern, thus considerably stressing humans.
- To control noise pollution use of sound-absorbent materials or by muffling noise; delimitation of harm-free zones, timings for loudspeakers etc. need to be enforced.

3 CONTROLLING VEHICULAR AIR-POLLUTION–A CASE STUDY OF DELHI

- In the 1990s, Delhi ranked 4th among the 41 most polluted cities of the world and a PIL was filed in the Supreme Court of India and under its directives:
  - All buses of Delhi were converted to run on CNG by the end of 2002, as CNG burns efficiently, was cheaper and cannot be siphoned off by thieves and adulterated like petrol and diesel.
  - Old vehicles were phased out.
  - Use of unleaded petrol.
  - Use of low-sulphur petrol/diesel.
  - Use of catalytic converters and stringent pollution norms etc.
- More stringent norms for fuels means steadily reducing sulphur and aromatic content in petrol and diesel fuels.
- **Euro III Norms** stipulate sulphur at 350 ppm in diesel and 150 ppm in petrol. Aromatic hydrocarbon at 42%. **Road map** is to reduce sulphur to 50 ppm in petrol and diesel and aromatic hydrocarbon to 35%.

4 WATER POLLUTION AND ITS CONTROL

- Government of India passed the water (prevention and control of pollution) Act, 1974 to safeguard our water resources.
- **Domestic Sewage and Industrial Effluents**
  - A mere 0.1% impurities make domestic sewage unfit for human use.
  - Domestic sewage primarily contains biodegradable organic matter, which decomposes readily by the help of bacteria and other micro-organisms.
  - Amount of biodegradable organic matter in sewage is estimated by measuring the Biochemical Oxygen Demand (BOD).
  - Micro-organisms involved in biodegradation of organic matter in the receiving water body consume a lot of oxygen, as a result there is a sharp decline in Dissolved Oxygen (DO), causing **mortality of fishes and other aquatic creatures**.

- Air pollution primarily results from burning of fossil fuel, e.g., coal and petroleum in industries and automobiles.

- Large amounts of nutrients causes algal bloom, which imparts colour to water bodies, deteriorates water quality and cause fish mortality. Bloom forming algae are extremely toxic to human beings and animals.
- *Eichhornia crassipes* (water hyacinth) world's most problematic aquatic weed also called Terror of Bengal; was introduced in India for their lovely flowers, have caused havoc by excessive growth and blocking water ways.

4A - Biomagnification

- Increase in the concentration of toxicant at successive trophic levels, in the aquatic food chain. As the toxic substance is neither metabolised nor excreted, so passed on to next trophic level.

e.g: Mercury or DDT.

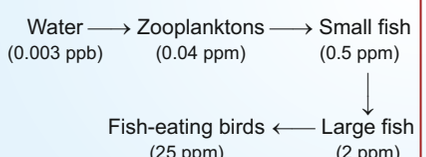


Fig: Biomagnification of DDT in an aquatic food chain.

4B - Eutrophication

- Natural aging of lake by **nutrient enrichment** of its water, which may span thousands of years.
- **Cultural or Accelerated Eutrophication:** Pollutants from man's activities like effluents from industries and homes can radically accelerate the aging process. Prime contaminants are **nitrates and phosphates**, which act as plant nutrients. They overstimulate algal growth causing unsightly scum and unpleasant odours, robbing water of dissolved oxygen vital to other aquatic life. Other pollutants flowing into a lake may poison whole populations of fish. The lake can literally choke to death.

Heated (thermal) Waste Waters from thermal power plants, eliminates or reduces the number of organisms sensitive to high temperature and may enhance the growth of plants and fish in extremely cold areas, after causing damage to indigenous flora and fauna.

5 CASE STUDY-INTEGRATED WASTE WATER TREATMENT

- **Town of Arcata** - along Northern coast of California (with biologists from Humboldt state university) utilising a mix of **artificial and natural processes** the towns people created an integrated waste water treatment process within a natural system. The cleaning occurs at two stages:
  - The conventional sedimentation, filtering and chlorination.
  - The biologists developed six connected marshes over 60 hectares of marsh land, seeding appropriate plants, algae, fungi and bacteria, which neutralise, absorb and assimilate the pollutants and water flows through the marshes and gets purified naturally. The marshes constitute a sanctuary with high biodiversity. Friends of the Arcata Marsh (FOAM) is responsible for the upkeep and safeguarding of this wonderful project.
- **'Ecosan' toilets** - Ecological sanitation is a sustainable system for handling human excreta, using **Dry Composting Toilets** - a practical, hygienic, efficient and cost-effective solution to human waste disposal.
- By this method, human excreta can be recycled into natural fertilizer, which reduces the need of chemical fertilizers. Ecosan toilets are working in many areas of Kerala and Sri Lanka.

- Domestic sewage, most common source of pollution of water bodies, reduces DO but increases BOD of receiving water.
- Domestic sewage is rich in nutrients like nitrogen and phosphorus which cause eutrophication and algal blooms.

6 SOLID WASTES

- Everything that goes out in trash is solid waste.

(A) Municipal solid waste: Comprise paper, food wastes, plastics, glass, metals, rubber, leather, textile, etc. Burning reduces volume of wastes. Open dumps serve as breeding grounds of rats and flies.

Sanitary land fills is a substitute for open burning dumps. Wastes are dumped in a depression or trench after compaction and covered with dirt everyday.

Landfills get filled in metros due to large amount of garbage, also there is danger of seepage of chemicals which pollute underground water resources.

(B) Electronic wastes (e-wastes): Irreparable computers and other electronic goods. E-wastes are burried or incinerated.

Over half of e-wastes generated in developed world are exported to developing countries like China, India and Pakistan where metals like copper, iron, silicon, nickel and gold are recovered during recycling process. **Recycling is the only solution for treatment of e-wastes**.

(C) Hospitals generate **hazardous wastes**, that contain disinfectants and other harmful chemicals and pathogenic micro-organisms. The use of INCINERATORS is crucial to disposal of hospital waste.

7 CASE STUDY OF REMEDY FOR PLASTIC WASTE

- Ahmed Khan, realised that plastic waste was a real problem.
- **Polyblend**, a fine powder of recycled modified plastic, was developed by his company. This mixture is mixed with bitumen that is used to lay roads.
- In collaboration with R.V. College of Engineering and Bangalore city corporation, Ahmed Khan proved that blends of polyblend and bitumen, when used to lay roads, enhanced the bitumen's water repellant properties and helped to increase road life by a factor of three.
- The raw material is any plastic film waste. So against the price of Rs. 0.40/kg Khan now offers Rs. 6 to ragpickers.
- Using Khan's technique by the year 2002, more than 40 kms of road in Bangalore has already been laid.

8 AGRO-CHEMICALS AND THEIR EFFECTS

- Pesticides, herbicides, fungicides, etc. are toxic to non-target organisms, that are important components of soil ecosystem.

Case Study of Organic Framing

- Integrated organic farming is a cyclical, zero-waste procedure, where waste products from one process are cycled in as nutrients for other processes. This allows maximum utilisation of resource and increases the efficiency of production.
- Ramesh Chandra Dagar, a farmer in Sonipat, Haryana, includes bee-keeping, dairy management, water harvesting, composting and agriculture in a chain of processes and allow an extremely economical and sustainable venture.
- No need to use chemical fertilizers, cattle dung used as manure, crop waste to create compost or used to generate natural gas for energy needs of farm. Dagar created the Haryana Kisan Welfare Club, with membership of 5000 farmers.

9 RADIOACTIVE WASTES

Nuclear energy has two very serious inherent problems

- **Accidental Leakage**
  - Three mile island
  - Chernobyl
- **Safe disposal of radioactive wastes**
  - Radiation from nuclear waste causes mutations at a very high rate.
  - Higher doses is lethal; lower doses creates various disorders like cancer.

- Storage of nuclear waste, after sufficient pre-treatment should be done in suitable containers buried in rocks, about 500 m deep below earth's surface.

10 GREENHOUSE EFFECT AND GLOBAL WARMING

- Greenhouse effect is a naturally occurring phenomenon responsible for heating Earth's surface and atmosphere. Without this average temperature at surface of Earth would be chilly - 18°C rather than the present average of 15°C.
- Greenhouse gases absorb long wave (infrared) radiation from Earth and emit it again towards the Earth. The cycle continues till the Earth's surface has no long wave radiation to emit.
- Relative contribution of various greenhouse gases to total global warming is CO_2 (60%); CH_4 (20%); CFCs (14%) and N_2O (6%).
- Increase in level of greenhouse gases led to considerable heating of Earth leading to GLOBAL WARMING and odd climatic changes (e.g. El Nino effect), melting of polar ice caps and Himalayan snow caps, rise in sea-level and submergence of coastal areas.

11 OZONE DEPLETION IN THE STRATOSPHERE

Ozone (Types)

Good Ozone

- Found in upper atmosphere, the stratosphere acts as a shield absorbing UV radiation from sun
- DNA and proteins absorb UV rays, so it is highly injurious to living organisms.

Bad Ozone

- Found in lower atmosphere, the troposphere, that harms plants and animals.

- **Chloro-Fluoro-Carbons (CFC)** used as refrigerants degrade ozone layer, by releasing cl-atoms.
- CFC have permanent and continuing effects on ozone levels.
- UV radiations, shorter to UV-B are completely absorbed by ozone layer.
- UV-B-damages DNA, causes aging of skin, inflammation of cornea called snow blindness cataract, etc.
- Montreal protocol signed in 1987 (effective in 1989) controls emission of ODS, i.e., CFCs.
- Thickness of the ozone in a column of air from the ground to the top of the atmosphere is measured in terms of dobson units (DU).
- Ozone hole over Antarctica develops each year between late August and early october.

12 DEGRADATION BY IMPROPER RESOURCE UTILISATION AND MAINTENANCE

- **Soil Erosion and Desertification**
  - Development of top-soil takes centuries.
  - But over-cultivation, unrestricted grazing, deforestation and poor irrigation degrades it making arid patches of land.
  - Large barren patches meet to form desert .
  - Desertification has become a major problem due to increased urbanisation.
- **Water Logging and Soil Salinity**
  - Irrigation without drainage results in water logging.
  - Water logging draws salt on surface of soil, depositing in a thin crust or collects at the roots, affecting growth.
  - Water logging and salinity have come due to Green Revolution.
- **Deforestation**
  - 40% forests have been lost in tropics compared to only 1% in temperate region.
  - National forest policy (1988) of India recommended 33% forest for plains and 67% for hills.
  - **Slash and burn agriculture (Jhum cultivation)** in North-East of India contribute to deforestation.
  - Enhanced CO_2 concentration, loss of biodiversity, disturbed hydrologic cycle, soil erosion and desertification are the consequences of deforestation.

13 CASE STUDY-PEOPLE'S PARTICIPATION IN CONSERVATION OF FOREST

- A Bishnoi woman **Amrita Devi**, her three daughters and hundreds other lost their lives saving trees by hugging and daring king's men at Jodhpur.
- The Government of India instituted **Amrita Devi Bishnoi wildlife protection award** for individuals or communities from rural areas that have shown extraordinary coverage and dedication in protecting wildlife.
- **Chipko Movement** of Garhwal Himalayas (1974): Local women showed bravery in protecting trees. People all over world have acclaimed Chipko movement.
- Government of India in 1980s introduced **Joint Forest Management (JFM)**. Local communities protect and manage forest, in return they get benefit of various forest products (fruit, gum, rubber etc.).

- Disposal of hazardous wastes like **defunct ships**, radioactive wastes and e-wastes requires additional efforts.
- Soil pollution result from pesticides and **leachates** from solid wastes deposited over it.
- Enhanced greenhouse effect is warming the earth, it may drastically change rainfall pattern, global temperature, besides deleteriously affecting living organisms.

Sharpen Your Understanding

1. The process of restoring a forest that once existed but was removed at some point of time in the past is known as [NCERT Pg. 284]
   (1) Jhum cultivation
   (2) Deforestation
   (3) Reforestation
   (4) Chipko movement

2. The liquid that exists as part of waste in a land fill and which can percolate and mix with the ground water near the site, if the land fill is not properly lined and managed is called [NCERT Pg. 285]
   (1) Leachates
   (2) Pesticides
   (3) Agrochemicals
   (4) Herbicides

3. To work closely with the local communities for protecting and managing forests, the Government of India in 1980s, introduced the concept of [NCERT Pg. 285]
   (1) Hugging a tree before cutting
   (2) Slash and burn agriculture
   (3) Joint forest management
   (4) Reforestation

NCERT Based MCQs

4. The Amrita Devi Bishnoi wildlife Protection Award for showing extraordinary courage and dedication in protecting wildlife, has been recently instituted by the Government of India for [NCERT Pg. 285]
   (a) Individuals
   (b) Communities
   (c) State Governments
   (d) NGOs
   Select the correct answer?
   (1) Only (a) and (b)
   (2) Only (c) and (d)
   (3) (a), (b) and (c)
   (4) All (a), (b), (c) and (d)

5. Select the **odd** one out w.r.t. the consequences of deforestation? [NCERT Pg. 284]
   (1) Enhanced carbondioxide concentration in atmosphere
   (2) Soil erosion
   (3) Enhanced biodiversity
   (4) Desertification in extreme cases

6. The percentage of forest cover recommended by National Forest Policy (1988) of India for the hills is [NCERT Pg. 284]
   (1) 33% (2) 67%
   (3) 40% (4) 21.54%

7. North-Eastern states of India, has also contributed to deforestation, mainly due to the practice of [NCERT Pg. 284]
   (1) Chipko movement
   (2) Jhum cultivation
   (3) Reforestation
   (4) Habitat management

8. High dose of UV-B causes inflammation of cornea, which may permanently affect vision. This condition is called [NCERT Pg. 283]
   (1) Cataract
   (2) Cancer
   (3) Snow-blindness
   (4) Wrinkles

9. Montreal protocol signed at Montreal (Canada) to control the emission of ozone depleting substances, became effective in [NCERT Pg. 283]
   (1) 1987
   (2) 1988
   (3) 1989
   (4) 1990

10. Bad ozone is formed in the [NCERT Pg. 282]
    (1) Upper atmosphere
    (2) Stratosphere
    (3) Exosphere
    (4) Troposphere

11. Select the odd one out w.r.t. measures for controlling global warming? [NCERT Pg.282]
(1) Reducing deforestation
(2) Slowing down growth of human population
(3) Accelerating and increasing the use of fossil fuel
(4) Improving efficiency of energy usage

12. Greenhouse gases mainly absorb [NCERT Pg. 281]
(1) Short-wave radiations
(2) Long-wave radiations
(3) Photo synthetically active radiations
(4) UV-radiations

13. Radiations given off by nuclear waste is extremely damaging to organisms, because it causes [NCERT Pg. 280]
(1) Greenhouse effect
(2) Global warming
(3) Ozone depletion
(4) Mutations at very high rate

14. The 'EcoSan' toilets working in many parts of Kerala and Sri Lanka [NCERT Pg. 278]
(1) Waste a lot of water
(2) Are unhygienic
(3) Need chemical fertilizers
(4) Are dry composting toilets

15. Pollutants from man's activities like effluents from industries and homes can radically accelerate the aging process of waterbodies or lakes, the phenomenon is called [NCERT Pg. 277]
(1) Biomagnification
(2) Bio-accumulation
(3) Cultural eutrophication
(4) Bio fortification

16. Sharp decline in dissolved oxygen in rivers and other water bodies results in [NCERT Pg. 275]
(1) Decline in BOD
(2) Mortality of fishes
(3) Good growth of aquatic creatures
(4) Increased fertility of the water body

17. The Government of India passed the water (Prevention and Control of Pollution) Act, to safeguard our water resources in the year [NCERT Pg. 274]
(1) 1974
(2) 1981
(3) 1987
(4) 1986

18. The world's most problematic aquatic need, i.e., *Eichhornia crassipes* [NCERT Pg. 275-276]
(1) Grows abundantly in eutrophic water bodies
(2) Helps in maintaining ecosystem dynamics
(3) Clears and cleans our water ways
(4) Is called the 'treasure of Bengal'

19. As the exhaust of automobiles passes through the catalytic converter, the unburnt hydrocarbons are converted into [NCERT Pg. 272]
(1) Carbon monoxide
(2) Nitric oxide
(3) CO_2 and H_2O
(4) Nitrous acid

20. Heated (thermal) waste waters flowing out of electricity generating units [NCERT Pg. 277]
(1) Do not constitute a pollutant type
(2) Enhance growth of plants and fish in extremely hot areas
(3) Increases number of organisms sensitive to high temperature
(4) Constitute another important category of pollutants

Thinking in Context

1. The Government of India has passed the Environment (Protection) Act, 1986 to protect and improve the quality of our _____. [NCERT Pg. 270]
2. Motor vehicles equipped with catalytic converter should use unleaded petrol because lead in the petrol _____ the catalyst. [NCERT Pg. 272]
3. A brief exposure to extremely high sound level __A__ or more generated by take off of a jet plane or rocket, may damage __B__ thus permanently impairing hearing ability. [NCERT Pg. 272]
4. Reduction of noise in our industries can be affected by use of _____ or by muffling noise. [NCERT Pg. 272]
5. _____ stipulate that sulphur be controlled at 350 parts-per-million in diesel and 150 ppm in petrol, to cut down vehicular pollution. [NCERT Pg. 273]
6. A mere _____ impurities make domestic sewage unfit for human use. [NCERT Pg. 274]
7. Presence of large amount of nutrients in waters causes excessive growth of planktonic (free-floating) algae, called _____. [NCERT Pg. 275]
8. High concentration of DDT disturb _____ in birds which causes thinning of egg shell and their premature breaking, eventually causing decline in bird populations. [NCERT Pg. 276]
9. In a young lake the water is _____, supporting little life. [NCERT Pg. 276]
10. Depending on climate, size of the lake and other factors the _____ of a lake may span thousands of years. [NCERT Pg. 277]
11. In _____, wastes are dumped in a depression or trench after compaction and covered with dirt everyday. [NCERT Pg. 278]
12. All the garbage generated should be sorted. What can be reused or recycled should be separated out; our _____ do a great job of separation of materials for recycling. [NCERT Pg. 278]
13. The use of _____ is crucial to disposal of hospital waste. [NCERT Pg. 279]
14. State Governments across the country are trying to push for reduction in use of _____ and use of eco-friendly packaging. [NCERT Pg. 278]
15. _____ is the only solution for the treatment of e-waste, provided it is carried out in an environment-friendly manner. [NCERT Pg. 279]
16. Pesticides, herbicides, fungicides are incidentally also toxic to _____ that are important components of the soil ecosystem. [NCERT Pg. 279]
17. Thanks to innovations like _____, we might still avoid being smothered by plastic waste. [NCERT Pg. 279]
18. Integrated organic farming is a cyclical, _____ procedure, where waste products form one process are cycled in as nutrients for other processes. [NCERT Pg. 280]
19. Clouds and gases reflect about _____ of the incoming solar radiation. [NCERT Pg. 281]
20. The thickness of the ozone in a column of air from the ground to the top of the atmosphere is measured in terms of _____. [NCERT Pg. 282]

❑ ❑ ❑

ANSWERS

Class XII

Chapter-1 : Reproduction in Organisms

Sharpen Your Understanding

1. (2) 2. (4)
3. (1) 4. (4)
5. (4) 6. (3)
7. (3) 8. (2)
9. (4) 10. (2)
11. (3) 12. (2)
13. (1) 14. (2)
15. (4) 16. (4)
17. (4) 18. (4)
19. (2) 20. (2)

Thinking in Context

1. Protists, Monerans
2. 12
3. Monoecious
4. Zygote
5. Embryogenesis
6. Internal
7. Ovary, Pericarp
8. Fusion of gametes
9. Meiocytes
10. Staminate
11. Haploid
12. Cell division, cell differentiation
13. Gametogenesis
14. Bisexual
15. One set
16. Motile, Stationary
17. Pollen tubes
18. Haplontic life cycle
19. Pea
20. Mitotic division

Chapter-2 : Sexual Reproduction in Flowering Plants

Sharpen Your Understanding

1. (1) 2. (2)
3. (4) 4. (3)
5. (2) 6. (3)
7. (1) 8. (2)
9. (3) 10. (4)
11. (1) 12. (3)
13. (3) 14. (2)
15. (3) 16. (2)
17. (1) 18. (2)
19. (4) 20. (2)

Thinking in Context

1. Hybrid seed
2. Apomixis
3. A-Dehydration & B-Dormancy
4. Tiny seeds
5. Seedless
6. Coleorhiza
7. Free-nuclear endosperm
8. Emasculation
9. Self-incompatibility
10. *Amorphophallus*
11. Foul odours
12. Nectar and pollen grains
13. Nectar
14. Tassels
15. Male gametes
16. Autogamy
17. (A) 8-Nucleate, (B) 7-celled
18. Crop-breeding programmes
19. Generative cells
20. Embryogeny

Chapter-3 : Principles of Inheritance and Variation

Sharpen Your Understanding

1. (4) 2. (1)
3. (3) 4. (2)
5. (4) 6. (1)
7. (2) 8. (1)
9. (4) 10. (1)
11. (1) 12. (3)
13. (3) 14. (1)
15. (4) 16. (2)
17. (1) 18. (2)
19. (3) 20. (3)

Thinking in Context

1. Sexual reproduction
2. Stable trait inheritance
3. Statistical analysis & mathematical logic
4. A genotype, B phenotype
5. Punnett square
6. Monohybrid
7. Co-dominance
8. Population
9. de Vries, Correns and Tschermak
10. Sutton
1. Genetic maps
12. Phenylketonuria
13. Influence of environment
14. X-chromosome
15. Number of sets
16. UV radiations
17. Point mutation
18. X-chromosome
19. Carrier
20. A Quantitative, B Qualitative

Chapter-4 : Molecular Basis of Inheritance

Sharpen Your Understanding.

1. (2) 2. (3)
3. (1) 4. (2)
5. (3) 6. (2)
7. (3) 8. (2)
9. (1) 10. (2)
11. (4) 12. (2)
13. (3) 14. (4)
15. (1) 16. (2)
17. (3) 18. (1)
19. (2) 20. (3)

Thinking in Context

1. Polymorphism in DNA sequence
2. Higher
3. Mini-satellite
4. Frederick Sanger
5. Bioinformatics
6. Constitutively
7. Transcriptional initiation
8. Amino acylation of tRNA
9. Initiator tRNA
10. Francis Crick
11. Polynucleotide phosphorylase
12. AUG
13. Tailing
14. Processed RNA
15. Origin of replication
16. Complementarity
17. Cesium chloride(CsCl)
18. A – Storage, B – transmission
19. Complementary strand
20. Genetic material

Chapter-5 : Strategies for Enhancement in Food Production

Sharpen Your Understanding

1. (2)
2. (2)
3. (2)
4. (4)
5. (4)
6. (2)
7. (1)
8. (2)
9. (3)
10. (1)
11. (2)
12. (2)
13. (1)
14. (1)
15. (2)
16. (1)
17. (2)
18. (4)
19. (3)
20. (2)

Thinking in Context

1. IR-8, Taichung Native-1
2. Hill bunt/ Leaf and stripe rust
3. Lysine and tryptophan
4. Protoplasts
5. Vitamin A
6. Micro-propagation
7. Somaclones
8. Pomato
9. Meristem
10. Auxin, cytokinins etc
11. Viruses
12. *Puccinia*
13. Collection of variability
14. Cowpea
15. Karan rai
16. Mutations
17. Meristem culture
18. Stem borers
19. Biofortification
20. Garden pea

Chapter-6 : Microbes in Human Welfare

Sharpen Your Understanding

1. (4)
2. (3)
3. (3)
4. (1)
5. (2)
6. (4)
7. (2)
8. (3)
9. (1)
10. (2)
11. (3)
12. (1)
13. (3)
14. (4)
15. (2)
16. (1)
17. (2)
18. (2)
19. (1)
20. (3)

Thinking in Context

1. Thermal vents
2. Disease causing microbes
3. Bacteria
4. Distillation
5. Against life
6. Penicillin
7. Statins
8. BOD test
9. Secondary treatment plant
10. *Methanobacterium*
11. Biogas production
12. Biocontrol
13. Natural predation
14. Toxic chemicals & pesticides
15. *Bacillus thuringiensis* (Bt)
16. *Trichoderma*
17. *Nucleopolyhedrovirus*
18. *Rhizobium*
19. Biofertilizers
20. Methanogens

Chapter-7 : Organisms and Populations

Sharpen Your Understanding

1. (1)
2. (3)
3. (2)
4. (3)
5. (1)
6. (2)
7. (1)
8. (3)
9. (1)
10. (4)
11. (3)
12. (3)
13. (4)
14. (2)
15. (3)
16. (4)
17. (2)
18. (1)
19. (3)
20. (2)

Thinking in Context

1. Habitats
2. Niche
3. Eurythermal
4. Chemical composition, pH
5. Flowering
6. Constant body temperature
7. Aestivation
8. Diapause
9. Allen's Rule
10. Immigration
11. Birth & deaths
12. Resource (food & space)
13. Exponential growth
14. Cactus-feeding predator (a moth)
15. Cryptically-coloured (Camouflaged)
16. Prudent
17. Phytophagous
18. Grazers and browsers
19. Competition and co-exist
20. Size, colour and markings

Chapter-8 : Ecosystem

Sharpen Your Understanding

1. (3)
2. (1)
3. (4)
4. (2)
5. (3)
6. (2)
7. (1)
8. (1)
9. (2)
10. (4)
11. (2)
12. (1)
13. (3)
14. (1)
15. (1)
16. (1)
17. (3)
18. (4)
19. (3)
20. (2)

Thinking in Context

1. Net primary productivity
2. Mineralisation
3. Decomposers
4. Trophic level
5. 10 percent law
6. Detritus
7. Functional level
8. Inverted
9. Climax community
10. Very slow process
11. Standing state
12. Recycled
13. Earth's crust
14. Reservoir
15. 4×10^{13} kg
16. Sediments
17. Phosphates
18. Phosphorus
19. Robert Constanza
20. Invasion

Chapter-9 : Biodiversity and Conservation

Sharpen Your Understanding

1. (3)
2. (4)
3. (1)
4. (3)
5. (2)
6. (3)
7. (1)
8. (2)
9. (3)
10. (3)
11. (4)
12. (2)
13. (2)
14. (3)
15. (2)
16. (2)
17. (1)
18. (2)
19. (3)
20. (4)

Thinking in Context

1. Seed Banks
2. *Clarias gariepinus*
3. Nile perch
4. Five Episodes
5. 2000 species
6. David Tilman
7. More stable
8. Much steeper
9. Less seasonal
10. Insect species
11. 15,500 species
12. Pollution
13. Over harvested
14. Decreases
15. 22 percent
16. Microbial species
17. A = 1,00,000 and B = 300,000
18. Edward Wilson
19. A = 50,000 and B = 1,000
20. Amphibian

Chapter-10 : Environmental Issues

Sharpen Your Understanding

1. (3)
2. (1)
3. (3)
4. (1)
5. (3)
6. (2)
7. (2)
8. (3)
9. (3)
10. (4)
11. (3)
12. (2)
13. (4)
14. (4)
15. (3)
16. (2)
17. (1)
18. (1)
19. (3)
20. (4)

Thinking in Context

1. Environment (air, water and soil)
2. Inactivates
3. A = 150 dB; B = ear drums
4. Sound absorbent materials
5. Euro III norms
6. 0.1 percent
7. Algal bloom
8. Calcium metabolism
9. Cold and clear
10. Natural aging
11. Sanitary land fills
12. Kabadiwallahs or rag-pickers
13. Incinerators
14. Plastics
15. Recycling
16. Non-target organisms
17. Polyblend
18. Zero-waste
19. One-fourth
20. Dobson Units (DU)

❑ ❑ ❑