

**HINTS TO MULTIPLE CHOICE QUESTIONS
& EVALUATION TESTS**



MHT-CET

TRIUMPH

BIOLOGY

MULTIPLE CHOICE QUESTIONS

BASED ON STD. XI & XII SYLLABUS OF MHT-CET

Archaeopteryx is the connecting link between birds and reptiles. This transitional fossil provides palaeontological evidence that birds evolved from reptiles.



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Hints



Classical Thinking

6. Watson is related with the proposition of DNA structure. Robert Hooke is associated with discovery of cell. Dixon is associated with the transpiration pull theory of plants.
17. Tribe is a race or division of people. Genus is a group of closely related species, which resemble one another in certain characters. Family represents a group of closely related genera.
18. The term 'species' occupies a unique position in taxonomic hierarchy. It is not only a basic unit in taxonomy, but also in evolution.
20. Concept of species was remodified as closely resembling and potentially interbreeding population by Ernst Mayr. Theophrastus first proposed the artificial system of classification. Darwin proposed the selection theory and Linnaeus gave the concept of morphospecies.
27. Kingdom is the highest taxonomic category composed of different sub-kingdoms.
39. The scientific name of any organism should always be printed in italics. The generic name (Genus) should always come first and begin with capital letter while the specific name (species) should come later and begin with small letter.
44. *Hibiscus* is a taxon, i.e. a particular plant while genus and species are categories or ranks in a classification.
56. *Thiobacillus* is chemoautotroph and belongs to kingdom Monera.
57. Organisms belonging to kingdom Monera are without membrane bound cell organelles like chloroplasts, mitochondria, etc. but rigid cell wall made up of peptidoglycan is present.
66. *Amoeba* and *Paramecium* are heterotrophic. Protists are unicellular and eukaryotic. *Trichophyton* belong to kingdom Fungi.
76. Yeast belongs to Kingdom – Fungi.

81. Lichenin or lichenan is a complex starch occurring in certain lichens. It is also known as moss starch
99. M. W. Beijerinck called the extract of infected tobacco plant as virus-venom or poisonous fluid. Stanley obtained viruses in crystallized form. F. Twort discovered bacterial viruses.



Critical Thinking

1. Classification helps in understanding diverse varieties of organisms and also gives an idea about the origin and evolution of organisms which are morphologically similar.
2. Systematics is the study of classification of living organism with emphasis on their evolutionary relationships. It is an interdisciplinary study involving the different branches such as genetics, embryology, palynology, etc. It involves identification and nomenclature, so it is often considered synonymous with taxonomy.

3.

Domain	Kingdom
Archaea	Archaeobacteria
Bacteria	Eubacteria
Eukarya	Protista, Fungi, Plantae and Animalia

6. Binomial nomenclature is the system of nomenclature of plants and animals in which the scientific name consists of two words or parts or epithets.
12. Class is a higher category than order, genus and species, so it will include the remaining three.
14. Biological concept of species by Darwin in addition to morphology, takes into consideration ecology, geography, genetics cytology, physiology, behaviour, etc.
18. Because Monera includes bacteria in which a few are photoautotrophs e.g. Cyanobacteria, a few are chemoautotrophs e.g. *Thiobacillus* and rest are heterotrophs e.g. *Bacillus* sp.



19. Because it is a prokaryote.
21. *Streptococcus* is a bacteria belonging to kingdom Monera. The organisms of this kingdom do not possess membrane bound organelles.
23. According to five kingdom classification, single cellular eukaryotes come under Protista and single cellular prokaryotes come under Monera. Thus, all single unicellular organisms belong to these two groups.
26. Protists are eukaryotes.
33. *Pinus* is a Gymnosperm.
36. Lichens are the association of algae and fungi.
37. Lichens are formed by close association of algae and fungi. In these, algae has autotrophic mode of nutrition.
40. The genetic material in viruses is either DNA or RNA and surrounded by a protein coat called capsid.
46. PSTV has ten times less genetic material than the smallest known virus.



Competitive Thinking

1. Taxonomy is a branch of biology which deals with the study of principles and procedures of classification, nomenclature and identification.
2. Nomenclature (*Nomen* = name; *clature* = to call) is giving distinct scientific names to various structures, including living organisms, so they can be easily identified.
12. Division is a major group in the Linnaean hierarchy used in the classification of plant (equivalent to phylum in animal classification). The suffix of division is ‘-phyta’.
16. Cohort is a group of correlated families.
19. Category is a rank or level in the hierarchical classification of organisms. Angiospermae is a division.
21. According to binomial system of nomenclature, the name of plant and animal is composed of two latin or latinized word. e.g. potato is *Solanum tuberosum*. The first word (*Solanum*) indicates the generic name and second word (*tuberosum*) denotes the specific name.
24. Carolus Linnaeus classification was published (1753) in a two volume book ‘Species Plantarum’ which include 7300 plant species.
25. The ‘Binomial system of nomenclature’ was explained by Carl Linnaeus in his book ‘Species Plantarum’ in 1753. According to this, system name of any organism/plant consist of two words. First represents its ‘genera’ and second its ‘species’.
28. In botanical nomenclature of plants, generic name always begin with the capital letter and the specific name with the small letter and it is printed in italics.
30. Zoological name of an organism is made up of two words, first is generic name and second is specific name.
31. Binomial system of nomenclature was introduced in the book ‘Species Plantarum’, which was published in 1753.
34. The main criteria of Whittaker’s five kingdom system of classification are: Cell type, thallus organisation, nutrition, reproduction and phylogenetic relationship.
35. In five kingdom classification of Whittaker, eukaryotes were assigned to only four of the five kingdom. Prokaryotes are included in kingdom – Monera.
36. A German biologist Ernst Haeckel created a third kingdom protista in 1866 for unicellular organism such as bacteria, protozoans, Algae and fungi.
37. Monera contains the most primitive living forms which are basically unicellular prokaryotes.
38. R.H. Whittaker (1969), an American ecologist, divided all the organisms into five kingdoms.
40. Cell wall is not present in *Mycoplasma*.
43. Overlapping shells are present in diatoms member of Chrysophytes.
46. The wall of diatoms contains cellulose and silica. They do not decay easily. After death, they are deposited at the bottom in water and form diatomaceous earth.
48. Chitin is a natural structural polysaccharide, which is found in both insects and fungi. In fungi it forms the cell wall while in insects it forms the protective covering.



49. Autotrophy is a characteristic of plants.
50. All single-celled eukaryotes like chrysophytes (diatoms and desmids), euglenoids (*Euglena*), dinoflagellates and slime moulds are included in kingdom Protista.
52. In deuteromycetes, sexual reproduction is not known and so they are termed as fungi imperfecti.
55. Slime mould is a fungi-like protist.
57. In fungi, cell wall is usually composed of chitin.
58. Methanogens are biogas producing, obligate anaerobes, which belong to Archaeobacteria.
60. Eubacteria are also called true bacteria.
64. Viruses are nucleoprotein particles.
66. Genetic material of TMV is single stranded RNA.
70. Viruses do not show activity outside the host body
71. The RNA of viroids is of low molecular weight.
74. *Saccharomyces* (yeast) is eukaryotic unicellular fungi. *Mycobacterium* is a bacterium. *Oscillatoria* and *Nostoc* are cyanobacteria.
75. In *Agaricus*, spores are produced exogenously whereas in *Neurospora* and *Saccharomyces* spores are produced endogenously. *Alternaria* does not produce sexual spores.
76. Pseudopodia are locomotory and feeding structures in protozoans.



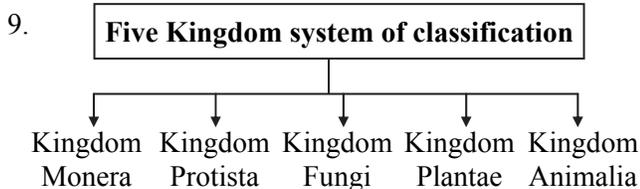
Evaluation Test

1. Taxonomy: Identification → Nomenclature → Classification
2. Ribosomal r-RNA produces the structural ribosomes.
3. In prokaryotes, the nuclear material (DNA) is double helical and circular. It is also known as genophore, nucleoid, naked nucleus, incipient nucleus.

4.

Fungi	Class
<i>Albugo</i>	Phycomycetes
<i>Aspergillus</i>	Ascomycetes
<i>Agaricus</i>	Basidiomycetes
<i>Neurospora</i>	Ascomycetes

6. Lichens are considered as pioneers in initiating plant succession on rocks.
7. Viruses are obligatory intracellular parasites. Organelles like nucleus, cell membrane, E.R., ribosome, mitochondria, etc. are absent.
8. In Kingdom Monera, the nucleus is called as naked nucleus since it lacks nuclear membrane.



10. Kingdom → Division → Class → Order
Species ← Genus ← Family
12. Actinomycetes belong to Kingdom Monera.
13. Rhizobium is a prokaryote belonging to Kingdom Monera.
14. Ascomycetes belongs to Kingdom Fungi.
15. Fungi exhibit heterotrophic mode of nutrition.
17. TMV (Tobacco Mosaic Virus) shows living as well as non-living characteristics.
19. Virus is surrounded by protein coat (capsid) consisting of helically arranged subunits (capsomeres).
21. Order has suffix ‘- ales’.
24. Paramyxo virus – Mumps
Myxo virus – Influenza



Hints



Classical Thinking

- Plants possess chlorophyll containing cells in their leaf which are specialized to perform photosynthesis to obtain food in the form of glucose.
- The proportion of C:H:O in carbohydrate is 1:2:1.
- $C_6H_{12}O_4$ and $C_6H_{12}O_5$ are the simple carbohydrates named as digitoxose and rhamnose respectively.
- Xylose is an aldose as it possesses an aldehyde group in its structure.
- Glyceraldehyde is a triose sugar containing three carbon atoms.
- Haemoglobin transports oxygen in blood while myoglobin transports oxygen in muscles.
- Saturated fatty acids do not have double bonds between carbon atoms.
- Fredrick Miescher discovered nucleic acids from pus cells. He called them 'nuclein'. Later Altmann gave the name 'nucleic acid' to the nuclein.
- In DNA, adenine always pairs with thymine with two hydrogen bonds, i.e. $A = T$ and guanine always pairs with cytosine by three hydrogen bonds as $G \equiv C$.



Critical Thinking

- CH_2O is the molecular formula of formaldehyde which is not a sugar.
- Cellulose is a complex carbohydrate having the general formula $(C_6H_{10}O_5)_n$ forming the structural unit of plants.
- Glucose acts as a respiratory substrate which undergoes catabolic reaction to produce ATP in plants and animals.
- Ribulose is a ketose sugar as it possesses ketone group ($C = O$).

- Ribose and deoxyribose are the pentose sugars present in RNA and DNA respectively.
- The two monosaccharides are joined by covalent bond called glycosidic bond to form disaccharide.
- Disaccharides are formed by monosaccharide units by the process of condensation in which one water molecule is released.
- Lactose = glucose + galactose
Sucrose = glucose + fructose
- Glucose, fructose, galactose and mannose have the same molecular formula but different configuration. Hence, they are isomers of each other.
- Removal of water molecule includes removal of OH from COOH and H from NH_2 .
- Keratin refers to a family of fibrous structural proteins. Keratin is the key structural material making up the outer layer of human skin. It is also the key structural component of hair and nails.
- Animal fats contain saturated fatty acids which remain solid at room temperature. Plant fats contain unsaturated fatty acids, hence liquid at room temperature.
- Lipids are esters of fatty acids.
- Saturated fats like animal fats (e.g.: butter) are solid at room temperature.
- Lipids are a group of heterogenous compounds like fats, oils, steroids, waxes, etc.
- Palmitic acid is saturated fatty acid while the others are unsaturated.
- Carotenoids occur in the thylakoids of chloroplasts (site of photosynthesis) which help in the process of photosynthesis.
- In DNA and RNA, the sugar present is deoxyribose and ribose respectively. The nitrogen bases present in DNA are adenine, guanine, cytosine and thiamine, while in RNA thiamine is replaced by uracil.



51. Enzyme phosphatase will remove phosphate group. Nucleotides without phosphate group are nucleosides.
52. Nucleoside = Sugar + Nitrogenous base.
63. In RNA, uracil is present as a pyrimidine base instead of thymine.
68. r-RNA forms about 80% of the total cell RNA.
69. mRNA forms 5% of total cell RNA.
70. The most active RNA during translation is t-RNA because during translation process, tRNA carries activated amino acids to ribosomes and helps in elongation of polypeptide.
71. Maximum amount of RNA is r-RNA forming 80% of the total cellular RNA. It is found associated with the ribosomes.
72. Nucleosides are named as adenosine, guanosine, thymidine, cytidine and uridine. Nucleotides are named as Adenosine monophosphate or Adenylic acid, Guanosine monophosphate or Guanylic acid, Cytosine monophosphate or Cytidylic acid, Thymidine monophosphate or Thymidylic acid and Uridine monophosphate or Uridylic acid.
73. In DNA, we know purines = pyrimidines. Hence, purines form 50% of the total DNA. Purines are adenine and guanine. Hence, $A + G = 50\%$.
If $A = 22\%$ then $guanine = 50 - 22 = 28\%$.
74. Chemically, cytosine, thymine and uracil are pyrimidines, while adenine is a purine.
75. Adenine, thymine and cytosine are present in DNA, while uracil is present in RNA.
90. Lyases: These enzymes catalyse the breakage of specific covalent bonds and removal of groups without hydrolysis. e.g. Fumarases, carboxylases, etc.
8. Disaccharides are composed of two units of monosaccharides. e.g. sucrose, maltose and lactose, etc.
14. Cellulose, starch, glycogen are carbohydrates that are homopolysaccharides.
22. Ester bonds are present in nucleic acids and lipids.
23. When protein adjoins with carbohydrates, is known as glycoprotein, which is a conjugated protein.
25. When the non-proteinaceous prosthetic group is FMN or FAD, the protein is flavoprotein, which is a type of conjugated protein.
27. A typical fat molecule is triglyceride formed by esterification of one glycerol and three fatty acid molecules.
28. Triglycerides called typical fats that consist of three fatty acid molecules attached to glycerol.
33. Phosphodiester bond is present between two nucleotides of a nucleic acid.
38. Because plant viruses have RNA as genetic material.
44. Nucleic acid is the polymer of nucleotide which is made up of nitrogenous base, sugar and phosphoric acid. Single nucleotide without phosphoric acid is called nucleoside.
45. Because nucleic acids are made up of sugar, phosphoric acid and nitrogenous base.
46. There is a double hydrogen bond between adenine and thymine ($A = T$) and triple bond between cytosine and guanine ($C \equiv G$).
47. In DNA, we know Purines = Pyrimidines.
Purines: Adenine (A), Guanine (G)
Pyrimidines: Cytosine (C), Thymine (T)
 $C + T = 75 + 75 = 150$
 $\therefore A + G = 75 + 75 = 150$
 \therefore Total nucleotides = 300
52. The two strands of DNA molecules run in opposite or antiparallel direction due to presence of hydrogen bond because two bases, i.e. one in each chain of DNA molecule, are joined together by hydrogen bonds.
60. Because DNA possesses deoxyribose sugar and thymine (T) in place of uracil (U).
62. All enzymes are proteins, but all proteins are not enzymes.



Competitive Thinking

4. Simple sugars are monosaccharides. These are the simplest carbohydrates and are building units of complex carbohydrates, i.e. Starch and Cellulose.
6. Sucrose is the common cane or table sugar which is composed of D-glucose and fructose attached together by the aldehyde and ketone carbon.



64. Holoenzyme is a conjugated enzyme formed by protein part (apoenzyme) and non-protein part (cofactor).
69. The term 'enzyme' was used by William Kuhne while working on fermentation.
80. Product is at lower level than substrate. Hence, the reaction is exothermic.
92. Melatonin and serotonin are the derivatives of tryptophan amino acid, while thyroxine and tri-iodothyronine are tyrosine amino acid derivatives.
93. Carbohydrates have carbonyl and hydroxyl groups as they are polyhydroxy aldehyde, ketone or their derivatives.



Evaluation Test

1. HCHO is Formaldehyde.
2. Histones are simple, globular proteins.
3. DNA contains deoxyribose sugar ($C_5H_{10}O_4$), while RNA contains ribose ($C_5H_{10}O_5$) sugar.

5.

Type of RNA	Shape
t-RNA	Hair pin or clover leaf
r-RNA	No particular shape
m-RNA	Linear

7. Fructose is a monosaccharide having formula $C_6H_{12}O_6$. The empirical formula of simple carbohydrate is $C_nH_{2n}O_n$.
8. The general formula for simple carbohydrates is $C_nH_{2n}O_n$ and for complex carbohydrates, it is $(C_6H_{10}O_5)_n$.
10. Unsaturated fatty acids are not fully saturated with hydrogen atoms.
14. In a given DNA segment, 25 adenine bases will pair with 25 thymine bases. Similarly, 45 cytosine bases will pair with 45 guanine bases. Thus, the total number of nucleotides in the segment is
 $A + T + C + G = 25 + 25 + 45 + 45 = 140$
16. After the Enzyme product (EP) complex is formed, the enzyme releases the product and free enzyme is ready to bind to another molecule of substrate.
18. Disaccharides $\xrightarrow{\text{Heat}}$ Monosaccharides
(Sweet)
20. Transferases transfers a functional group from one molecule to another.



Hints



Classical Thinking

7. Imbibition is the process of absorption of water by hydrophilic compounds. Wood absorbs moisture during rainy season and swells up. Hence, the wooden doors get stuck during the rainy season.
8. Hydrophilic substances are the compounds which are water loving substances and having affinity for water which are the characteristics of both, cellulose and pectic compounds.
13. A solution with higher solute concentration is called hypertonic solution. When cells are kept in hypertonic solution, exosmosis occurs which results in plasmolysis.
14. A semi permeable membrane is the one which allows the passage of only selected particles to pass through.
21. When a plasmolyzed cell is placed in water or hypotonic solution, it reabsorbs water by endosmosis. This phenomenon is called deplasmolysis.
22. Sap in root hair has relatively strong solution of sugar and various salts. Sap has lower water potential. Due to this, through osmosis, water enters the root hair.
30. In plants, due to DPD, water travels from less negative to more negative water potential.
32. Osmotic potential or solute potential is denoted by sign Ψ_s .
36. Four regions in a typical root are region of cell division, region of cell elongation, region of absorption and region of maturation.
37. Root hairs occur in the zone of absorption.
44. In symplast pathway, water travels from cell to cell through cytoplasmic bridges called plasmodesmata.
67. Leaves possess large number of stomata, which are the main sites of transpiration.
68. Transpiration occurs mainly through stomata present on leaves, also through cuticle of

herbaceous stem, through lenticels present on bark of old stems and pericarps of woody fruits.

74. Guard cells are kidney-shaped or dumb-bell shaped cells surrounding the stomata and help in transpiration.
96. Mesophyll tissues of the leaf is made up of thin walled cells. If excessive transpiration occurs, then mesophyll tissues are destroyed, which causes wilting of leaves.
116. C, H, O, N, P, K, Ca, S, Mg, Fe, Cu, Zn, Mn, B, Mo and Cl are essential elements.
134. Phosphorus deficiency causes premature leaf fall and leaves become dark to blue-green in colour.
167. In passive absorption, no metabolic energy is required, but in active absorption, metabolic energy is utilized.



Critical Thinking

2. In osmosis, semi-permeable membrane allows the movement of solvents and not solutes. Thus, osmosis is a process of selective permeability.
3. Diffusion is the movement of solutes (here sugar) from region of higher concentration to region of lower concentration till equilibrium is attained.
4. In diffusion, solute transports from higher concentration to lower concentration. Diffusion occurs because gases, liquids, solids are in constant motion in all directions.
6. Osmosis and diffusion are the two processes which are related to the movement of molecules from two different areas varying in their concentration.
7. Plasmolysis is the process in which the protoplasm of the cell shrinks when kept in hypertonic solution (solution having higher solute concentration) due to exosmosis.



9. Boiling water will destroy the plasma membrane which results in the entry of water in the cabbage leaves. Hence, it loses its colour.
12. If a potato tuber is placed in a strong solution of sugar, it would become shrink or flaccid due to loss of water from its cell.
13. If a plasmolyzed cell is placed in a hypotonic solution, it reabsorbs water by endosmosis and its protoplast resumes its original shape and position, which is known as deplasmolysis.
15. Diffusion pressure is the potential ability of a solid, liquid or gas to diffuse from an area of its greater concentration to an area of lesser concentration. So, due to diffusion, water will enter into the cell till the diffusion pressure inside the cell is same as outside.
16. Cell wall is freely permeable, but when there is deposition of suberin on the cell wall, it becomes impermeable and does not allow passage of either solute or solvent.
17. A saline drop is a hypertonic solution. When a plant cell is kept in it, plasmolysis will occur, resulting in the decrease in size.
18. When a red blood cell is kept in a hypotonic solution, the solution enters into it due to osmosis resulting in its swelling and hence, it bursts.
19. When a cell is fully turgid, its OP is equal to TP.
Thus, in the equation, $DPD = OP - TP$.
If OP is equal to TP then, $DPD = 0$.
20. In a cell A: $DPD = 10 - 5 = 5$
In a cell B: $DPD = 15 - 12 = 3$
 \therefore Flow of water will be from cell B to cell A.
22. Cell sap consists of minerals and salts. As per the concept of water potential, the water potential of pure water is zero. Thus, the water potential of plant cell sap is lower.
28. Increase in transpiration creates a tension called transpiration pull which leads to absorption of water by root.
32. During transpiration, water is released to atmosphere from mesophyll cells. In turn, mesophyll cells draw water from xylem of leaf. As a result of this, transpiration pull is developed from petiole and stem to root. If water column breaks, water will not be transmitted to mesophyll cells and hence it will become flaccid.
33. The process of exudation of liquid drops from the edges of leaves is called guttation.
34. Guttation is found in herbaceous plants e.g. Garden nasturtium (*Tropaelum najas*), oat (*Avena sativa*), Barley (*Hordeum vulgare*) and colocasia (*Colocasia antiquorum*), etc. growing in moist, warm soil and under humid conditions.
35. In night, root pressure will be maximum because in night, transpiration is zero.
38. The guttated liquid is never pure water. It contains 0.6 – 2.5 gm/litre of solutes both organic (carbohydrates, organic acid, amino acids, enzymes) and inorganic (Ca^{2+} , Mg^{2+} , K^+ , Na^+ , CO_3^{2-} , SO_4^{2-} , Cl^-).
39. Transpiration helps in reducing temperature by removing water from the leaves and avoiding from plants being overheated.
41. Transpiration is the loss of water in the form of water vapour from the aerial parts of the plants. In dry atmosphere, the water will be lost more from the aerial parts and more amount of water will be absorbed from the soil to prevent dehydration. Due to this, the transpiration pull will be maximum.
47. Food migrates from leaves to roots in downward direction for storage. Food migrates in upward or lateral direction during growth and development of fruits and flowers. Lateral/radial translocation of organic solutes occurs within the stem. e.g. cells of pith to cortex.
48. The movement of organic food materials or the solutes in soluble form from one place to another in higher plants is called as translocation of organic solutes.
50. In diffusion, energy is not required for absorption of minerals.
54. Some bacteria such as *Thiobacillus denitrificans*, *Pseudomonas aeruginosa* and *Micrococcus denitrificans* present in the soil which convert the nitrate and ammonia into atmospheric free elemental nitrogen.



Competitive Thinking

12. Selectively permeable membrane such as membrane of root hairs and tonoplast membrane of vacuole allows passage of certain substances more readily than semipermeable membranes.
13. In a fully turgid cell, OP is equal to TP and thus, DPD is zero.
15. Some solutes when dissolved in pure water reduce water potential (Ψ). Thus, when sodium chloride is dissolved in water, its solution will have lower water potential than pure water. The Ψ_s is always negative.
19. Root cap has no function in water absorption because it has no root hair and it is mainly for protection of root tip against any injury.
20. Active absorption takes place by the activity of root itself, particularly root hairs. A root hair cell functions as an osmotic system. Water is absorbed by the root hair due to osmotic differences between soil water and cell sap.
22. The cohesive force of water along with transpiration pull maintains the continuous upward movement of water stream against the force of gravity (ascent of sap).
25. Guttation, is the process in which water drops come outside by margins of leaves by hydathodes.
27. Root pressure is caused by absorption of water through root hairs, which develops hydrostatic pressure in root known as root pressure.
32. Due to actively pumping protons from companion cells to the outer cells, phloem sap is alkaline.
34. When K^+ ions enter the guard cells, stomata open and when K^+ ions move out, stomata close.
41. Grass is a monocot therefore, stomata is dumb-bell shaped whereas stomata in dicotyledons are kidney shaped.
44. In the evening, photosynthesis stops. Carbon dioxide concentration increases in the leaf interior. It results in decrease in pH. Glucose is phosphorylated to form glucose-6-phosphate. It is changed to glucose-1-phosphate from which starch is synthesized.
47. Starch does not exert any osmotic potential and therefore, guard cells lose water to nearby epidermal cells. Their turgidity falls and the stomatal pore closes.
49. Stomata open during day time because the guard cells prepare osmotically active substances by photosynthesis. As a result, their osmotic pressure increases and their turgor pressure increases due to endosmosis.
49. In banana as well as in other fruits, the accumulation of starch is necessary because later on, it (starch) converts in sucrose, so that the ripened banana becomes sweet.
52. Etiolation is a type of growth exhibited by plants grown in darkness, usually in seeds. They lack chlorophyll and therefore appear white or yellow.
54. Zn, B, Mn are micronutrients.
55. N and K are mobile elements.
56. Necrosis (die-back) of the tip of young leaves is due to deficiency of copper.
57. Mg is an important constituent of chlorophyll molecule where it occupies a central position. It is essential for photosynthesis. Fe plays an important role in ETS, photosynthesis and respiration because iron is a part of cytochromes. It is also essential for chlorophyll synthesis.
58. Mg is one of the major constituent of the chlorophyll molecule.
59. The splitting of water during photosynthesis is called photolysis. Mn and Cl plays important role in photosynthesis especially light reaction of photosynthesis in splitting of water.
60. Boron is absorbed by the plants as borate. It is involved in the transport of carbohydrates (Sugar).
61. Micro-elements are mostly involved in the functioning of enzymes, as cofactors or metal activators.
62. It is the mode of mineral absorption which involves expenditure of metabolic energy. Energy is generally obtained from ATP.
63. In leguminous plants, atmospheric nitrogen is fixed by its symbiotic associate *Rhizobium* in root nodules, as a result first stable product NH_3 (ammonia) is formed.



67. Nitrogen fixing bacteria such as *Rhizobium* have symbiotic relationship with the roots of gram (leguminous) plants. This association produces nodules on roots.
68. The bacterium *Rhizobium* infects the roots through the root hairs of groundnut plant and reproduces in the cells of cortex of roots. Simultaneously, the division of cortex cells takes place due to which the nodules are formed in the root.
70. Nitrogenase enzyme is a Mo-Fe protein.
72. Leghaemoglobin acts as O₂ scavenger as it combines with O₂ to form oxyleghaemoglobin and regulates O₂ concentration in root nodules of leguminous plants.
75. ATP releases small amount of energy required for building new chemical bonds or chemical reactions in cell. Energy in the form of ATP is provided by mitochondria present in the cell and not by water.
76. Xylem is responsible for transport of water. If xylem is blocked, plant will undergo wilting due to the lack of proper transport of water.
77. If exosmosis continues, the protoplasm shrinks from the cell wall. The phenomenon is called

plasmolysis (flaccid in appearance). Plant part or the cells shrink due to scarcity of water. This is termed as wilting.

79. The water potential = solute potential + Pressure potential
Thus, water potential for 'A' = $-9 + 4$
= -5
Water potential for 'B' = $-8 + 5$
= -3
As the water potential of 'B' cell is greater than that of 'A' ($-3 > -5$) thus movement of water would be from Cell B to Cell A.
80. The process of water exudation is known as 'Guttation' while the process of loss of water by evaporation through the aerial parts of plants is transpiration.
81. If a cell is placed in hypotonic solution, the cell will swell and become turgid, as water will move from hypotonic solution to the cell (which is hypertonic with respect to the solution).
83. High tensile strength of water helps in prevention of breakage of water column within xylem vessels of high tree.



Evaluation Test

1. A cell can gain or lose water from an adjacent cell on the basis of its D.P.D. This movement is from lower DPD (X) to higher DPD (Y).
2. Water moves from higher water potential (Less negative) to lower water potential (more negative).
5. Transpiration occurs in plants, only from living cells. Evaporation occurs from any free surface; both from living and non-living surface.
6. Mineral salts are absorbed mostly in the form of ions, i.e. anions and cations. Ions are accumulated by the plants against their concentration in the soil.
8. Leaf is modified into spine for preventing loss of water (transpiration).
10. Since in the given figure, the two molecules A and B move in opposite direction, the diffusion is antiport.

11. *Dryopteris* is a plant, while others are nitrogen fixing bacteria.
12. $2\text{NH}_3 + 3\text{O}_2 \xrightarrow[\text{Nitrococcus}]{\text{Nitrosomonas and}} 2\text{NO}_2^- + 2\text{H}_2\text{O} + 2\text{H}^+$
 $2\text{NO}_2^- + \text{O}_2 \xrightarrow{\text{Nitrobacter}} 2\text{NO}_3^-$
14. Hydroponics is the cultivation of plants in nutrient solution by placing their rooted part in the nutrient solution. This technique was first demonstrated by Julius Sachs in 1860.
16. Since the plant cell is placed in a hypertonic solution, i.e. a solution having lower water potential than the plant cell, the cell will lose water by the process of exosmosis.
20. Symbiotic bacteria are found in the root nodules of the members of bean family. This bacteria converts atmospheric nitrogen in the form of nitrates, hence it is important for rotation of crop.



22. Frame work elements include C, H, N, O, P, S. These six elements are called as frame work elements which constitute the body of plants.
23. Cu – Copper takes part in electron transport as plastocyanin (between PS II and PS I) and cytochrome to oxygen.
Mn – Manganese is activator of a number of enzymes like reductases, oxidases, etc. taking part in respiration and photosynthesis.
Fe – Iron is component of e^- transferring bio-molecules like cytochromes and ferredoxin. They are essential components of photosynthesis.
24. Chlorosis is the main symptom of nitrogen deficiency. As a result, the leaves gradually become pale or yellow. These symptoms first appear in old leaves and later in young leaves.

07 Plant Growth and Development



Hints



Classical Thinking

20. Castor shows epigeal germination, whereas the other three germinate by hypogeal germination.
21. Jowar shows hypogeal germination.
41. In log phase, the growth of a plant is fastest. Log phase is also called as exponential phase.
52. In 1928, F.W. Went isolated auxin from coleoptile tip of oat (*Avena sativa*) in the form of IAA. This experiment is called Avena curvature test.
60. Parthenocarpy is the natural or artificially induced production of fruit without fertilization of ovules. Fruit is therefore seedless. Auxin is used to induce parthenocarpy.
61. Rhizogenesis is the process of root development in plants.
66. Bakane disease is a disease of rice plant caused by the fungus *Gibberella fujikuroi* which produces GA. It is also known as 'foolish seedling disease'. This results in the etiolation of the plant with chlorosis. The plants become infertile, producing non-edible grains.
92. Cytokinins delay the senescence by preventing the degradation of metabolites or promoting their synthesis.
104. Abscissic acid is called as stress hormone because abscissic acid increases the tolerance of plants to various kinds of stresses, for e.g. weather stress as cold, drought, etc.
109. "The response of plants to the relative length of light and dark periods with reference to initiation of flowering is called Photoperiodism."
111. Photoperiodism was discovered in a "Maryland Mammoth" variety of tobacco.
118. *Xanthium* is a short day plant, while rest all are day neutral plant.



Critical Thinking

4. Growth is unidirectional forward because it is an irreversible process.

5. Cork cambium is formed by dedifferentiation.
8. In the phase of cell division, cells divide mitotically in apical meristem to increase mass. In the phase of cell elongation, cells increase in size due to vacuolation, i.e. by absorption of water. In the phase of cell differentiation, cells start maturing to gain a permanent size and function.
13. Fruit drop refers to the natural process of shedding of immature fruits by plants. Auxin prevents it.
14. Auxins like IBA, NAA are used to produce seedless or parthenocarpic fruits in tomato plants.
17. A balance combination of cytokinin and auxin is useful for inducing organogenesis. More auxins than cytokinins initiate rhizogenesis (root formation). Less auxins than cytokinins initiate caulogenesis (shoot formation).
22. Photoperiod is the critical length of day necessary for flowering in plants.
23. Critical dark period is that continuous duration of darkness which must be exceeded in short day plants and must not be exceeded in long day plants.
24. Long day plants do not require continuous dark period. They are also called short night plants.
26. Soybean is a short day plant which requires uninterrupted dark period for flowering. Thus if dark period is broken, it will cause less production.



Competitive Thinking

2. Scarification is a mechanical or chemical method of softening/weakening the hard seed coat by chipping, filing or machine threshing, also by hot water, fat solvent, H₂SO₄ treatments.
5. The growth of an organism/organ passes through different phases. If the growth rate of a plant part is plotted against time on a graph paper, a sigmoid/S-shaped growth curve is obtained.



6. In the lag phase, the preparatory changes for the growth occur in the cells.
12. 2, 4-D (2, 4 dichlorophenoxy acetic acid) is a artificial (synthetic) auxin.
14. Weeds are undesirable in a field with a crop that causes poor yield. 2,4-D is a famous herbicide or weedicide by which broad-leaved weeds can be destroyed, but does not affect mature monocotyledonous plants.
15. 2,4-D is a selective weedkiller. It is highly toxic to broad-leaved plants.
18. *Avena* curvature test carried out by F.W. Went demonstrated the effect of auxins on plant growth by performing some experiments with the oat (*Avena sativa*) coleoptile. IAA is the natural auxin.
19. Because removal of apical bud results in the growth of lower buds.
20. Gibberellins are weakly acidic hormones having gibbane ring structure which cause cell elongation of intact plants in general and increased internodal length of genetically dwarf plants (i.e. corn, pea).
21. In 19th century, Japanese farmers observed that the seedlings of rice were abnormally elongated due to infection of fungus *Gibberella fujikuroi*. This effect is called as foolish seedling disease.
22. *Gibberella fujikuroi* is the ascomycetous fungus, which is parasitic in nature.
23. Gibberellin is acidic in nature.
24. Aleurone layer of endosperm releases α -amylase and protease hydrolytic enzyme, promotes seed germination.
25. Gibberellins in the seed embryo signals starch hydrolysis through synthesis of enzyme α -amylase in the aleurone cells.
27. Gibberellin enhances seed germination by activating stored food hydrolyzing enzymes like amylase, protease, lipase.
28. Ethylene is a gaseous hormone which stimulates transverse or isodiametric growth but retards the longitudinal one.
30. Ethylene is a gaseous plant hormone and it is responsible for fruit ripening.
31. Ethylene inhibits longitudinal growth but stimulates transverse growth.
34. ABA stimulates the closure of stomata in the epidermis and increases the tolerance of plants to various kinds of stresses.
35. Because IAA, NAA and GA are growth promoters and ABA is a growth inhibitor.
39. In photoperiodism, photoreceptor pigment is called phytochrome and fully developed mature leaves receive the stimulus of light.
40. The effect of photoperiod on flowering was discovered by American plant breeders Garner and Allard in 1920 in case of Maryland Mammoth variety of tobacco which is a SDP.
42. Long dark period by interruption with brief exposure of light inhibits flowering in short day plants.
46. Phytochrome occurs in two forms, i.e. Pr. (Red light) and Pfr. (far red light) and both are interconvertible.
47. 'Vernalin' produced in vernalized plants is responsible for flowering.
49. Vernalization is the effect of low temperature on the initiation and development of flower.
50. Auxins stimulate apical meristem, but gibberellins stimulate intercalary meristem, thus help in stem elongation.

**Evaluation Test**

1. Senescence is the deterioration that ends functional life of an organism or organ. It occurs in leaves, flowers, fruits, stem and roots.
2. Gibberellin was discovered in Japan by Kurosawa (1928) in rice plants infected by a fungus *Gibberella fujikuroi*.
3. Cytokinin was extracted from Herring (a silvery fish) sperm DNA.
4. Fruit ripening is accelerated by ethylene rich atmosphere.
5. 2, 4, 5-T is an artificial (synthetic) auxin. It is used as a weedicide.



6. GA enhances seed germination by enhancing α -amylase synthesis and thus overcomes dormancy.
7. Cytokinin promotes cell division and elongation.
9. Cytokinins retard ageing (senescence) of leaves.
11. Florigen is a flower forming substance. It is synthesized in leaves and then transferred to the meristems where flowering is induced.
12. Growth is defined as permanent, irreversible increase in dry weight, size, mass or volume of a cell, organ or organism.
14. Viviparous germination is seen in halophytes and mangrove plants such as *Rhizophora*, *Avicenia*, *Sonneratia*, etc.
15. Kinetin (Cytokinin) retards leaf senescence.
18. Scarification is mechanical or chemical method of softening or weakening the hard seed coat by chipping, filing or machine threshing, hot water, fat solvent, H_2SO_4 .
19. Suitable combination of gases for fruit ripening is 80% ethylene (C_2H_4) and 20% CO_2 .
20. Phytochrome exists in two interconvertible forms— P_r form absorbing red light (near 660 nm) and the P_{fr} form absorbing far red light (near 730 nm).
21. Day neutral plants can flower in all possible photoperiods. Some common examples of this category of plants are cucumber, cotton, sunflower, tomato, etc.
23. Far-red light is considered to be biologically active.
25. Vernalization involves low temperature treatment ($1 - 10\ ^\circ C$) to reduce vegetative growth period and induce early flowering.

09 Organization of Cell



Hints



Classical Thinking

16. Genes are the hereditary units which carry information about genotype characters. For e.g. height, skin, colour, etc.
23. There are two major types of organisms on the basis of cellular organization, i.e. prokaryotes and eukaryotes. In prokaryotes, cells are simple, small and most primitive; whereas in eukaryotes, cell organelles are more specific in functions.
27. Bacilli are rod shaped, Vibrios are comma shaped, Spirilla are long twisted bacteria.
28. Cyanobacteria are also known as blue-green algae. Cyanobacteria fix the nitrogen in the form of nitrites, nitrates or urea which can be absorbed by plants.
35. Crystal violet stain is used to detect gram +ve bacteria. After staining, gram +ve bacteria retains the stain and appears purple, whereas gram -ve bacteria shows pink colour.
47. Chromatophores are plastids having pigments other than chlorophyll. Chromatophores are found in photosynthetic bacteria and cyanobacteria.
51. Plasmid is used as a vector in genetic engineering because it is capable of autonomous replication. Plasmids are naked DNA and can carry genes that need to be transferred.
55. In lipid bilayer, tails are hydrophobic and oriented inwards.
61. Mitochondria is known as the energy store house of the cell or power house of the cell, as it is related with the production of energy in the form of ATP.
72. Endoplasmic reticulum is absent in prokaryotes, in ova and in mature RBCs.
77. In a dead cell, lysosomal membranes break and hydrolytic enzymes are released. These enzymes digest the dead cell. Hence, they are called suicidal bags.

97. The contractile vacuole in *Paramecium* is specialized for osmoregulation and excretion. It maintains the turgidity of the cell and helps in maintaining a proper internal balance of cellular contents.
99. Cell inclusions are non-living substances present in vacuoles, cytoplasm or cell wall.
109. Nucleus is ovoid in columnar cells. Nucleus is disc-shaped in squamous epithelium cells. Nucleus is c-shaped in *Vorticella*.
122. Sperm cells, blastomeres, muscle cells are found to contain smaller or no nucleoli.
128. In an interphase nucleus, when chromatin is stained with feulgen stain, chromatin material which is darkly stained is called heterochromatin and that which is lightly stained is called euchromatin.



Critical Thinking

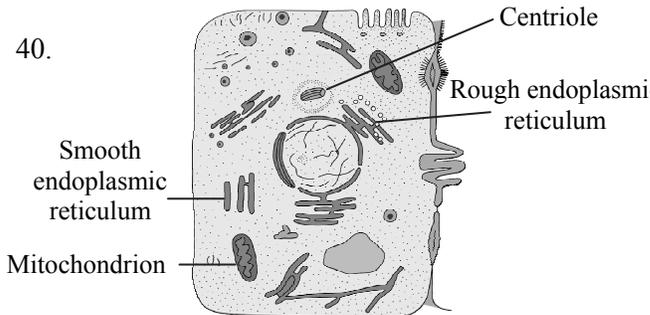
2. The prokaryotic cells do not have nuclear membrane, while eukaryotic cells have well organized nuclear membrane.
5. Peptidoglycan, also known as murein, is a polymer consisting of sugars and amino acids that forms a mesh-like layer outside the plasma membrane of bacteria (but not Archaeobacteria), forming the cell wall.
6. Gram's staining distinguishes bacteria into two broad groups – Gram positive and Gram negative bacteria based on the peptidoglycan composition of their cell wall.
9. Chloroplasts are green plastids containing green pigment chlorophyll. Leucoplasts are colourless plastids. Chromoplasts are yellow, orange or red colour.
11. Oxysomes (Elementary particles or inner membranes sub-units or F_1 particles) are responsible for respiratory chain phosphorylation.



14. Plasma membrane is a bimolecular layer of lipids and proteins.
18. Cell will die due to the release of hydrolytic enzymes present in lysosomes (autolysis).
22. If nucleus is removed, the cell will die because all the metabolic activities will be ceased.



Competitive Thinking

1. M.J. Schleiden and T. Schwann (1838 – 39) proposed cell theory.
2. Viruses are not applicable to cell theory. They are made up of proteins and one nucleic acid, i.e. DNA or RNA. So, they lack protoplasm, the essential part of the cell.
12. Glycocalyx when forms a loose sheath is known as 'slime layer' while when a thick layer is formed it is known as 'capsule'.
14. Mesosomes are involved in aerobic respiration in bacteria.
16. Eukaryotic cell wall is made up of polysaccharides, such as cellulose, pectin, lignin, hemicellulose, cutin and suberin.
18. A polysaccharide is made up of many units of monosaccharides.
23. ATP is the energy currency of cell which is synthesized and stored in mitochondria.
24. Mitochondria and chloroplast possess protein synthesizing machinery.
25. Cristae are finger-like processes projecting inwards.
27. Peroxisomes have catalase enzyme to break hydrogen peroxide into water and O₂.
28. Elementary particles (oxysomes) are present on the cristae of mitochondria.
30. Plastids are the characteristic feature of photosynthetic eukaryotes. Blue green algae and bacteria are prokaryotes and fungi are saprophytic eukaryotes.
31. Anthocyanin is found in cell sap of vacuoles.
32. Ribosomes are bounded on RER with the help of ribophorin.
34. Phospholipid synthesis takes place in smooth endoplasmic reticulum.
35. The hair-like movable protoplasmic processes known as the cilia and flagella arise from the basal body which is a modified centriole – like organelle.
37. Mitochondria are double membrane-bound organelles responsible for the synthesis of ATP molecules in eukaryotic cells. Lysosome is a membrane-bound vesicle containing hydrolytic enzymes for the digestion of many complex molecules. Golgi complex is responsible for the final modification, sorting and distribution of proteins and lipids.
39. Given figure is of Rough endoplasmic reticulum which has ribosomes on its surface and is involved in protein synthesis.
40. 

Animal cell
41. Golgi complex is involved in synthesis of glycoproteins and glycolipids.
43. Chromoplast – carotenoids present
Amyloplasts – store starch
Elaioplasts – store fats
44. Lysosome is polymorphic (primary, secondary, tertiary, autophagic) and polyfunctional cell organelle.
46. Leucoplasts store food material.
48. Lysosomes exist as primary, secondary and tertiary lysosomes.
50. Ribosomes are solid particles of protein and are not bounded by any membrane.
52. Microfilament are made up of 2 molecules of 6 nm actin protein. Microtubules are 25 nm hollow tube-like structures, while intermediate filaments are 10 nm and lamins are nuclear proteins.
53. Vacuole is involved in osmoregulation in plant cell.



56. Colloidal sap inside the nucleus is known as karyolymph or nucleoplasm.
58. Ribosomes lack DNA, but contain RNA and proteins while Nucleus, Chloroplast and Mitochondria contain DNA.
59. The outer envelope of the nucleus is continuous with the rough endoplasmic reticulum (endoplasmic reticulum bearing ribosomes).
60. Centromere is the region of the chromosome that becomes attached to the nuclear spindle during mitosis and meiosis. It does not stain with basic dyes. It is also called primary constriction or kinetochore.
61. Ribozyme is catalytic RNA.
66. Microtubules are the structures present in cilia, flagella, centrioles and spindle fibres.
67. Nuclei, mitochondria and chloroplasts are double membrane bound organelles. Lysosomes are single membrane bound organelle.
68. Mitochondria, nucleus and chloroplast are double membrane bound organelles.
69. The inner membrane of mitochondria is thrown into series of unfoldings known as the 'cristae'.
70. In bacterial cells, motility is performed by flagella while fimbriae provide attachment to base and pili forms conjugation tube during conjugation.
73. Large nucleoli are found in cells that are actively engaged in protein synthesis. Nucleolus is non-membranous structure.
74. Plasmids have circular double stranded DNA molecule.



Evaluation Test

1. Chloroplast → Chromoplast
(Green plastid) (Red or yellow plastid)
3. Terminal oxidation and oxidative phosphorylation take place in the cristae membrane of the mitochondria.
4. Cell wall is the outermost, rigid, protective, supportive and semi-transparent covering of plant cell, fungi and some protists. It is absent in animal cells.
5. There are many different proteins embedded in the membrane. Except for flip flop movements, rest occur. Choice (A) is amply demonstrated when the travelling proteins aggregate at sites of endocytosis. Choice (C) type of proteins can be enzymes which are confined to certain domains (for *e.g.*, present only on cell surface). Choice (D) types are non-transmembrane proteins.
8. Rough Endoplasmic Reticulum (RER) takes part in protein synthesis due to presence of ribosomes.
11. Infoldings of plasma membrane in bacteria are called mesosomes, which are analogous to mitochondria.
14. Prokaryotes do not possess well-organized nucleus.
17. Ribosomes are the sites of protein synthesis.
19. The given figure is of Golgi apparatus which consists of cisternae, vesicles and tubules. Golgi complex is formed from Endoplasmic Reticulum.
20. Lysosome contains digestive enzymes capable of lysis, thus it is a lytic body or suicidal bag.
21. Lysosomes are surrounded by a single unit membrane.
22. Cell organelles without membrane covering → ribosome, centrosome, centriole, nucleolus, cytoskeletal structures.
23. Chloroplast is a semi-autonomous organelle having DNA.



Hints



Classical Thinking

5. Somatic tissues are of four types: epithelial, connective, muscular and nervous.
12. Cuboidal epithelium has cube shaped cells and columnar epithelium has tall pillar like cells.
22. Microvilli increase the surface area for absorption.
48. Macrophages are phagocytic in nature, i.e they engulf micro organisms.
53. Mast cells are found surrounding the blood vessels. Cytoplasm of each mast cell contains heparin and histamine granules. Heparin prevents blood clotting and histamine is useful in dilation of blood vessels. Stratum germinativum is a layer, present in compound epithelium. Lacuna is the fluid filled cavity within the bone matrix.
72. The small immature chondroblasts (cartilage forming cells) in due course of time, get converted into chondrocytes (cartilage cell).
107. Epiphyseal region of long bone are the enlarged ends of long bones. Diaphyseal region of long bone are the shaft of long bone. Metaphyseal region is the connecting region between the shaft and ends of long bones.
127. Nerves of the autonomic nervous system controls involuntary activities and hence, they are present in smooth muscles.
156. The space enclosed between the telodendron of first neuron and cyton of second neuron forms synaptonemal complex.



Critical Thinking

10. The nucleus in columnar epithelial cells is placed at the basal end.
17. Endocrine glands include pituitary, thyroid, parathyroid, ovary, testis, adrenal, islets of Langerhans. All these glands of endocrine system produce secretions which helps in maintaining the homeostasis.

18. The enzymes produced by exocrine gland:

Exocrine gland	Enzyme produced
Tear gland	Lysozyme
Salivary gland	Salivary amylase
Gastric and intestinal gland	Pepsinogen

21. Sebum is an oily substance secreted by the sebaceous gland present in the mammalian skin. Sebum keeps the hair and skin water proof and protects them from drying.
28. The capsule covering the major organs is made up of fibrous connective tissue. It protects the organs.
35. Collagen fibres provide tensile strength to the tissues. Yellow fibres provide elasticity. Hence, tissue becomes loose but elastic.
55. Matrix of cartilage is semisolid called chondrin.
57. Stratified epithelium is an epithelial tissue.
58. Mammalian pinnae are external ear which shows presence of elastic cartilage.
60. Muscle cells are thin and elongated. They look like threads or fibres. Hence, it is called muscle fibre.
69. Smooth muscles are located in stomach and intestine. They are responsible for movement of food in digestive system.
74. Neuroglial cells are capable of regeneration. Axoplasm lacks Nissl's granules. Telodendrons are present in both myelinated and non-myelinated neurons.
75. Neuron contains granular cytoplasm.
76. In non-medullary neurons, Schwann cells are present but they do not secrete myelin sheath.



Competitive Thinking

4. The ciliated epithelium in trachea, is in fact pseudostratified ciliated epithelium having long ciliated columnar cells and short cuboidal cells.



5. The function of the ciliated epithelium is to aid in the movement of particles or mucus in a specific direction over the epithelium (e.g. fallopian tube).
6. Cells of simple epithelial tissue are arranged in a single layer.
7. The cells of simple squamous epithelium are flat tile like, polygonal cells with a centrally located and oval or spherical nucleus. It is also known as tessellated or pavement epithelium.
8. The entire body is enveloped in a casing of cornified (epithelium) dead cells that protect against drying and bacterial invasion.
9. Cells of squamous epithelium are flattened scale-like and attached to each other like a mosaic.
11. Simple columnar epithelium lines the stomach, small intestine and large intestine, the digestive glands and the gall bladder.
13. Squamous epithelium in the blood vessels is called as Endothelium.
15. Moist surface of buccal cavity – Stratified non-keratinised squamous epithelium; Inner surface of bronchioles – Ciliated epithelium; Inner lining of salivary ducts – Cuboidal epithelium
19. Collagen fibres are white formed of a protein, occur in bundles, thick non-elastic with great tensile strength.
20. Three types of fibres collagen, elastic and reticular are found in connective tissue. Each fibre consist of collagen, elastin and reticulin respectively.
21. Areolar tissue contains fibroblasts, macrophages, mast cells, plasma cells, lymphocytes and adipose cells.
23. Adipocytes are fats cells, which are derived from a fibroblast. These adipocytes are found in connective tissue.
26. Ligament is a yellow elastic fibrous connective tissue, while tendon is a white collagen fibrous connective tissue.
28. Mast cells are found in the ground substance of areolar connective tissue. They secrete heparin and histamine.
29. Macrophages engulf the invading microbes and destroy them.
31. Tendon is a white fibrous connective tissue which attaches muscle to bone.
33. Ligament is a modified yellow elastic fibrous tissue which occur in the form of cords and binds a bone cartilage with another bone cartilage It contains white fibres along with yellow fibres.
36. Cartilage is surrounded by a sheath of dense connective tissue called perichondrium.
37. The chondrocytes secrete the flexible matrix called chondrin.
39. Hyaline cartilage forms the articular surfaces at the joints of long bones where it is called as Articular cartilage.
40. Mammalian bone is characterized by the presence of haversian system or osteon. Osteon is the basic structural unit of mammalian bone consisting of the haversian canal, lamellae and lacunae.
42. Bone is surrounded by dense, white fibrous sheath called periosteum.
44. Haversian canals are interconnected by transverse canals known as Volkmann's canals.
47. Haversian system is the characteristic feature of long bones.
48. Endosteum is a thin single layer of epithelium, lining the marrow or medullary cavity.
50. Areolar and adipose tissues are loose connective tissues, while tendon is a dense connective tissue.
52. The plasma membrane covering the muscle fibre is called sarcolemma.
54. Smooth muscles are unstriated muscles. Cross-striations are absent, thus there are no dark and light bands.
55. Smooth muscle fibre is spindle-shaped, thick in the middle and thin at either ends, uninucleated and have no sarcolemma. Contraction is slow, involuntary under the control of ANS.
58. Unstriated muscles are the most widely distributed muscles in the body, e.g. Gastrointestinal tract, uterus, urinary bladder, iris, ciliary body, blood vessels, etc.
61. A striped muscle fibre has many nuclei and it is a syncytium (coenocyte).



62. Actin and myosin are the structural proteins. So, they are found in both skeletal and visceral muscles, although skeletal muscles are cylindrical and visceral muscles are pear-shaped or spindle-shaped.
63. Because skeletal muscles are striated and voluntary.
66. H-zone in skeletal muscle is the central gap between actin filaments extending through myosin filaments in the A band.
69. Cardiac muscles are striated, involuntary. Contract quickly and do not get fatigued.
70. Because of the absence of centriole, neurons have lost the power of division and have minimum power of regeneration.
75. Nerve fibres are extended axons or dendrites. Dendrites carry nerve impulses towards the cell body and axons away from it.
76. Nissl's granules or Nissl's bodies as basophilic structure of various shapes-angular, conical or rhomboidal. They are pieces of granular endoplasmic reticulum with or without free polyribosomes. They are found in cytons.
79. If a nerve impulse was initiated somewhere in the middle of a nerve fibre, it would proceed to both ends. However, in the synapse, the propagation is strictly one-way from the axon to the dendrite, never the reverse.
81. Schwann cells surrounds axons of myelinated nerve fibres, and produce myelin sheath.
83. Neurons are structural and functional units of nerve tissue. Their number is quite high, more than 1×10^{12} in brain alone.
85. Synapse is the microscopic gap between axon and dendrites of two different neurons.
87. Columnar epithelium is present in the lining of stomach. Tendon is a dense connective tissue and connects muscle to bone. Tip of nose consists of elastic cartilage.
88. Adipose connective tissue is a loose connective tissue, as it has cells and fibres loosely arranged, and not compactly packed.
89. The myelin sheath surrounding the axon is interrupted at regular intervals, forming Nodes of Ranvier.
90. Myelin sheath is a layer covering of vertebrates nerve fibre.
91. Osteoclasts dissolve minerals in bone matrix and release them back into the blood. Osteocytes regulate mineral homeostasis. They direct the uptake of minerals from the blood and the release of minerals back into the blood as needed.



Evaluation Test

4. Epithelial tissue forms a protective covering all over the body as well as the internal organs.
5. The entire nerve is surrounded by a vascular connective tissue called epineurium.
6. In the given figure, the cells are polygonal and cuboidal in appearance. They appear square in side view. The nucleus is centrally located and rounded. All these are characteristic features of simple cuboidal epithelium.
8. The apocrine secretion of mammary gland takes place by means of decapitation, a process in which the apical portion of the secretory cell cytoplasm pinches off and enters the lumen of the gland.
10. In an animal cell, centrioles are absolutely necessary for cell division. They are absent in neurons (but present in neuroglia).
11. The given figure shows the presence of large fat globules (monolocular) and fat droplets (polylocular) which is a characteristic feature of adipose tissue, specialized for storage of fats.
12. Inner lining of cheeks have compound stratified squamous epithelium.
13. If a bone is kept in dilute acid (HCl) for few days, it becomes soft and flexible. This is called decalcification of the bone.
14. Areolar tissue has a large matrix with almost all types of cells and fibres.
15. Dendron or dendrites are thin processes arising from neuroplasm that could be $100 \mu\text{m}$ long and have multiple branches.
23. Myocardial layer contains cardiac muscles.
24. Cardiac muscles can contract without the stimulation of nerves and they contract rhythmically.

12 Human Nutrition



Hints



Classical Thinking

17. In small intestine, duodenum is 1st part, jejunum is 2nd part and ileum is the 3rd part.



Critical Thinking

1. Oxidation is a chemical reaction which involves loss of electron by a molecule, atom or ion. Oxidation is not a part of nutrition.
2. Permanent teeth are the second set of teeth formed in humans. There are 32 permanent teeth (Incisors – 2/2, Canines – 1/1, Premolars – 2/2, Molars – 3/3)
4. Tongue helps in swallowing and speech.
5. Incisors are used for cutting, whereas premolars and molars are used for grinding the food.
14. Ileum is a part of small intestine.
19. Parotid, sub-lingual, sub-mandibular are salivary glands, but acinar is not a salivary gland.
26. Salivary amylase present in saliva acts on starch to convert it into maltose.
28. Bile salts bring about emulsification of fats.



Competitive Thinking

3. Premolar teeth are absent in human childhood (milk teeth dentition). Premolar teeth are monophyodont.
4. Premolars are absent in primary dentition. Milk teeth are 20 in number i.e. 10 in upper and 10 in lower jaw.
6. In humans, 3 pairs of salivary glands are present. They are sublingual, parotid and submaxillary.
7. Parotid glands are the largest salivary glands which are situated below ear (pinna).
8. Human beings have 3 pairs of salivary glands – parotid, submandibular and sublingual which digest starch.
11. Vermiform appendix is a vestigial organ of man which is found in alimentary canal.

12. Lacteals are central lymph vessels found in villi of intestine. It is related to absorption of fats.
13. Liver cells synthesize vitamin A from carotene and store vitamins A, D and B₁₂.
25. Bile is secreted by liver and stored in gall bladder.
26. Ptyalin (salivary amylase) and pancreatic amylase are the starch splitting enzymes released by salivary gland and pancreas.
28. Bilirubin and biliverdin are bile pigments present in the bile juice.
29. Pancreas is a digestive gland that secretes pancreatic juice. This juice acts on all types of food, i.e. protein, starch, fat and nucleic acid. If pancreas is removed from the body, the digestion will not occur.
30. Pepsin and rennin are enzymes, secreted by the gastric glands in stomach wall. Hence they are found in gastric juice. Maltase is present in the intestinal juice.
33. Succus entericus or intestinal juice contains many enzymes – enterokinase, maltase, sucrase, lactose, dipeptidase, lipase.
34. Amino acids are absorbed in intestine through blood capillaries in the villi.
35. Emulsified fat is digested by enzyme lipase which is secreted by pancreatic juice, and intestinal juice.
36. Breaking of large fat droplets into fine emulsion is done by bile salt (Bile juice contain bile pigment and bile salt) of the liver.
38. Trypsin is a protein digesting enzyme found in pancreatic juice.
39. Enterokinase converts trypsinogen to trypsin and chymotrypsinogen to chymotrypsin. Trypsin further acts on proteins to convert it to polypeptides. Thus, without enterokinase protein digestion is incomplete.
44. Pepsin initiates the digestion of protein in stomach producing proteoses and peptones.



45. Pepsin is a proteolytic enzyme produced by stomach that is responsible for beginning the digestion of proteins.
46. It is a hormone secreted by the mucosa of small intestine.
50. Pepsin breaks proteins into proteoses and peptones, while trypsin breaks peptones into dipeptides. Ptyalin acts on polysaccharides and dipeptidase breaks dipeptides into amino acids.
53. Amino acids, glucose, electrolytes like Na^+ are absorbed into the blood by active transport.
58. Oedema is not observed in marasmus. It is one of the symptoms of kwashiorkor.
61. Thecodont means teeth that are present in the sockets of the jaw bone.
Diphyodont means teeth that erupt twice, temporary milk teeth are replaced by a set of permanent or adult teeth.
Heterodont dentition refers to different types of teeth namely incisors, canines, premolars and molars.



Evaluation Test

1. Enterogasterone is a hormone released by the mucosa of duodenum.
2. Most of our foods have complicated chemical structure. In order to be absorbed and utilized by the body, they must be broken down into relatively simple molecules. The process by which the complex food materials are changed to simple molecules is called digestion.
3. $\text{Trypsinogen} \xrightarrow[\text{enzyme}]{\text{Enterokinase}} \text{Trypsin} + \text{Inactive dipeptides}$
(Proenzyme)
4. Bile salts with the help of monoglycerides emulsify fats.
5. The process in which absorbed food materials become an integral component of the living protoplasm and are used for energy, growth and repair is called assimilation of food.
7. Human alimentary canal lacks cellulase enzyme and symbiotic micro-organisms.
9. Dental formula of human being is $\frac{2,1,2,3}{2,1,2,3} = \frac{8}{8} \times 2 = 32$. It shows the number of incisor 2, canine 1, premolar 2, molar 3 in each half upper and half lower jaw with 32 teeth in buccal cavity.
10. The pyloric canal is the distal part of the stomach which opens into the duodenum.
11. There are two types of intestinal glands – Crypts of Liberkuhn and Brunner's glands. Secretions of both these glands are collectively called Intestinal juices or Succus entericus.
16. $\text{Pepsinogen} \xrightarrow{\text{HCl}} \text{Pepsin}$
(Inactive) (Active)
- $\text{Trypsinogen} \xrightarrow{\text{Enterokinase}} \text{Trypsin}$
(Proenzyme) (Active)
(Inactive)
21. Marasmus is Protein Energy Malnutrition (PEM).
25. Kwashiorkor occurs due to protein deficiency. Meat, butter, milk and eggs are sources of proteins.

13 Human Respiration



Hints



Classical Thinking

28. Although external nares seems to be anteriormost but it is not a part of nasal chamber.
62. Passive process is a process that occurs without the input of energy.



Critical Thinking

15. In man, the mid-ventral portion of the thyroid cartilage forms a prominent protuberance called Adam's apple.
49. Chlorophyll is a photosynthetic pigment present in leaves of the plant. Myoglobin is an iron and oxygen binding protein found in the muscle tissue of vertebrates. Insulin is a hormone.
55. Spirometry is the process of recording the changes in the volume movement of air in and out of the lungs and the instrument used for the purpose is called spirometer or respirometer.
57. In carbon monoxide poisoning, the oxygen combining capacity with haemoglobin decreases, which results in oxygen starvation of tissues.
58. Asphyxia – a condition in which an extreme decrease in the concentration of oxygen occurs in the body cells.
60. Hypoxia is a pathological condition in which the body or region of the body is deprived of adequate oxygen supply.
Anoxia means a total decrease in the level of oxygen.
Hyperoxia is excess oxygen than normal partial pressure of oxygen.
65. Emphysema is caused as result of long term irritation by air pollution, cigarette smoke or industrial dust. Lungs become permanently inflated because the lung wall loses elasticity.



Competitive Thinking

2. Earthworm respire but has no respiratory organs. Exchange of gases takes place through moist skin.
3. Diaphragm has no role in respiration in frogs but in mammals, it increases the surface area for respiration.
5. The pharynx provides passage to both air and food.
7. Vocal cords are present inside the larynx. These are two pairs of fold of mucous membrane that extend into the lumen of the larynx from the sides.
10. Epiglottis serves to close the glottis during deglutition (swallowing), thereby preventing entry of food into the respiratory tract.
11. Each lung is enclosed in two membranous coverings called pleurae. The outer covering is adhered to chest wall and diaphragm and is called parietal pleura. The inner covering membrane, which closely covers the lung, is called visceral pleura.
17. In man, the left lungs has two lobes – superior lobe and inferior lobe, the right lungs has three lobes – superior lobe, middle lobe and inferior lobe.
18. 'b' is pleural membrane, it does not surround ribs on both the sides. 'd' is diaphragm and not the lower end of lungs. Trachea is supported by incomplete cartilaginous rings.
20. During expiration, diaphragm relaxes and becomes dome-shaped thereby reducing intrathoracic volume to pass out the air from body.
24. One molecule of haemoglobin has 4 haem groups and each of them is capable of taking up one molecule of O₂.
25. pO₂ in alveoli is 104 mmHg, while in oxygenated blood it is 95 mmHg.



28. CO₂ is transported in the form of H₂CO₃ dissolved in plasma and NaHCO₃ and KHCO₃ as bicarbonates.
34. 70% of CO₂ is transported in the form of bicarbonate ions due to the presence of carbonic anhydrase enzyme inside the RBC.
37. Tidal volume is the volume of air inspired or expired with each breath. This is about 500ml in an adult person.
38. Breathing is controlled by pneumotaxic and apneustic centres in pons varolii and expiratory and inspiratory centres in medulla oblongata.
39. Baroreceptors are sensitive to changes in blood pressure.
40. Vital capacity = ERV + TV + IRV
= 1000 + 500 + (2500 to 3000)
= (4500 to 5000)
44. Residual volume is the air that remains in the lungs even after forceful expiration. The residual volume prevents the collapsing of alveoli after forceful expiration.
45. The air inspired or expired by a healthy man (tidal volume) is about 500mL. Since, a healthy man breathes around 12-16 times per minute, the amount of air inspired or expired per minute would be between 6000-10000 mL.
48. In asthma, the allergen reaction occurs in the bronchioles of the lungs. During this reaction, mast cells release a substance which causes muscular spasm.
49. In asthma, allergic reactions swell up the tissue surrounding the bronchiole of the lung, causing difficulty in breathing. During allergic response, mast cells secrete chemicals.
51. Emphysema is pulmonary disease caused by air pollutants. It causes break down of alveolar wall which reduces the surface area for gaseous exchange.
52. Emphysema is characterised by inflation of alveoli which is mainly due to chronic cigarette smoking.
54. Reduction in pH of blood favours the dissociation of oxyhemoglobin.
55. Basal metabolic rate is inversely proportional to the body size. Smaller animals have higher metabolic rate, thus have more energy and find it easier to run uphill.
56. Botulism is caused by bacterium *Clostridium botulinum* that produces dangerous toxins (botulinum toxins) under anaerobic conditions. Anthrax is a serious infectious disease caused by gram-positive, rod-shaped bacteria known as *Bacillus anthracis*. Emphysema is a disease of lung that causes shortness of breath.



Evaluation Test

1. Carboxyhaemoglobin is a stable complex of carbon monoxide and haemoglobin.
2. Total lung capacity is the sum of the vital capacity and residual volume, i.e.
TLC = VC + RV = 4800 ml + 1200 ml
= 6000 ml
3. At high altitude, PO₂ of alveolar air falls because of low O₂ tension of tissues. So, O₂ is absorbed very quickly from alveoli, thus, increasing breathing rate. Heart beat also increases to supply required amount of O₂ to tissues.
4. Tidal volume – 500 ml
Residual volume – 1500 ml
Expiratory reserve volume – 1000–1100 ml
Vital capacity – 3500–4500 ml
5. Due to direct chemical control on respiratory centres, CO₂ stimulates respiratory centres in CNS.
10. The partial pressure of O₂ will fall drastically along with the fall in barometric pressure. So hypoxia will develop which causes increase in the rate of respiration.



11. The respiratory centres that control the breathing mechanism are present in medulla oblongata. These respiratory centres are expiratory and inspiratory centres.
12. 'COHb' is a stable compound formed by the combination of carbon monoxide and haemoglobin. CO has more affinity than oxygen.
13. During normal breathing, the respiratory movement in 25 years old is about 12-18 times.
16. Epiglottis is the structure which prevents the entry of food into the respiratory tract.



Hints



Classical Thinking

4. Morgan gave the function of chromosomes in transmitting heredity. Johannsen coined the term 'gene'. Karl Correns explained incomplete dominance.
7. Theophrastus – Father of botany
Stephen Hales – Father of physiology
Aristotle – Father of biology
15. Mendel published his findings in 1866 in the journal "Annual Proceedings of Natural History Society".
16. In the year 1900, Hugo De Vries, Karl Correns and Erich Tschermak independently rediscovered the research carried out by Mendel, his experiments on heredity and variations and laid the basis of modern genetics.
17. Sutton (1902) showed importance of reduction division and proposed chromosomal theory of heredity. Boveri (1888) described centriole. Lederberg and Tatum discovered conjugation in bacteria (1944). Morgan (1933) gave the function of chromosomes in transmission of heredity.
18. Mendel's work was re-discovered by Hugo De Vries (Holland), Correns (Germany) and Tschermak (Austria).
19. Mendel observed many variable characters in pea plant like short life span so that he could study more generations in a short duration. Pea plant produced many seeds, so he could grow thousands of pea plants. There were no intermediate characters. Large flowers would help in easy hybridization.
20. *Lathyrus odoratus* is sweet pea. *Mangifera indica* is mango and *Solanum tuberosum* is potato.
22. Out of the 7 pairs of characters, wrinkled or round character was restricted to seeds and not to the leaves. Mendel did not consider any leaf character.
24. Gene is a particular segment of DNA which is responsible for the inheritance and expression of a particular character.
25. The characters that Mendel chose for experiments were passed down to next generations. Mendel suggested that these characters are governed by factors, which are passed on to next generations. These hereditary factors are now known as genes.
28. Alleles, the abbreviated form of term allelomorphs indicates alternative forms of the same gene.
30. Karyotype is the physical appearance of chromosomal set of an organism as seen in metaphase. Morphology is the study of form and structure of organisms without consideration of function.
31. Genotype designates the genetic makeup or genetic constitution of an organism.
33. Heterozygous is a condition, where one of the genes of an allelic pair is dominant and the other is recessive, i.e. heterozygous, it indicates a pair of dissimilar alleles.
34. A polyploid organism has more than the normal diploid number of chromosomes. A mutant is an organism which shows a sudden genetic change due to a natural or induced mutation. Variant is deviation in characters in an individual from the group to which it belongs or deviation in characters of the offspring from those of its parents.
35. The 1st generation obtained from crossing two parents is called as first filial generation or F₁ generation.
38. Punnett Square (British geneticist, R.C. Punnett, 1927) is a checkerboard used to show the result of a cross between two organisms.
44. Pea flower shows diadelphous condition of stamens, where stamens are arranged to form two bundles of 9 fused stamens and 1 free stamen.



48. Mendel thought that reappearance of dwarfness may be due to female dominance, i.e. tall plants were females and dwarf plants were male. So, he performed the reciprocal cross.

54. Homozygous tall : TT
 Homozygous dwarf : tt
 P generation : TT × tt

Gametes : $\begin{matrix} \text{T} \\ \swarrow \\ \text{YR} \end{matrix}$ $\begin{matrix} \text{t} \\ \swarrow \\ \text{yr} \end{matrix}$

F₁ generation : Tt
 (Heterozygous tall)

55. The dominant trait is expressed in F₁ generation.

P generation : RR(Red) × rr (white)

Gametes : $\begin{matrix} \text{R} \\ \swarrow \\ \text{YR} \end{matrix}$ $\begin{matrix} \text{r} \\ \swarrow \\ \text{yr} \end{matrix}$

F₁ generation: Rr
 (Heterozygous red flower)

56. The three genotypes – TT (pure tall), Tt (hybrid tall) and tt (dwarf).

57. Only one progeny will receive recessive trait and therefore it is dwarf (tt).

61. In some cases, there is incomplete dominance or no dominance. Law of dominance could not support such cases. Hence, it is not universally acceptable.

62. Mendel's first law is the law of dominance. Law of independent assortment is the third law. Epistasis is a drawback in Mendel's studies, where intergenic suppression of characters is observed.

70. The two parental combinations were yellow round and green wrinkled. The two new combinations were yellow wrinkled and green round.

73. In Mendel's experiments of inheritance, the progeny was systematically shown in the checker board or Punnet's square.

75. Parents : YYRR × yyrr
 (yellow round) (green wrinkled)

Gametes : $\begin{matrix} \text{YR} \\ \swarrow \\ \text{YR} \end{matrix}$ $\begin{matrix} \text{yr} \\ \swarrow \\ \text{yr} \end{matrix}$

F₁ generation : YyRr
 (Yellow Round)

76. **Phenotypic ratio** Yellow round : Yellow wrinkled : Green round : Green wrinkled
 9 : 3 : 3 : 1

77. Parent : Yellow Round × green wrinkled
 YYRR × yyrr

Gametes : $\begin{matrix} \text{YR} \\ \swarrow \\ \text{YR} \end{matrix}$ $\begin{matrix} \text{yr} \\ \swarrow \\ \text{yr} \end{matrix}$

F₁ generation : YyRr
 Yellow round

Selfing of F₁ generation to get F₂ generation.

F₂ generation:

	YR	Yr	yR	yr
YR	YYRR	YYRr	YyRR	YyRr
Yr	YYRr	YYrr	YyRr	Yyrr
yR	YyRR	YyRr	yyRR	yyRr
yr	YyRr	Yyrr	yyRr	yyrr

Phenotypic ratio:

Yellow round : Yellow wrinkled : Green round : Green wrinkled
 9 : 3 : 3 : 1

Genotypic ratio:

YYRR YYRr YyRR YyRr YYrr Yyrr yyRR yyRr yyrr
 1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1

85. When F₁ hybrid is crossed with homozygous recessive parents, it is called a test cross.

87. The cross between F₁ hybrid (Aa) with homozygous dominant (AA) is a back cross.

91. The offsprings Rr are pink due to partial expression of both alleles, i.e. incomplete dominance.

92. P generation : RR (Red) × rr (white)

Gametes : $\begin{matrix} \text{R} \\ \swarrow \\ \text{YR} \end{matrix}$ × $\begin{matrix} \text{r} \\ \swarrow \\ \text{yr} \end{matrix}$

F₁ generation: Rr (all pink)

F₂ generation:

	R	r
R	RR (Red)	Rr (Pink)
r	Rr (Pink)	rr (white)

∴ 1 Red : 2 Pink : 1 White

94. More than two alternative forms (alleles) of a gene in a population occupying the same locus on a chromosome or its homologue are known as multiple alleles.



95. vg^{ni} = Nicked wings
 vg^{no} = Notched wings
 vg = Vestigial wings
96. The three alleles of ABO blood group – I^A , I^B and i . In this, I^A and I^B are co-dominant.
97. When a single gene controls two or more different traits, it is called pleiotropic genes and the inheritance is called pleiotropic inheritance.
98. Pleiotropy: Influencing more than one trait by a single gene.
 Haemophilia: A metabolic disorder characterized by free bleeding from slight wound due to lack of formation of clotting substances. It is sex-linked recessive gene.
 Sickle cell anaemia: It is a hereditary disease caused by a recessive mutant gene that controls haemoglobin structure, usually lethal in homozygotes.
 Thalassaemia: It is a group of hereditary haemolytic anemia.
 Colour blindness: It is a sex-linked disease.

103. Parents : Red × White
 : kernels kernels
 : AABB aabb

Gametes : (AB) (ab)

AaBb

F₁ generation : Intermediate red

Selfing of F₁ generation : AaBb × AaBb

Gametes : (AB)(Ab)(aB)(Ab) × (AB)(Ab)(aB)(ab)

F₂ generation :

	AB	Ab	aB	ab
AB	AABB ●●●●	AABb ●●●○	AaBB ●●●○	AaBb ●●○○
Ab	AABb ●●●○	AAbb ●●○○	AaBb ●●○○	Aabb ●○○○
aB	AaBB ●●●○	AaBb ●●○○	aaBB ●●○○	aaBb ●○○○
ab	AaBb ●●○○	Aabb ●○○○	aaBb ●○○○	aabb ○○○○

●●●● ●●○○ ●○○○ ●○○○ ○○○○
 Darkest Medium Intermediate Light White
 Red red red red

Phenotypic ratio : 1 : 4 : 6 : 4 : 1

106. Hugo De Vries and Karl Correns rediscovered the Mendel's work.
107. Skin colour in humans is controlled by three pairs of genes: Aa, Bb, Cc

108. The phenotypes are
 - Pure black (negro)
 - Black (less dark than negro parent)
 - Lesser black or brown
 - Mulatto (intermediate – sanwla)
 - Fair
 - Very fair
 - Pure white (albino)
109. The genotype of negro = AABBCC
 The genotype of albino = aabbcc
110. Genetics is the branch of science that is concerned or deals with the phenomenon of heredity and variation. Cytology is the study of structure and life processes of cells and their components along with cellular details of a tissue or organ. Embryology is the study of development of embryo. Cytology is the study of cells.
111. The peculiar characteristic of pea flower is papilionaceous corolla, i.e. butterfly like, having five petals.



Critical Thinking

- Yellow round = 9
 Yellow wrinkled = 3
 Green round = 3
 Green wrinkled = 1
 From above,
 i. Yellow coloured seeds = 9 + 3 = 12
 Green coloured seeds = 3 + 1 = 4
 ∴ Yellow : Green = 12:4 = 3:1
 ii. Similarly,
 Round seeds = 9 + 3 = 12
 Wrinkled seeds = 3 + 1 = 4
 ∴ Round wrinkled = 12:4 = 3:1
- Alleles are various forms of a gene or Mendelian factors, which occur on the same locus on homologous chromosomes and control the same trait (e.g. Tallness and dwarfness in Pea).
- When a gene expresses itself fully and codes for a complete functional polypeptide irrespective of the presence or absence of a recessive gene, is called as a dominant gene.
- In F₁ generation, only dominant characters are expressed by dominant genes, whereas recessive genes and their expressions are suppressed.
- 'Tt' and 'Rr' are the two pairs of heterozygous alleles.

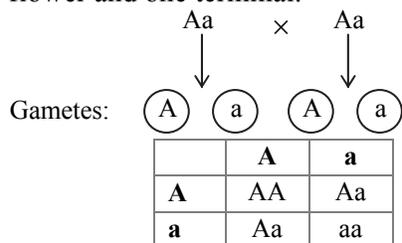


8. A pure line is the organism which is homozygous for a particular character.
9. Mutants are organisms which are produced due to mutations. F₂ is the second filial generation. P is parental generation.
12. Hybridisation is a process in which plants belonging to different species are artificially cross pollinated. The important step in this is emasculation, which means removal of anthers or stamens before anthesis to prevent self-pollination in bisexual flowers.
14. The character which is expressed in F₁ generation is dominant and the recessive character is suppressed in F₁ generation.

17. Rr × Rr

	R	r
R	RR tall	Rr tall
r	Rr tall	rr dwarf

18. When a homozygous dominant (AA) is crossed with homozygous recessive (aa) in F₁ generation heterozygous dominant (Aa) is obtained which does not resemble any of the parents genotypically.
19. The phenotypes obtained from growing 190 grains of Jowar are 140 tall and 50 dwarf. This approximately equal to 3 : 1 ratio. Hence, this will be F₂ generation and there will be 3 genotypes and two phenotypes. The genotypes will be homozygous tall, heterozygous tall and homozygous dwarf, i.e. TT, Tt, tt respectively.
20. In F₂ generation, both the dominant and recessive characters are expressed and hence it will show both the types of flowers.
21. Axillary position (A) is dominant over terminal (a) position. When Aa × Aa is crossed, we get 3 : 1 ratio, i.e. three axillary flower and one terminal.



3 Axillary : 1 terminal

22. When homozygous dominant parent (TT) crossed with heterozygous parent (Tt), the offspring produced is of same phenotype as that of parents.

	T	T
T	TT	TT
t	Tt	Tt

Hence, the percentage of offsprings with different phenotype is '0'.

23. Plant heterozygous for tallness has two alleles, one governing tallness and other governing dwarfness. This plant will produce two types of gametes during gamete formation because of segregation. The gametes produced are T and t. Hence, the possibility of 't' gamete fertilizing either 'T' or 't' is $\frac{1}{2}$, i.e. 50 %.
24. The law of segregation states that when a pair of allelomorphs is brought together in the F₁ hybrid they co-exist or remain together in the hybrid without blending or in any way contaminating each other and they separate completely and remain pure during the formation of gametes.
25. The four phenotypes: Tall round, Tall wrinkled, Dwarf round, Dwarf wrinkled.
26. Parents : TTYy × ttyy
(Tall Yellow) (Dwarf green)

Gametes : (TY) (ty)

F₁ generation : TtYy

Gametes: (TY) (Ty) (tY) (ty)

F₂ generation:

	TY	Ty	tY	ty
TY	TTYy	TTYy	TtYY	TtYy
Ty	TTYy	TTyy	TtYy	Ttyy
tY	TtYY	TtYy	ttYY	ttYy
ty	TtYy	Ttyy	ttYy	ttyy

There is only one double recessive plant = ttyy

27. The single homozygous plants are YYRr (2), YyRR (2), Yyrr (2) and yyRr (2).
28. Phenotype of TtRr, TTRR and TtRR is Tall Round, but phenotype of Ttrr is tall wrinkled.
29. The dihybrid phenotypic ratio is 9 : 3 : 3 : 1.
9 – Tall yellow 3 – Tall green
3 – Dwarf yellow 1 – Dwarf green



∴ If there are 36 tall and green plants there will be 36 dwarf yellow, 12 dwarf green and 108 tall yellow plants. Thus the total number of progeny will be 192.

30. When a plant heterozygous for tallness and yellow colour are selfed, they will produce F₂ generation with 16 different genotypes. Out of these, only one will be homozygous recessive genotype. Hence, the ratio of pure homozygous dwarf and green is 1 : 16.

31. Parents : TTRR × ttrr
 ↓
 F₁ generation : TtRr
 F₂ generation : TtRr × TtRr
 Gametes : $\begin{matrix} \text{TR} & \text{Tr} & \text{tR} & \text{tr} \\ \text{TR} & \text{Tr} & \text{tR} & \text{tr} \end{matrix} \times$

	TR	Tr	tR	tr
TR	TTRR	TTRr	TtRR	TtRr
Tr	TTRr	TTrr	TtRr	Ttrr
tR	TtRR	TtRr	ttRR	ttRr
tr	TtRr	Ttrr	ttRr	ttrr

∴ In F₂ generation, TTrr is 1/16.

32. Four double heterozygous individuals (AaBb) are formed in a typical Mendelian dihybrid cross.

33. When the F₁ dihybrid is crossed with a recessive plant, it is called dihybrid test cross.

Yellow Round × Green Wrinkled
 Parents: YyRr × yyrr
 ↓
 Gametes: $\begin{matrix} \text{YR} & \text{Yr} & \text{yR} & \text{yr} \\ \text{yr} & \text{Yr} & \text{yR} & \text{yr} \end{matrix} \times$

	YR	Yr	yR	yr
yr	YyRr	Yyrr	yyRr	yyrr

1 : 1 : 1 : 1
 Yellow Round : Yellow Wrinkled : Green round : Green wrinkled

34. The ratio given is → 9: 3: 3: 1 (56.25 : 18.75 : 18.75 : 6.25)

This ratio occurs due to the F₁ hybrid which is heterozygous for both the genes, i.e. TtRr.

35. The eight gametes produced will be – ABC, ABc, AbC, Abc, aBC, aBc, abC, abc

36. A cross between yellow round and green wrinkled pure line plants, yields all yellow round plants in F₁ generation as this character is dominant. No recessive character is expressed in F₁ plants so, the number of yellow wrinkled plants produced is 0.

37. In AABBCc, there is no heterozygous allele. So, only one type of gamete can be formed.

39. Law of independent assortment can also be stated as “If the inheritance of more than one pair of characters (two pairs or more) is studied simultaneously, the factors or genes for each pair of characters assort independently of the other pairs”.

In the example given above, the two allelomorphic pairs for characters – blood group and colour of hair are taken into consideration, which can be expressed by Law of Independent Assortment.

40. The law of independent assortment is applicable only for the traits which are located on different chromosomes.

41. When F₁ offsprings are crossed with recessive parent it is called as test cross and it produces recessive and dominant in equal proportion and hence used to distinguish between homozygous or heterozygous dominant characters.

43. Parents: Tt × tt
 Gametes: $\begin{matrix} \text{T} & \text{t} \\ \text{t} & \text{t} \end{matrix}$

	T	t
t	Tt	tt
t	Tt	tt

Equal number of tall and dwarf plants are produced.

45. In Mendelian inheritance, the F₂ offsprings are obtained by self-pollination in the F₁ hybrids. But, the F₁ hybrids can be crossed with either of the two parents. Such a cross between offspring and parents is known as back cross.

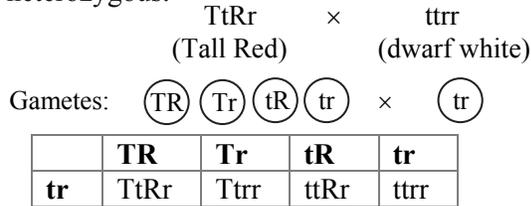
46. The genotype of pure inflated pod variety = II
 The genotype of pure constricted pod variety = ii
 The cross will be;

Parents : II × ii
 Gametes: $\begin{matrix} \text{I} & \text{i} \end{matrix}$
 F₁ generation : Ii
 (F₁ hybrid)
 Ii × II
 (F₁ hybrid) (pure inflated)
 Gametes: $\begin{matrix} \text{I} & \text{i} & \text{I} & \text{I} \\ \text{II} & \text{II} & \text{Ii} & \text{Ii} \end{matrix}$
 (All inflated pods)



47. The gametes produced by parents YyRr will be YR, Yr, yR, yr. Hence, the percentage of yr will be 25.

48. This is a dihybrid test cross, so the tall pea plant with red flowers has to be TtRr, i.e. heterozygous.



50. Parents: Red (RR) × White (rr)

Gametes: R × r

F₁ generation: Rr (All pink)

F₂ generation:

	R	r
R	RR (Red)	Rr (Pink)
r	Rr (Pink)	rr (white)

Phenotypic ratio: Red : Pink : White
1 : 2 : 1

Genotypic ratio: RR : Rr : rr
1 : 2 : 1

51. *Mirabilis jalapa* (4 O' clock plant) exhibits Incomplete dominance. Both the genes of an allelomorphic pair, i.e. Red (R) and White (r) express themselves partially. Thus, the F₁ hybrid is Pink flowered plant which is intermediate between the Red and White varieties.

52. RR (Red) × WW (White)

Gametes: R × W

F₁ generation: RW (Roan)

F₂ generation: RW × RW

	R	W
R	RR (red)	RW (roan)
W	RW (roan)	WW (white)

Phenotypic ratio: 1 Red : 2 Roan : 1 White
Genotypic ratio : RR : RW : WW
1 : 2 : 1

53. The homozygous and heterozygous genotypic condition for blood group A will be I^AI^A and I^Ai respectively.

54. Three types of progenies which result from marriage between sickle-cell carriers are one normal, two sickle-cell carriers and one sickle-cell anaemic. The one sickle-cell anaemic dies leaving behind one normal and two sickle-cell carriers. Hence, the ratio is 1 : 2.

56. The disease sickle-cell anaemia is caused by a gene Hb^S which is recessive. A marriage between two carriers of sickle-cell anaemia (Hb^AHb^S) will produce – normal children with genotype (Hb^AHb^A), sickle cell carriers with genotype (Hb^AHb^S) and sickle-cell anaemic with genotype Hb^SHb^S. Sickle-cell anaemic dies leaving behind carriers and normal. Thus, the gene for sickle-cell anaemia (recessive gene) is lethal in homozygous condition.

57. Genotype of albino person is aabbcc (pure white, melanin is not produced at all).

58. Whenever any organism consisting of two contrasting alleles of a gene or trait, the one which expresses itself phenotypically is known as dominant, whereas other allele or trait which fails to express itself is recessive. On the basis of his experiments, Mendel formulated this law of dominance when a pair of contrasting characters was crossed.

59. The ratio produced is 9 : 3 : 3 : 1 which is also called the “dihybrid” ratio. Therefore, the genotype of the parents should be RrTt. (i.e. heterozygous for both the genes.)



Competitive Thinking

- Heredity is the transmission of genetic characters from parents to the offspring.
- Law of dominance, law of segregation and law of independent assortment come under Mendel's laws of inheritance.
- The homozygote is pure for the character and breeds true, i.e. it gives rise to offsprings having the same character on self-breeding. e.g. TT or tt.
- Heterozygous is not pure and is called hybrid. Heterozygote does not breed true on self fertilization. e.g. Tt.



16. Recessive character will be expressed only in presence of recessive alleles. A dominant allele will not allow the expression of a recessive allele.

18. Parents: RR × rr
(red) (white)

Gametes: (R) × (r)

F₁ generation: Rr

F₂ generation:

	R	r
R	RR	Rr
r	Rr	rr

∴ 3 red coloured (RR, Rr, Rr): 1 White coloured (rr)

20. 1 : 2 : 1; one homozygous dominant, two heterozygous dominant and one homozygous recessive.

22. Tt × TT
(F₁ hybrid) (homozygous dominant)

	T	T
T	TT	TT
t	Tt	Tt

No recessive combination is obtained.

23. Parents: RR × rr

Gametes: (R) × (r)

F₁ generation: Rr

F₂ generation: Rr × Rr

	R	r
R	RR	Rr
r	Rr	rr

∴ Red : white = 3 : 1

24. 50; because after selfing of Rr, 2 homozygous and 2 heterozygous individuals are formed in F₂ generation.

	R	r
R	RR	Rr
r	Rr	rr

26. In a dihybrid cross between YYRR and yyrr, the genotypic ratio of F₂ generation is as follows:

YYRR YYRr YyRR YyRr YYrr Yyrr yyRR yyRr yyrr
1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1

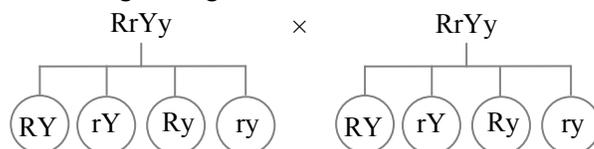
Thus, ratio of individuals showing one dominant and other recessive characters is YYrr : Yyrr : yyRR : yyRr i.e. 1/16
1 : 2 : 1 : 2

28. In a dihybrid cross between YYRR (yellow round) and yyrr (green wrinkled), the phenotypic ratio of F₂ generation is as follows:

Yellow : Yellow : Green : Green
round wrinkled round wrinkled
9 : 3 : 3 : 1

Thus, the ratio of recombinant offspring is 6/16.

29. Selfing of F₁ generation:



F₂ generation (Punnett square):

	RY	rY	Ry	ry
RY	RRYY (Round Yellow)	RrYY (Round Yellow)	RRYy (Round Yellow)	RrYy (Round Yellow)
rY	RrYY (Round Yellow)	rrYY (Wrinkled Yellow)	RrYy (Round Yellow)	rrYy (Wrinkled Yellow)
Ry	RRYy (Round Yellow)	RrYy (Round Yellow)	RRyy (Round Green)	Rryy (Round Green)
ry	RrYy (Round Yellow)	rrYy (Wrinkled Yellow)	Rryy (Round Green)	rryy (Wrinkled Green)

Yellow: 12; Green: 4

Yellow : Green

12 : 4

3 : 1

32. Law of segregation is universally applicable.

33. Genotype → AaBbcc

No. of gametes produced = 2ⁿ (n = no. of heterozygous alleles)

Here, n = 2 (Aa, Bb)

∴ No. of gametes produced = 2² = 4
(ABc, Abc, aBc, abc)

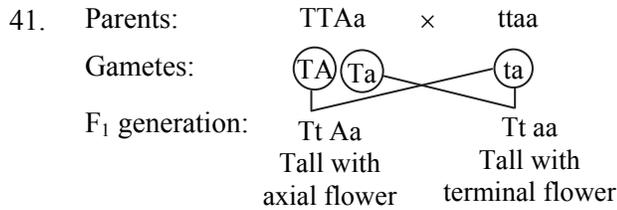
34. RrYy is a dihybrid, so four types of gametes are formed – RY, Ry, rY, ry

35. Different types of gametes formed by genotype TtYy are TY, Ty, tY, ty

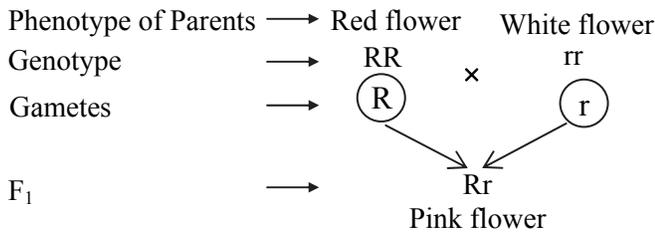
36. AABb × aaBb

	AB	Ab
aB	AaBB	AaBb
ab	AaBb	Aabb

∴ AaBB : AaBb : Aabb : aabb
1 : 2 : 1 : 0

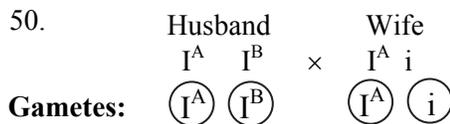


45. *Mirabilis jalapa* shows incomplete dominance.
 46.



48. In codominance, both the genes of an allelomorphic pair express themselves equally and independently in F₁ hybrids. In co-dominance, the phenotypic and genotypic ratio is identical, i.e. 1 : 2 : 1

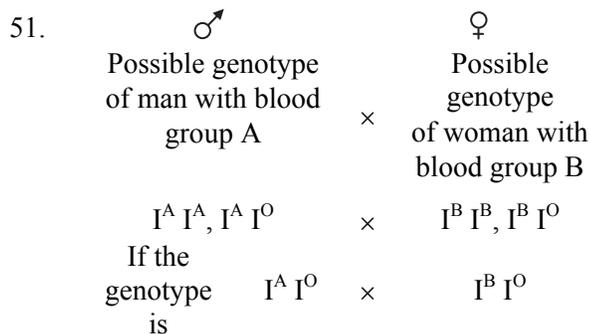
49. In Co-dominance, both the alleles of a gene pair in heterozygous condition are fully expressed, with neither one being dominant or recessive to the other.



offsprings:

	I ^A	i
I ^A	I ^A I ^A 'A' blood group	I ^A i 'A' blood group
I ^B	I ^A I ^B 'AB' blood group	I ^B i 'B' blood group

Thus, number of genotypes : 4
 number of phenotypes : 3



The possible blood groups can be A, B, AB and O.

54. The allele I^A and I^B produce a sugar and allele i does not produce any sugar.

55. The six genotypes are – I^A I^A or I^Ai, I^BI^B or I^Bi, I^AI^B, ii.
 The four phenotypes are – A, B, AB, O.

56. In Co-dominance, both alleles of a gene pair in heterozygote are fully expressed, with neither one being dominant or recessive to the other. Allele I^A and I^B when present together in AB blood group, express their own type of sugar on the surface of RBC. Thus, it is an example of Co-dominance.

58. When a single gene controls two (or more) different traits, the phenomenon is called pleiotropy.

59. A marriage between two carriers of sickle cell anaemia will produce normal, carrier and anaemic progeny in 1 : 2 : 1 ratio.

61. Human characters such as height, skin showing gradations (continuous variations) in expression. These characters are determined by two or more gene pairs and they have additive or cumulative effect. These genes are called cumulative genes or polygenes or multiple factors.

62. Considering the three genes A, B and C that control skin colour;
 Genotype AABBCC has six dominant, genes thus giving the darkest skin colour and genotype aabbcc has no dominant genes thus giving the lightest skin colour.

66. The F₁ generation has mullatoes with 8 types of gametes. The genetic combination is AaBbCc. As there are three pairs of heterozygous alleles, it will form 8 types of gametes.

67. Mendel enunciated three major principles of inheritance, i.e. Law of dominance, law of segregation and law of independent assortment.

69. P : AABBDDEE X aabbdde



F₁ : AaBbDdEe

Types of gametes formed = 2ⁿ
 (tetrahybrid) 2⁴ = 2 × 2 × 2 × 2 = 16 gametes



Evaluation Test

- The four gametes produced by AaBb – AB, Ab, aB, ab. Therefore percentage of 'ab' gamete produced by 'AaBb' parent will be 25% .
- Dwarf plants of F₂ generation of a monohybrid cross are homozygous dwarf and hence form pure line parents or breed true for dwarfness.

- Parents: Tt × Tt
Gametes: (T) (t) (T) (t)

	T	t
T	TT	Tt
t	Tt	tt

3/4th of the offsprings appear dominant (TT, Tt, Tt)

- In F₂ generation, Mendel got tall and dwarf plants in approximately 3:1 ratio (here ratio is 2.84:1)
- Test cross is a back cross but back cross is not necessarily a test cross.
- In pea flower, the stamens and carpels are enclosed in the innermost two petals that are appressed together forming a boat-shaped structure called Carina.
- A dominant allele expresses itself in hybrids.
- F₂ progeny of monohybrid cross shows two phenotypes and three genotypes, viz. homozygous dominant, heterozygous dominant and homozygous recessive. The cross between F₁ progeny obtained from homozygous tall (TT) and homozygous dwarf (tt) plant will yield (three types of genotypes) homozygous tall (TT), heterozygous tall (Tt) and homozygous dwarf (tt). The two phenotypes will be tall and dwarf.

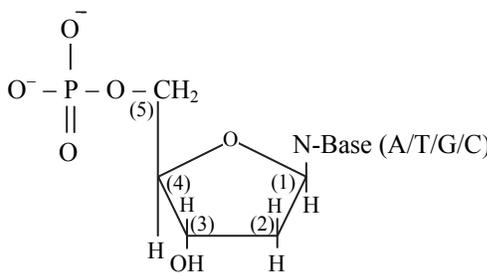
Gene: Its nature, expression and regulation



Hints



Classical Thinking

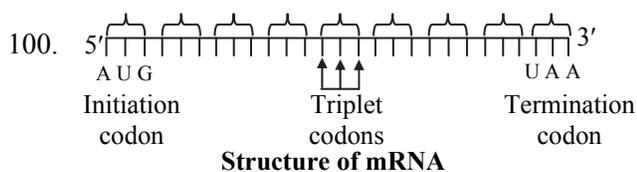
8. Meselson and Stahl proved that DNA replicates by semi conservative method. Avery et. al. modified Griffith's experiment of transformation and provided the first clear evidence that DNA is the genetic material and is responsible for transformation in bacteria. Zinder and Lederberg proved that transduction occurs with the help of viruses.
11. The strongest evidence that DNA is a genetic material comes from the transformation experiment which indicates that DNA enters the bacterial cells and not proteins. Thus, DNA is the genetic material.
17. Recon is the smallest unit of DNA capable of undergoing crossing over and recombination.
25. Chemically, cytosine, thymine and uracil are pyrimidines, while adenine is a purine.
27. Purines (Adenine and guanine) are double ring compounds.
28. Uracil is a pyrimidine absent in DNA and present in RNA.
29. Thymine, cytosine and uracil are monocyclic bases.
31. A pentose sugar when attached to the nitrogen base, either purine or a pyrimidine is called as nucleoside.
32. Nucleoside = Pentose + Nitrogen base
Nucleotide = Pentose + Nitrogen base + Phosphate
33. 

The diagram shows a phosphate group (O⁻-P(=O)(O⁻)-O-) attached to the 5th carbon (CH₂) of a pentose sugar ring. The sugar ring has carbons numbered 1 to 5. Carbon 1 is attached to an N-Base (A/T/G/C). Carbon 2 has a hydrogen atom (H). Carbon 3 has a hydrogen atom (H) and a hydroxyl group (OH). Carbon 4 has a hydrogen atom (H).
34. In sugar molecule, nitrogen base is attached to 1st carbon and phosphate is attached to 5th carbon.

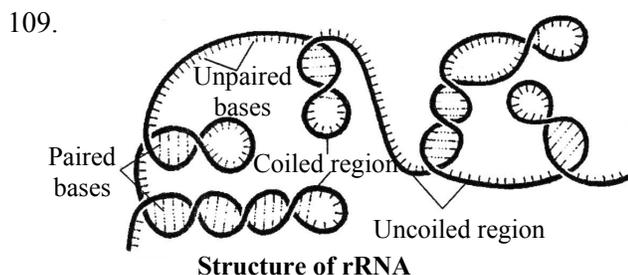
44. The successive nucleotides of the same strand are linked by 3' - 5' phosphodiester linkages, i.e. phosphate attached to 5th carbon of a sugar of nucleotide is joined to 3rd carbon of another.
45. In the DNA double helix, purines, i.e. Adenine and Guanine and pyrimidines, i.e. Thymine and Cytosine exist in base pairs. e.g. Adenine always pairs with Thymine and Guanine always pairs with Cytosine. [A = T], [C ≡ G].
48. According to Chargaff's rule, number of purine bases is equal to number pyrimidine bases.
49. Cytosine and guanine show complementary base pairing.
50. At the 5' end, there is free phosphate group, while at the 3' end, there is free OH group.
52. In the helix of DNA, there are two types of grooves, major or deep grooves and minor grooves.
53. The diameter of the DNA double helix is 20 Å. (It is also measured as 2 nm as 1nm = 10Å.)
58. Both DNA and RNA have similar purines, i.e. adenine and guanine, but in RNA, the pyrimidine, thymine is replaced by uracil.
60. The nucleotides present in the nucleoplasm in the form of monophosphates are activated into triphosphates in the presence of phosphorylase.
64. DNA strands are separated by DNA unwinding protein called helicase or rep protein.
66. To initiate the formation of a new strand on the template strand, DNA polymerase needs presence of RNA primer ('short RNA segment').
70. The DNA strand on which transcription occurs is the sense strand. The coding sequences on a mRNA strand are the exons and the non coding sequences are the introns.
71. Okazaki fragments are formed during discontinuous replication. These small pieces of newly formed DNA are joined to each other by phosphodiester linkage by enzyme DNA ligase.



72. During replication, short Okazaki fragments are joined by the enzyme DNA ligase.
77. In prokaryotes, circular DNA is present. There is only one origin and the replication is called 'θ' replication, as it looks like Greek letter Theta.
80. The negatively charged DNA is wrapped around the positively charged histone octamer to form nucleosome.
83. DNA is negatively charged and it is wrapped around positively charged histone octamer.
95. Ribonucleic acids are of three types (i) mRNA (ii) tRNA (iii) rRNA.
98. RNA is characterised by absence of thymine which is replaced by uracil.



104. AUG is an initiation codon present at the 5' end of mRNA.



117. tRNA is the smallest of all the RNA types with molecular weight between 23,000 – 30,000.
121. Since anticodon is complementary to codon it is also known as 'nodo', i.e. reverse of codon.
123. The short end is 5' end which has guanine.
124. D loop is a amino acyl binding loop present on DHU arm and T loop is ribosomal binding loop present on TψC arm of clover leaf model of tRNA.
126. tRNA is also called s-RNA (soluble) because it cannot be easily separated even by ultracentrifugation technique.
128. mRNA molecule is always simple and straight without any fold, whereas rRNA and tRNA show folds and pairing between complementary bases in folding regions.

131. Gene is a specific segment of DNA which codes for a polypeptide. It also controls hereditary characters.
134. One-gene-one polypeptide hypothesis proposed by Vernon Ingram explains that many genes code for proteins which are not enzymes.
142. As each codon has three nitrogen bases i.e. triplet, then the number of codons will be $= 4^3 = 4 \times 4 \times 4 = 64$
143. Threonine – ACU, ACC, ACA, ACG
Phenylalanine – UUU, UUC
Histidine – CAU, CAC
144. Genetic code is non-ambiguous, i.e. each codon codes for particular amino acid, the same codon will not code for two amino acids.
146. UAG (amber), UAA (ochre) and UGA (opal) serve as stop codons or termination codons.
151. There are '61 codons', therefore there has to be 61 tRNA anticodons. However, the actual types of t-RNAs is much less than 61. This indicates that the anticodon of tRNA can read two or more codons on mRNA. This was explained by Wobble hypothesis by Crick. According to this hypothesis, in codon-anticodon pairing, the third base may not be complementary.
152. Central dogma of molecular biology shows a unidirectional or one way flow of information from DNA to RNA and from RNA to protein.
165. In the presence of an enzyme aminoacyl tRNA synthetase, the amino acid (AA) molecule is activated and then each amino acid is attached to the specific tRNA molecule at 3' end to form aminoacyl-tRNA complex.
169. During the initiation process of translation, the mRNA gets attached to the smaller (30S) subunit of ribosome.
170. Ribosomes has three sites namely aminoacyl site (A), peptidyl site (P) and exit site (E).
177. Release factors play important role in identifying the stop/termination codon and in releasing the polypeptide chain.
186. Promoter gene (P) is the actual site of start of transcription and it is the site where RNA polymerase binds to the DNA prior to beginning of transcription.
187. Operon model was given by Jacob and Monod (1961) for regulation of protein synthesis in prokaryotes.



190. Gene is defined as a segment of DNA which is made of polynucleotides.
195. According to Wobble hypothesis, in codon-anticodon pairing the third base may not be complementary. The third base of the codon is called wobble base and this position is called wobble position.



Critical Thinking

3. Use of deoxyribonuclease (DNAase) enabled Avery, Macleod and McCarty to prove that DNA is the transforming principle.
5. Each strand has one free phosphate group on 5th carbon of the sugar molecule. This end of the strand is called as the 5' end. The other end of the strand has a free – OH group on 3rd carbon of the sugar molecule. This is called as the 3' end of the strand.
6. Since, A pairs with T and G pairs with C
 $A = T, G \equiv C$
 Then, A G C T T C G A
 | | | | | | | |
 T C G A A G C T
9. The number of nucleotides will double as adenine will pair with thymine and cytosine will pair with guanine.
10. There are in all 150 base pairs of which 60 base pairs are A = T.
 \therefore there will be 90 G \equiv C base pairs.
 There are 2 hydrogen bonds between A = T, i.e. 120 bonds.
 There are 3 hydrogen bonds between G \equiv C, i.e. 270 bonds.
 \therefore The 150 base pairs will have 390 hydrogen bonds.
11. According to Chargaff's law, the amount of purine is equal to the amount of pyrimidine, the ratio of purine : pyrimidine is 1 : 1.
 If G = 10% then C = 10% (Because guanine pairs with Cytosine)
 As, A + G = T + C
 $\therefore A + (10\%)G = T + (10\%)C$
 $\therefore (40\%)A + (10\%)G = (40\%)T + (10\%)C$
13. The length of one complete spiral DNA = 34Å. The length of DNA with 10 spirals = $34 \times 10 = 340 \text{ Å}$.
14. \therefore 10 base pairs = one turn of DNA double helix
 \therefore 45 base pairs = 'x' turn of DNA double helix.
 $\therefore x = \frac{45}{10}$ turns of DNA double helix

15. In 340 Å long DNA molecule, there are 100 base pairs, hence 200 nucleotides and 198 phosphodiester bonds.
17. During DNA replication, the separated strands are prevented from coiling by SSBP (Single strand DNA binding protein) or helix destabilizing protein.
18. RNA primer is a small RNA molecule synthesized by enzyme RNA primase. Synthesis of new complementary strand takes place with the help of RNA primer.
19. The enzyme DNA polymerase is strictly polar and works only in one direction, i.e. from 5' to 3' direction. Hence, production of new DNA strands is always complementary to the template strand which begins at 3' end on the DNA template and proceeds towards 5' direction.
20. The DNA is polymerised in 5' to 3' direction, i.e. the enzyme "DNA polymerase" can only catalyze DNA synthesis in 5' \rightarrow 3' direction or it can add nucleotides only to the free 3' –OH terminal, thus only extending a pre-existing nucleotide sequence called "Primer".
21. DNA synthesis occurs in 5' to 3' direction, i.e. the phosphate group attached to C₅ of incoming nucleotide reacts with the hydroxyl group attached to C₃ of the older nucleotide strand.
24. Synthesis of new strand is possible only in 5' \rightarrow 3' direction.
27. In semi-conservative mode of replication, after replication, each DNA molecule has one old and one new strand.
30. Histones are protein, rich in basic amino acid residues such as lysines and arginines.
31. 10bp = 34Å
 146 bp = ?
 Therefore, 146 bp = 496 Å
32. The genetic RNA is found in retrovirus. e.g. TMV, Hepatitis virus, etc. whereas mRNA, tRNA and rRNA are nongenetic RNAs.
35. The base composition of RNA does not agree to the A + G = U + C, as it is found in DNA, because RNA is single – stranded structure consisting of a single polynucleotide chain.
39. DHU arm has amino acyl binding loop, middle arm has anticodon loop and T ψ C arm has ribosomal binding loop.



42. Transfer RNA is the smallest RNA having molecular weight of about 25,000 to 30,000, while the Ribosomal RNA (rRNA) has a molecular weight between 40,000 to one lakh. The highest molecular weight is that of DNA which is about 1.2 million.
43. During protein synthesis, mRNA carries message from DNA to ribosomes. rRNA provides proper binding site for mRNA and orients mRNA in such a way that all the codons are read properly. tRNA translates the coded message of mRNA on the ribosome in terms of amino acids.
45. During protein synthesis, the sequence of amino acids in polypeptide chain is determined by sequence of nitrogenous bases in the polynucleotide chain of DNA composing specific gene.
46. In the given example AUG → Methionine, CAG → Glycine, AUA → Isoleucine, CGC – Arginine are ‘commaless’ or without punctuation. It is the characteristic of genetic code. In this case, after one amino acid is coded, the second amino acid will automatically be coded by the next three letters.
48. According to the Wobble hypothesis, in codon – anticodon pairing, the third base may not be complementary. The third base of the codon is wobble base and this position is called wobble position.
49. A genetic code is said to be degenerate as a single amino acid may be specified by many codon.
50. If 2 nitrogen bases had been used to represent a single amino acid, it would have resulted in $4^2 = 16$ codons.
51. In $\frac{GCG}{CGA}$, the base pairing is wrong as per the A = U, G = C base pairing rule. But according to the Wobble hypothesis, in codon-anticodon pairing the third base may not be complementary. Thus, the Wobble hypothesis applies to option (B).
53. During transcription, genetic information from DNA is copied into RNA in the presence of enzyme DNA dependent RNA polymerase.
54. During replication, both DNA strands function as template, but during transcription, only one of it functions as a template and is called as anti sense strand.
56. Eukaryotic mRNA is monocistronic. It carries triplet codons for synthesis of only one protein.
57. mRNA is formed in nucleus on DNA by transcription.
59. In presence of an enzyme aminoacyl tRNA synthetase, the amino acid molecule is activated with the help of ATP.
60. In the presence of an enzyme aminoacyl tRNA synthetase, the amino acid molecule is activated and then each amino acid is attached to the specific tRNA molecule at 3' CCA end to form aminoacyl tRNA complex. The reaction needs ATP. This process is called charging of tRNA.
62. Codon of mRNA always base pairs with anticodon of tRNA. The base pairing is complementary. The initiation codon or start codon in mRNA is 5' AUG 3', so the anticodon has to be 3' UAC 5' which is present on tRNA.
63. Energy in the form of ATP is required during termination, amino acid activation and binding of aminoacyl tRNA to P site during translation except peptidyl transferase reaction, i.e. elongation.
64. UAG, UAA, UGA are termination codons.
66. In order to increase the cellular efficiency of protein synthesis, many ribosomes bind to the mRNA strand and form the polypeptide chains for synthesis of protein molecule. Such a structure with many ribosomes bound to mRNA is called polyribosome.
67. One triplet codon codes for 1 amino acid. There are 13 amino acids, therefore $13 \times 3 = 39$ and for termination, we have a nonsense codon = $39 + 3 = 42$ bases.
68. During protein synthesis, the single stranded RNA serves as an intermediate between DNA and polypeptide chain. This unidirectional flow of information from DNA → RNA → protein is described as the ‘central dogma’ in molecular biology and therefore, DNA is not directly involved in the synthesis of protein.
69. The ribonucleotide triphosphates get joined to the bases of the DNA template chain one by one by hydrogen bonding according to the base pairing rule of Watson and Crick.



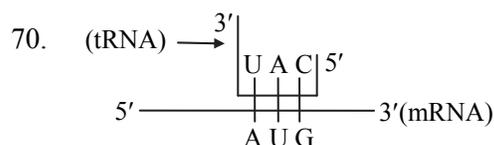
70. Operon model consists of structural genes, regulatory gene, promoter gene and operator gene.
76. Protein synthesis occurs on the ribosome. Hence if it is removed, protein synthesis will stop.
77. An amino acid is coded by a triplet of nitrogen bases known as codon.
 $\therefore 150 \times 3 = 450$



Competitive Thinking

3. Griffith used bacterium *Diplococcus pneumoniae* in the transformation experiment.
12. DNA carries and transfers the genetic information from one generation to another.
22. The two strands (polynucleotide chains) of double helix are antiparallel and complementary. The sequence of nitrogenous bases in one strand determines the sequence of nitrogenous bases in the other.
27. $A + G / T + C$ ratio is constant in DNA of different species, but it is variable in organisms of different genus.
28. According to Chargaff's rules, $A + T \neq G + C$.
29. According to Chargaff's principle,
 $A = T$ and $G = C$
If $C = 17\%$, then $G = 17\%$
and $A + T + G + C = 100\%$
So, $A = T = 33\%$
30. According to Chargaff's rule ; $A = T$; $C = G$
If the % of $A = 20\%$, therefore $T = 20\%$ or,
 $A + T = 40\%$. Therefore, $G + C = 60\%$ and hence $G = 30\%$
32. Formation of new DNA from old DNA is called replication or multiplication of DNA.
34. Matthew Meselson and Franklin Stahl first shown semi-conservative DNA replication in *Escherichia coli*.
36. New DNA strand is formed on $3'$ to $5'$ strand continuously in $5' \rightarrow 3'$ direction. This strand which is formed continuously is called leading strand.
40. DNA polymerase catalyzes polymerization, i.e. addition of nucleotides to synthesizing strands. DNA ligase join the Okazaki fragments.

42. Okazaki segments are formed during semidiscontinuous replication. The Okazaki fragments are later joined together, forming a continuous lagging strand.
57. The mRNA carries the message from DNA about the sequence of particular amino acids to be joined to form a polypeptide hence it is necessary for protein synthesis.
65. Anticodon are also called codon recognition site. This site has three unjoined bases whose sequence is complementary with a codon in mRNA.



72. Marshall Nirenberg, Heinrich Matthaei and Har Gobind Khorana deciphered complete genetic code by using artificial mRNA templates and cell free system of protein synthesis.
73. A single amino acid is specified by a sequence of three nucleotides in mRNA called codon. Due to triplet nature, it consist of 64 codon.
75. Triplet base on mRNA are coded by three bases present on tRNA anticodon and ultimately form amino acid by translation.
77. As the number of codons are 64 (among these 3 are termination codons) and number of amino acids to be coded is 20, so more than one codons is available for a single amino acid.
81. Start codon or initiation codon on mRNA is AUG, which is the first codon in the transcribed mRNA that undergoes translation. The anticodons on tRNA are complementary to codons on mRNA. Thus, the anticodon will be UAC.
[A = U, U = A, C ≡ G]
83. The genetic code is universal, i.e. it is similar in all the organisms from simple bacteria to complex organisms.
87. mRNA has same nucleotide sequence as that of coding strand but thymine (T) is replaced by uracil (U) in mRNA.
88. The codon UGG present on the mRNA codes for amino acid tryptophan. The anticodon present on the tRNA, complementary to this sequence is ACC.



93. The concept of Central Dogma was proposed by Crick in 1958.
99. Exon is the active part of mRNA which codes for the formation of specific protein.
100. Exons are coding sequences of a DNA which are retained in mature mRNA whereas introns are removed during post-transcriptional modification and do not appear in mature mRNA.
101. Introns are DNA sequences that do not appear in mature or processed RNA.
102. The eukaryotic cell, transcribes a precursor RNA much longer than mRNA. This is called heterogeneous nuclear RNA.
105. Addition of adenylate residues to 3' end in a template independent manner – Tailing
Methyl guanosine triphosphate is added to 5'-end of hnRNA – capping.
107. AUG only initiates protein synthesis.
109. 999 bases = 333 codons
.... (\because 3 bases = 1 codon)
When 901th base gets deleted, the first 900 bases will not change. Thus, the unaltered codons will be 300.
The number of codons getting altered due to the change in 99 bases will be 33.
114. Regulator gene produces a repressor that binds to operator gene and stops the working of the latter.
119. The structural gene 'z' codes for β - galactosidase, 'y' for permease and 'a' for transacetylase.
123. Nucleotides are the building blocks or monomeric units. Each nucleotide contains Nitrogen bases (Purines and pyrimidines), pentose sugar (5C) and phosphoric acid.
124. DNA generally acts as template for the synthesis of DNA (in replication) and RNA (in transcription).
126. The sequence of transcript (i.e., RNA transcribed) is same as the template strand except in place of thymine it is uracil.
127. Transcription is writing information from DNA to mRNA, not from DNA to tRNA.
138. Matthew Meselson and F. Stahl experimentally proved semi-conservative mode of DNA replication. Alfred Hershey and Martha Chase (1952) used bacteriophages and conducted a series of experiments to prove that DNA is the genetic material. British geneticists Alec Jeffreys discovered the technique of DNA fingerprinting.
140. Prokaryotes(bacteria) do not have introns in their mRNA. Thus, transformed bacteria cannot process introns(non coding regions) present in the human gene and fail to produce the desired protein.
143. DNA of chloroplast is circular, closed, naked ring and is called as plastidome. Polyhedral bodies are present in several autotrophic bacteria that assimilate inorganic carbon. Nucleosome is a structure formed by wrapping negatively charged DNA around the octamer formed of positively charged histone proteins.



Evaluation Test

1. RNA $\xrightarrow{\text{Reverse Transcription}}$ DNA
6. At the 3' end of t-RNA, an unpaired CCA base sequence is present. It is called as amino acid attachment site.
7. Histones are absent in prokaryotes.
13. DNA contains only phosphorous (phosphate group) derived from phosphoric acid (H_3PO_4).
16. As, A = 25, hence, T = 25 (since number of adenine = number of thymine).
- Similarly, C = 45, hence, G = 45 (since number of cytosine = number of guanine).
Hence, number of nucleotides in DNA segment = A+T+G+C= 25+25+45+45= 140.
17. Endonuclease enzyme cuts DNA at specific sites. DNA polymerase helps in formation of complementary strand and proof reading of bases.
19. Release of polypeptide chain takes place during termination process.



Hints



Classical Thinking

7. Eli Lilly (American company) in 1893 produced genetically engineered insulin called humulin with the help of *E. coli*.
14. Endonucleases are also called molecular scissors or chemical scissors or molecular knives or chemical scalpels.
24. The first transposons were discovered in maize (*Zea mays*) by Barbara McClintock in 1948.
75. Nif gene is a nitrogen fixing gene isolated from *Rhizobium*. It is cloned inside *Agrobacterium tumefaciens* and then transferred into other plants.
76. Polygalactouranase is the enzyme produced by antisense gene in Flavr savr tomato which retards ripening.



Critical Thinking

4. YAC is Yeast Artificial Chromosome and used as a vector in yeast cells.
9. Transposition can create phenotypic mutation and alter the cell's genome size.
10. Retrotransposons copy in two stages, first from DNA to RNA by transcription and then from RNA back to DNA by reverse transcription. The DNA copy is then inserted in new position thus, it works in copy and paste manner.
12. Plasmids are extrachromosomal double stranded DNA found mostly in prokaryotes.
13. pUC is the plasmid from University of California.
14. Large DNA molecules cannot be inserted through plasmids as large inserts increase the plasmid size making the transformation inefficient. Therefore, bacteriophage is used for this purpose.
16. Endolysin brings about the lysis of cell wall and release of virions.

21. Exonucleases remove nucleotides from the ends of DNA. Endonucleases make cuts at specific positions within the DNA.
22. While naming restriction endonuclease, the first letter of enzyme indicates the genus name followed by the first two letters of the species, then strain of the organism and finally a Roman numerical indicating the order of discovery.
27. The sticky ends with unpaired bases form hydrogen bonds with the base pairs of complementary sticky ends on any other DNA.
35. Transgenic plants are developed by genetic engineering by introducing foreign genes.
37. Bt toxin produced by *Bacillus thuringiensis* occurs as inactive protoxins. However, when this inactive form is ingested by insect, it is converted into active toxic form.
38. *Agrobacterium tumefaciens* contain Ti plasmids. Due to the ability of the bacterium to insert Ti plasmids into nuclear genome of the infected plant, gene transfer in higher plants through Ti-plasmids can be achieved.
39. Flavr savr tomato is developed by introducing an antisense gene that retards ripening.
40. In Flavr-savr variety of tomato, the expression of a native gene coding for pectin degrading enzyme polygalacturonase is blocked. In the absence of this enzyme, the fruit ripening is delayed and the fruit remains fresh for a longer period.
46. Atlas-66 is a genetically engineered wheat variety.



Competitive Thinking

3. Cohen and Boyer (1973) were the first to produce recombinant DNA by introducing a foreign gene into plasmid of *E. coli*.
6. First human hormone produced by recombinant technology is insulin by Eli Lilly, an American company in 1983.



12. Plasmids are extrachromosomal covalently closed, circular, double stranded molecules of DNA present in most prokaryotes. Therefore, it is used as a vector in genetic engineering.
15. Plasmids are naturally found in bacteria, yeast and occasionally in plant and animal cells.
16. Plasmid pBR 322 was one of the first widely used cloning vectors. It contains both ampicillin and tetracycline resistance genes.
18. Plasmid can clone only a small fragment of DNA (0.5-8 kb). Other can clone large fragments of DNA eg. Cosmid (30 - 45 kb); BAC (50 - 300 kb); YAC (1000 - 2500 kb)
26. Restriction endonucleases cleaves DNA double helix at specific point in such a way that single stranded free ends project from each fragment of DNA double helix.
27. DNA ligase is also called as molecular glue because it is used to join inserted DNA with the plasmid vector.
31. 'R' indicates the strain (RY 13) of the bacterium *E.coli*.
35. PCR is a method for amplifying a specific piece of DNA molecule without the requirement for time-consuming cloning procedures.
42. Bt cotton was produced by transgenic technology in which 'cry' gene was introduced into cotton plant genome. This gene was obtained from *Bacillus thuringiensis*.
43. Bt toxin gene is isolated from *Bacillus thuringiensis*. This gene is cloned and expressed in plants through plasmids.
45. The 'Cry' gene codes for Bt toxin.
49. One of the most interesting plasmids is the tumour-inducing (Ti) plasmid of *Agrobacterium tumefaciens*. *Agrobacterium tumefaciens* is a causative agent of a common plant disease termed 'crown gall disease'.
52. Ti plasmids present in *Agrobacterium tumefaciens* is used as a vector for gene transfer in various plants.
53. GEAC - Genetic Engineering Approval Committee.
58. Lerma Rojo and Sharbati Sonora are high yielding varieties of wheat.
59. Genetic engineering means manipulation of genes and it depends upon recombinant DNA technology.
60. Bt cotton is a transgenic plant, which have been genetically modified by incorporating foreign and other specific genes through recombinant DNA technology.
66. *Eco* RV has restriction sequence –
Eco RV
 5' – GAT ATC – 3'
 3' – CTA TAG – 5'
69. *Haemophilus influenzae*: Hind III
Escherichia coli: Eco R I
Bacillus amyloliquefaciens: BamH I
Agrobacterium tumefaciens: Atu



Evaluation Test

2. The palindromes in DNA are base pair sequences that are the same, when it is read forward (left to right) or backward (right to left) from a central axis of symmetry. The given sequences read the same in 5' → 3' direction and 3' → 5' direction.
3. Restriction enzymes are widely found in prokaryotes and provide protection to host cell by destroying foreign DNA that makes entry into it.
5. Agarose is a polysaccharide extracted from sea weeds and is commonly used as matrix in agarose gel electrophoresis.
7. Nucleases is a class of enzymes that cleaves DNA.
9. Plasmid and bacteriophage are cloning vectors used to transfer foreign DNA into the host cell.
10. Electrophoresis is a technique of separation of charged molecules under the influence of an electrical field through a matrix. DNA fragments generated by restriction endonuclease are separated by gel electrophoresis.
13. In PCR, Taq polymerase is used which is obtained from *Thermus aquaticus* bacteria. It is a relatively thermostable enzyme thus used in PCR, as during this process, the step involving denaturation of DNA strands requires high temperature of about 94° C.



Hints



Classical Thinking

3. Plant breeding involves collective use of an art and science for changing and improving the heredity of plants in order to create desired types.
10. Hybrids are obtained by the process of hybridization, i.e. crossing two selected varieties differing from each other genotypically.
11. Heterosis is also known as Hybrid vigour.
29. Dwarf wheat varieties like Sonora-64, Lerma rojo-64 and Norin-10, were introduced in India and increased wheat production.
38. Pusa sadabahar is the variety of chilli developed against disease leaf curl caused by chilli mosaic virus.
54. Steward gave the concept of totipotency. P. Maheshwari is a famous Indian embryologist. White prepared a culture medium for tissue culture experiments.
62. At pH between 5 to 5.8, the conditions are ideal for proper callus growth.
72. Micropropagation is raising plants from a very small part of the plant in-vitro. When the explants are cultured, they form micropropagules which ultimately give rise to new plantlets. As large number of plantlets is obtained from a small amount of explant, it is called as micropropagation.
75. PEG (Polyethylene glycol) is a fusogenic agent which promotes the fusion of protoplast. Sugars are used as carbon source and mannitol and sorbitol are used as osmotic retardants.
77. Tobacco – nicotine.
Rauwolfia – serpentine.



Critical Thinking

1. Selection is the important and essential process in plant breeding. Selection helps in choosing plants with desirable characters for hybridization.
2. Emasculation is defined as the removal of stamens from the flowers of the female parent well before anthesis, i.e. before anthers mature, dehisce and release pollen grains. Purpose of emasculation is to prevent self-pollination. Emasculation is not necessary if parents are dioecious.
4. Bagging is done before and after emasculation to prevent pollination by unwanted pollen.
5. Unwanted pollination gives undesirable results, thus it should be avoided during hybridisation.
7. Hybrid vigour (heterosis) is the superiority of the hybrid over either parent in one or more characters.
10. *Saccharum barberi* (sugarcane) is poor yielding and has less sugar content. Sharbati Sonora is a hybrid variety of wheat.
11. A large scale damage that is caused to crops is by attack of insects and pests. Therefore, the most common trait that was improved in commercialized crops was insect resistance.
12. ‘Pusa Sawani’ and ‘Pusa A-4’ is a variety of Okra (Bhindi) which shows resistance towards shoot and fruit borer insects.
14. Golden rice contains genes from the soil bacterium *Erwinia*. These genes inserted in the rice genome produce the enzyme necessary for the synthesis of beta-carotene, i.e. Provitamin A which is a precursor of vitamin A.
15. Golden rice is a GM crop containing genes from the soil bacterium *Erwinia* and either maize or daffodil plants. It contains increased levels of β -carotene which can be converted by the body into Vitamin A.
17. Totipotency is the ability of the cells to differentiate and regenerate an entire plant.
18. The cells of the meristem divide very fast and are pathogen free.



20. Agar melts on heating but solidifies at room temperature. So, it is used to prepare a solid culture medium.
22. The pH of the culture medium is 5-5.8
23. Organogenesis is formation of an organ such as root, shoot, leaf, etc. from undifferentiated tissue or 'callus'. It is controlled by hormones or phytohormones or plant growth regulators like auxins and cytokinins. Auxins induce root formation, while cytokinins induce shoot formation.
24. The auxin : cytokinin ratio is manipulated in order to induce root or shoot growth as required.
26. Micropropagation is method of rapid multiplication because through micropropagation large number of genetically identical plants is obtained within short period of time.
28. Apical meristems are used as explant to produce disease free plant by tissue culture technique.
29. Virus-free plants are obtained by shoot tips (apical meristem) culture because they are free from pathogens such as viruses.
32. Pomato is formed by protoplast fusion of potato and tomato.
35. Totipotency is the principle by which tissue culture is performed.



Competitive Thinking

1. Germplasm collection is an entire collection of plants and seeds having all diverse alleles for all genes in a particular crop.
4. Removal of stamens from a bisexual flower before anthesis is called emasculation. Emasculation is useful for preventing self pollination in female parent which is concerned with hybridisation.
19. *Brassica* – Pusa Gaurav – Aphids
Brassica – Pusa Swarnim – White rust
Flat bean – Pusa Sem-2, Pusa Sem-3 – Jassids, aphids and fruit borers
21. Tissue culture technique is based on totipotent nature of plant cell or phenomenon of totipotency, i.e. each and every plant cell has inherent capacity to develop into a complete plant.
22. Micropropagation means rapid vegetative multiplication of valuable plant material for agriculture, horticulture and forestry. Propagation through tissue culture is called micropropagation.
32. Introduction, hybridization and mutations are methods of plant breeding.



Evaluation Test

1. IR-8 is an improved rice variety, while Rojo-64 A, Sonora-64 and Kalyan Sona are improved varieties of wheat.
2. The explants in tissue culture method require continuous supply of sugar, mineral salts, providing macro and microelements for normal plant growth, a few vitamins, an amino acid glycine and auxin, cytokinin in varying ratio in the culture medium. Agar is a solidifying agent which is not absolutely essential for culturing tissues.
6. ICAR : Indian Council for Agricultural Research – Evaluation of newly developed variety w.r.t. yield, quality, etc is done at ICAR.

- NSC : National Seed Corporation – The quality of seed is certified by an agency, i.e. NSC.
- IARI : Indian Agricultural Research Institute – Many biofortified crops have been developed by IARI.
- IRRI : International Rice Research Institute – IR-8 is a semidwarf variety of rice developed at IRRI.
9. Pusa shubhra is a variety of cauliflower for disease Curl blight black rot.



Hints



Classical Thinking

10. *Volvariella volvacea* is a paddy straw mushroom.
21. Vitamin B and C are water soluble.
42. Facultative anaerobic bacteria such as *Clostridium* and obligate anaerobes such as methanogens produce biogas.
45. Acidogenic bacteria convert the solubilised biomass (monomers) into organic acids such as acetic acid.
54. The protozoan pesticide, *Nosema locustae* is used against grasshoppers, caterpillars, cornborers and crickets.
58. Biofertilizers are environment friendly and enhance the soil fertility.
61. Free-living nitrogen fixing bacteria such as *Azotobacter* and *Azospirillum* are used as biofertilizers.
62. Cyanobacteria are the autotrophic blue-green bacteria. Cyanobacteria are prokaryotic. Nearly 20–22 species of cyanobacteria possess the nitrogen-fixing ability.
65. *Azolla* is an aquatic fern, while others are Cyanobacteria.
67. *Azolla* is a small aquatic free-floating fern consisting of branched floating stem with deeply bilobed leaves and true roots.
68. VAM is an association of intracellular fungi with the roots of higher plants.
69. VAM is a biofertilizer.
71. Biogas contains about 50-80% methane, 15-45% CO₂ and other gases in traces.
73. Fungal hyphae penetrate into the host cells and form vesicles or finely branched arbuscles, hence the name Vesicular Arbuscular Mycorrhizae.



Critical Thinking

1. Gluten is a stored protein of rice and other cereal grains.
2. During kneading of dough, glucose is hydrolysed by yeast (*S. cerevisiae*) releasing CO₂ which makes the bread fluffy.
3. Distillation is a process of purification which involves evaporation and subsequent collection of a liquid by condensation. Whisky is obtained by fermenting mixed grains of corn, wheat, barley, etc. The product of fermentation is then distilled.
9. During secondary treatment, the primary effluent is constantly agitated in aeration tank. This results into growth of aerobic microbes which brings about the digestion of organic matter in the effluent.
12. Bioenergy is the energy obtained from the biological sources. It is also defined as various forms of energy e.g. heat, fuel oil, biogas (methane), etc. generated from the biomass by using simple or complex biotechnological methods.
15. Biogas contains about 70% methane and about 40% carbon dioxide.
16. The hydrolytic bacteria (lytic bacteria) brings about anaerobic digestion of complex insoluble component into simpler components.
17. Proteolytic bacteria are not involved in biogas production. Hydrolytic and methanogenic are first and third group of bacteria involved in biogas production.
18. The carbon dioxide gas which is produced, facilitates the outflow of slurry.
21. *Rhizobium* forms symbiotic relationship with roots of leguminous plants. They bring about nodule formation on the roots and multiply inside the root.
22. *Rhizobium leguminosarum* produce root nodules in pea plants.



23. Heterocyst is the site of nitrogen fixation in *Nostoc*. Nitrogenase enzyme present in heterocyst fixes atmospheric nitrogen which increases the soil fertility.
25. *Rhizobium*, *Azotobacter* and *Bacillus* are non-photosynthetic bacteria. *Anabaena* is a cyanobacteria, i.e. blue-green algae.
26. *Anabaena* is a cyanobacterium (blue-green alga). It has the ability to fix atmospheric nitrogen. Since *Anabaena* and *Azolla* are symbiotically associated, it forms an excellent source of nitrogenous biofertilizer, especially for rice.
28. Ectomycorrhizae have well-developed mycelium which forms mantle on the outside of the roots. This increases the surface area of roots and accelerates water and nutrient uptake.
32. VAM or Vesicular Arbuscular Mycorrhizae play an important role in phosphate nutrition of plants. VAM is an efficient biofertilizer of high agricultural value and a very good supplement to the chemical fertilizers.



Competitive Thinking

6. Vitamin B₁₂ is produced by *Pseudomonas denitrificans*.
15. *Clostridium butylicum* is used in production of butyric acid.
20. In anaerobic sludge digester, due to activity of anaerobic bacteria like Methanomonas

and Sulphur bacteria, gases like CH₄, H₂S and CO₂ are produced.

21. During sewage treatment, the biogas that is produced in anaerobic sludge digester by anaerobic bacteria, is a mixture of gases like CH₄, H₂S and CO₂.
22. The BOD of effluent decreases significantly after the secondary treatment.
29. Conversion of organic acid into methane gas is brought about by the activity of methanogenic bacteria (anaerobes).
32. In biological control or modern agriculture, microbes which can be predators are used for controlling pests.
34. *Xanthomonas* is a bacterial pathogen used as a herbicide.
37. Rhizobia are the nitrogen fixing bacteria which form symbiotic association with roots of leguminous plants.
45. *Nostoc/Anabaena* are the nitrogen-fixing cyanobacteria. They increase nitrogen content of moist soil and water bodies, which can be used in increasing paddy yield.
49. Mycorrhiza forms symbiotic association between fungi and roots of higher plants.
55. During waste water treatment, trickling biofilter, is a biological reactor that operates under aerobic conditions within the waste water treatment plant.



Evaluation Test

1. Vinegar (Acetic Acid) is produced by the bacteria *Acetobacter aceti*.
2. *Azotobacter* is asymbiotic, free-living bacteria.
3. *Rhizobium* is a symbiotic, non-motile, gram -ve aerobic bacterium. It harbours inside the roots of leguminous plants forming symbiotic association.
4. VAM is an endomycorrhizae and shows importance in phosphate nutrition.
6. *Agrobacterium* is a plant vector.

06 Photosynthesis

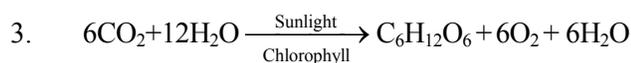


Hints



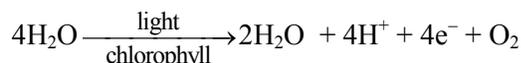
Classical Thinking

2. Photosynthesis is an intracellular anabolic process, characteristic of the green cells of plants in which carbohydrates are synthesized from CO_2 and water in presence of light and chlorophyll. In this process, light energy is converted into chemical energy and stored in carbohydrate molecules while oxygen is liberated.



9. Oxygen evolved in photosynthesis comes from photolysis of water, during which, water is split into O_2 and hydrogen, which is accepted by unknown hydrogen acceptor.

11. During photolysis of water, water is oxidized in presence of light and chlorophyll. Hydrogen is removed from water and oxygen is released.



This was first indicated by Van Neil and was demonstrated by Robert Hill (1937).

12. By using O^{18} , Ruben, Hassid and Kamen confirmed that O_2 evolved in photosynthesis comes from water. It was also calculated that for evolving a molecule of O_2 , atleast two water molecules must participate.
13. Ruben and Kamen used heavy isotope of oxygen, i.e. $^{18}\text{O}_2$ to confirm that oxygen evolved during photosynthesis comes from water.
14. Photosynthetic autotrophs use solar energy to synthesize food.
17. Chloroplast can form copies of itself due to presence of DNA and protein synthesis machinery.
23. The chlorophylls are readily extracted from fresh green tissues of plants by using organic solvents like acetone and from powdered dry leaves by both acetone and alcohol. Benzene is a good solvent for chlorophyll.

24. Chlorophyll molecule contains N, O, C and H.
26. Xanthophyll is the oxygenated derivative of carotenes.
The molecular formula of
(1) Chlorophyll-a – $\text{C}_{55}\text{H}_{72}\text{O}_5\text{N}_4\text{Mg}$
(2) Chlorophyll-b – $\text{C}_{55}\text{H}_{70}\text{O}_6\text{N}_4\text{Mg}$
(3) Carotene – $\text{C}_{40}\text{H}_{56}$
27. Carotenes and phycobilins are useful in harvesting light energy and transferring it to chlorophyll-a which is the reaction centre.
28. The porphyrin head of chlorophyll has Mg atom in the centre.
29. The head of chlorophyll consists of four pyrrole rings with Mg atom in the centre and the tail is a lipid derived phytol tail with twenty carbon atoms.
30. Chlorophyll-a is the essential pigment in photosynthesis, because only chlorophyll-a can utilize the absorbed light energy for the synthesis of chemical energy (ATP). Other pigments act as accessory pigments. They collect the light energy and transfer it to chlorophyll-a for photosynthesis. Chlorobium chlorophyll is found in bacteria.
32. There are 6 oxygen atoms in chlorophyll-b, i.e. $\text{C}_{55}\text{H}_{70}\text{O}_6\text{N}_4\text{Mg}$.
47. PS-I shows maximum absorption at 700 nm.
52. Cyclic photophosphorylation is a photochemical reaction which requires participation of PS-I only. Movement of electrons is cyclic in this photochemical reaction of photosynthesis.
60. Biochemical phase or Blackman's reaction is named as dark reaction because it does not require light to carry out its reactions.
61. M. Calvin (1954) in Berkeley, California using ^{14}C demonstrated the path of carbon in photosynthesis and traced the C_3 cycle. He was awarded with Nobel Prize in 1961.



63. Calvin cycle begins with reaction of atmospheric CO₂ with a RuBP (5C) to form a unstable compound (6C) which immediately splits up into two molecules of PGA (3C).
66. In Calvin cycle, a (5C) pentose sugar, Ribulose biphosphate (RuBP) acts as the first acceptor of CO₂.
67. Addition of carbon dioxide is called carboxylation reaction and in first reaction of dark phase, CO₂ is added to RuBP to form unstable additive compound which forms phosphoglyceric acid.
76. Glucose is a 6C compound. Sedoheptulose is a 7C compound and xylulose is a 5C compound.
81. Plants like Maize, Amaranthus, Sugarcane jowar are C₄ plants. They show characteristic Kranz anatomy and the first stable product formed is 4C-OAA.
82. C₄ cycle was discovered by Hatch and Slack in 1965 in sugarcane plant.
85. C₄ plants typically show Kranz anatomy in which leaves show dimorphism in anatomical features. Mesophyll cells contain normal chloroplasts, while the chloroplasts in bundle sheath are larger and do not contain grana.
90. In CAM plants, CO₂ combines with PEPA to form 4-carbon compound called as oxalo acetic acid.
92. In CAM plants, stomata remain open during night time and oxalo acetic acid gets reduced to malic acid.
93. In CAM plants, the acid concentration increases during night and decreases during the day.
98. Though water is one of the raw materials for photosynthesis, it doesn't affect rate of photosynthesis directly.
3. Photosynthesis is an intracellular anabolic process in which glucose is synthesized from CO₂ and H₂O in presence of sunlight.
4. Because O₂ is released during photosynthesis.
7. Van Neil observed that purple and green sulphur bacteria use H₂S and CO₂ to synthesize carbohydrates.
9. This reaction explains that NADP is the hydrogen acceptor in photolysis of water.
10. During photolysis of water, the proton is accepted by water molecule and then reduced to NADPH₂.
11. Photolysis of water occurs during light reaction of photosynthesis. In this process, water is oxidized in presence of light and chlorophyll. Hydrogen is removed from water and oxygen is released as follows:
- $$4\text{H}_2\text{O} \xrightarrow{\text{light}} 2\text{H}_2\text{O} + 4\text{H}^+ + 4\text{e}^- + \text{O}_2$$
12. Grana are connected with the help of tubular connections called stroma lamellae or fret.
15. Chlorophyll is a photosynthetic pigment which absorbs light energy and converts it into chemical energy.
18. Xanthophylls are yellow coloured carotenoid also called xanthols or carotenols.
19. The red, orange or yellow coloured leaves are caused by light reflected from yellow orange coloured pigments called as carotenoids.
20. The highest rate of photosynthesis in green plants takes place in red region of spectrum.
21. Wavelength in red part of the spectrum is 650-760 nm.
22. The action spectrum of photosynthesis shows highest peak in red region and smaller peak in blue region.
23. Carotenoids protect the essential pigment chlorophyll-a, from photo-oxidation.
24. Chlorophyll-b and carotenoids are antenna pigments which absorb light energy of different wavelength and transfer it to the chlorophyll-a by resonance.
25. Antennae molecules absorb the radiant energy of the sun and transfer it to chlorophyll-a in higher plants.



Critical Thinking

1. During photosynthesis, the volume of CO₂ absorbed and O₂ released is equal and this was proved by Bossingault in 1864.
2. $\text{CO}_2 + 2\text{H}_2\text{O} \xrightarrow[\text{Chlorophyll}]{\text{Light energy}} (\text{CH}_2\text{O})_n + \text{H}_2\text{O} + \text{O}_2 \uparrow$



26. Chlorophyll-a is the reaction centre of photochemical reaction and other pigments such as xanthophylls, chlorophyll-b, carotenes are the accessory pigments called as antennae molecules.
27. When chlorophyll-a absorbs light energy, it gets excited and expels electrons. These electrons are taken up by electron carriers and leaving the reaction centre ionized or positively charged.
30. Photophosphorylation means formation of ATP molecules from ADP and H_3PO_4 in the presence of light and chlorophyll-a during the photochemical phase of photosynthesis.
31. Cyclic photophosphorylation involves only ATP formation. The ATP molecules are generated when the electron is transported from ferredoxin to cytochrome b_6 and from cytochrome b_6 to cytochrome f.
32. a – Ferredoxin
b – Cytochrome b_6
c – Plastocyanin
33. In both cyclic and non-cyclic photophosphorylation, ATP formation takes place. Involvement of both PS – I and PS – II pigment systems, release of O_2 and formation of NADPH takes place only in non-cyclic phosphorylation.
36. Due to the movement of hydrogen ion from an area of higher proton concentration to an area of lower proton concentration, a proton gradient is created across the thylakoid membrane. This movement of protons generating energy is used for the synthesis of ATP.
38. NADPH₂ provides the hydrogen and ATP supplies energy for reduction. NADPH₂ + ATP is called assimilatory power.
39. One molecule of $C_6H_{12}O_6$ is produced from CO_2 and RuBP during dark reaction and the assimilatory power used up is 12 ATP and 12 NADPH₂.
41. Phosphoglyceric acid is reduced to phosphoglyceraldehyde by $NADP + H^+$. The enzyme phosphoglyceraldehyde dehydrogenase supports this reaction.
42. 6 molecules of CO_2 require 18 ATP and 12 NADPH₂ molecules. Hence, a single CO_2 molecule will require 3 ATP and 2 NADPH₂.
43. Dark reaction (reductive CO_2 fixation) occurs in stroma of chloroplast. Dark reaction is purely enzymatic and is independent of light. The conversion of CO_2 to carbohydrate takes place with the help of assimilatory power, i.e. NADPH₂ and ATP. The CO_2 acceptor is a 5-C compound Ribulose biphosphate (RuBP).
44. Starch is the detectable end product of photosynthesis because glucose is converted and stored in the form of starch.
45. In all the autotrophic organisms, the C_3 cycle or Calvin cycle appears to be the principle CO_2 fixation pathway. It is apparent that for the operation of this cycle, both energy and reducing power are required. Hence, the overall equation for photosynthesis would be :
- $$6 CO_2 + 18 ATP + 12 NADPH + 12 H^+ \longrightarrow C_6H_{12}O_6 + 18 ADP + 18 iP + 12 NADP + 6 H_2O$$
46. Calvin cycle is common to all green plants. The way in which CO_2 is fixed, however differs in C_3 , C_4 and CAM plants.
47. On a hot summer day, the stomata remain closed due to which less amount of CO_2 is taken in the cells. As less CO_2 enters the plant cell, the amount of O_2 increases. Due to increased amount of O_2 , RuBP carboxylase is converted to RuBP oxygenase which results in photorespiration.
49. In C_4 plants, malic acid formed during CO_2 fixation in the early reactions of C_4 pathway is transported to bundle sheath cells. The malic acid in the bundle sheath cells undergoes de-carboxylation to form pyruvic acid which then leads to formation of carbohydrates through Calvin cycle.
50. In C_3 plants, the substrate that accepts CO_2 is Ribulose 1, 5 – bisphosphate. Where as in C_4 plants the substrate that accepts CO_2 is phosphoenol pyruvic acid.
51. Sugarcane is a C_4 plant. So, it will show Kranz anatomy.
52. Most of the C_4 plants have a characteristic leaf anatomy and dimorphic chloroplasts, i.e. of two types, chloroplasts in mesophyll cells are smaller and possess grana, chloroplasts in bundle sheath cells are larger and with very less amount of grana.



53. The primary reaction in C_4 plants is the formation of oxaloacetic acid which is catalysed by the enzyme Phosphoenol pyruvic carboxylase and is active in the mesophyll cells.
55. Phosphoenol pyruvic acid carboxylase has high affinity towards CO_2 , as a result of which C_4 plants are efficient even in low concentrations and have a higher photosynthetic yield than other plants.
56. The CO_2 released in decarboxylation of malic acid combines with 5C RuBP (Ribulose biphosphate) to form 2 molecules of 3C PGA in Calvin cycle in presence of enzyme RuBisCO carboxylase. In C_4 plants, all these steps of CO_2 fixation occurs twice, first in mesophyll cells ($PEPA + CO_2$) and then again in bundle sheath cells ($RuBP + CO_2$). For this reason, C_4 pathway is also called dicarboxylation pathway.
58. C_4 plants can absorb CO_2 even at low concentrations because PEP carboxylase can more efficiently fix atmospheric CO_2 than RUBP carboxylase in C_3 plants and they also lack photorespiration.
59. The CO_2 released from malate is fixed by RuBP in presence of RuBisCO enzyme in Calvin cycle which occurs in bundle sheath.
60. In succulent plants (CAM plants), during night time, when stomata is open, CO_2 is taken up by phosphoenol pyruvic acid (PEPA) and oxaloacetic acid is formed. OAA gets reduced to malic acid which gets accumulated during night. During day time, when stomata are closed, malate undergoes decarboxylation and gets converted into pyruvate. CO_2 , thus released, enters in Calvin cycle.
61. CAM pathway occurs in those plants which grow in desert condition and keep the stomata closed during day time, when the temperature is high.
62. Because the mechanism was first observed in the plants belonging to Family Crassulaceae.
63. In CAM plants, CO_2 fixation takes place by PEP during night time. Stomata are open during night and are closed during day time.
64. Malic acid which is formed at night is stored in vacuoles, thereby increasing acidity. During day time, the malic acid is broken down, thereby decreasing the acidity.
65. Maize shows C_4 pathway, whereas, CAM pathway is observed in xerophytic plants such as cacti. Hence, the option (D) is not the correct match.
66. During photosynthesis, the excess of sugars produced are either stored in the form of starch or used in the biosynthesis of other organic compounds.
69. Availability and fixation of CO_2 is the rate limiting reaction in photosynthesis. Hence, when CO_2 is present, rate of photosynthesis increases.
70. There is a linear relationship between rate of photosynthesis and light intensity. Rate of photosynthesis increases with increase in light intensity. But at very high light intensity, it causes breakdown of chlorophyll and decreases the rate of photosynthesis.
72. C^{14} was used by Calvin to trace the path of carbon in dark reaction leading to the formation of starch. O^{18} was used by Ruben and Kamen to confirm that oxygen released during photosynthesis is obtained from water.
73. The second part or phase-II of photosynthesis is known as the dark reaction. This is because the reactions in this phase do not require light. The dark reaction involves reduction of CO_2 to form carbohydrates. The reaction begins with the fixation of CO_2 , involve utilization of the assimilatory power for the reduction of CO_2 and ends with the formation of carbohydrate, i.e. the end product of photosynthesis.
75. Photosynthesis is an anabolic process, while Respiration is a catabolic process.



Competitive Thinking

1. Photosynthesis reaction shows formation of carbohydrates from CO_2 and H_2O by illuminated green cells of plants. O_2 and H_2O are the byproducts.
7. Photosynthesis and respiration are not alike in many ways like O_2 is evolved and CO_2 is taken in photosynthesis, but in respiration, this process is just opposite. Carbohydrates are synthesized in photosynthesis and oxidation of carbohydrates take place in respiration.



8. CO_2 is used and O_2 is released in photosynthesis and in respiration CO_2 is released and O_2 is used.
9. Plants utilize CO_2 in photosynthesis.
16. Chlorophyll is essential for photosynthesis.
17. The main function of chloroplast is photosynthesis, in which radiant energy of sun is converted into chemical form of energy (ATP), which is utilized by all living organisms to perform their life activities.
18. According to Park and Biggins, photosynthetic pigments are located in the membranes of thylakoids in specific areas called quantasomes.
20. Grana are the sites for light reaction of photosynthesis and consist of photosynthetic units 'quantasomes' (Found in surface of thylakoids).
22. Chlorophyll-a is widely distributed in green plants and it is also called primary photosynthetic pigment and universal photosynthetic pigment.
27. A chlorophyll molecule has a tadpole like structure with a porphyrin head and phytol tail. The porphyrin head is made up of four pyrrole rings, which are linked by methine ($-\text{CH}=\text{}$) groups forming a ring system.
29. The chloroplast pigments are fat soluble and are located in the lipid part of the thylakoid membranes.
31. Maximum photosynthesis has been observed in red light than in blue light. The green light has minimum effect. On the other hand, red algae show maximum photosynthesis in green light.
38. When photon of light energy falls on a chlorophyll molecule, one of the electron pair from ground or singlet state passes into higher energy level called excited singlet state.
41. Arnon et al. (1954) demonstrated that isolated chloroplasts can produce ATP from $\text{ADP} + \text{iP}$ and they called this ATP production as photophosphorylation.
52. During cyclic photophosphorylation, formation of ATP occurs in two steps:
ferredoxin \rightarrow cytochrome b_6
cytochrome $\text{b}_6 \rightarrow$ cytochrome
59. O_2 is not liberated in bacteria during process of photosynthesis. Their photosynthesis is non oxygenic. Because bacteria use H_2S in place of water as hydrogen donor.
62. NADH is a product of respiration process, while ATP, NADPH + H^+ and oxygen are products of light reaction.
69. RuBisCO constitutes 16% of chloroplast protein. It is the most abundant protein on this planet.
70. Water, carbon dioxide, light and chlorophyll are required in the synthesis of carbohydrates. Nitrogen is not involved in the process of photosynthesis.
80. Phosphoglyceraldehyde is a product of dark reaction which is formed when 1,3-diphosphoglyceric acid reacts with 12 molecules of NADPH₂.
82. $\text{O}_2 + \text{RuBP} \xrightarrow{\text{RuBP oxygenase}} \text{phosphoglycolate}$
87. Phosphoenol pyruvic acid carboxylase fixes CO_2 in sugarcane. Due to this, enzyme $\text{PEP} + \text{CO}_2$ is converted into oxaloacetic acid.
90. CO_2 fixation occurs twice in C_4 plants (e.g Maize) i.e once in mesophyll cells by PEP carboxylase and the second time in bundle sheath cells by RuBisCo.
93. Carboxylation takes place twice in C_4 cycle. First carboxylation is done by phosphoenol pyruvate and second, in bundle sheath cell, by Ribulose 1, 5 biphosphate.
95. C_4 plants can avoid photorespiration. Also, they can tolerate high temperature. C_4 plants show high rate of photosynthesis and productivity.
103. In CAM plants, there is no Kranz anatomy, but there occurs dark acidification, i.e. during night, malic acid is formed. This malic acid breaks up into CO_2 and pyruvic acid in day time and CO_2 released is utilized in C_3 cycle.
111. Cytochromes are iron containing proteins serving as electron carriers in respiration, photosynthesis and other oxidative reduction reactions.
112. ATP is formed during photophosphorylation which moves in dark reaction and it is known as assimilatory power.
114. 12 NADPH₂ are used to reduce 12 1,3 bi PGA molecules in Calvin cycle.
115. C_4 plants, due to double carboxylation can utilize even relatively low CO_2 concentration.



Evaluation Test

1. $6\text{CO}_2 + 12\text{H}_2\text{O} \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{H}_2\text{O} + 6\text{O}_2 \uparrow$
Glucose
2. PEP carboxylase is found in leaf mesophyll cells of C_4 plants. The mesophyll and bundle sheath cells are in close contact with one another and are connected by cytoplasmic connections. There is an exchange of metabolites between the two kinds of cells, CO_2 fixed in mesophyll cells by PEP carboxylase is converted to malic acid, which is then exported to the bundle sheath cells. Here, malic acid is decarboxylated to produce pyruvic acid and CO_2 . The pyruvic acid is exported back to the mesophyll cells, where it is converted to phosphoenolpyruvic acid, the CO_2 acceptor in the C_4 pathway.
3. 6 CO_2 and 6 molecules of RuBP combine to form an unstable (6C) compound which immediately splits into two molecules of stable 3C compound, i.e. PGA.
4. Cyclic photophosphorylation produces only ATP and not NADPH_2 .
5. In this process, water is oxidized in presence of light and chlorophyll, hydrogen is removed from water and oxygen is released.
6. Photosynthesis is a process in which carbondioxide and water combine to form carbohydrates in presence of light and oxygen is evolved.
7. Blackman's reaction is the dark reaction taking place in stroma and is independent of light.
11. Chlorophyll-a $\longrightarrow \text{C}_{55}\text{H}_{72}\text{O}_5\text{N}_4\text{Mg}$
Chlorophyll-b $\longrightarrow \text{C}_{55}\text{H}_{70}\text{O}_6\text{N}_4\text{Mg}$
15. ATP and NADPH_2 together are called 'Assimilatory power' as they are required for assimilation of CO_2 .
17. Hill's reaction \longrightarrow Light dependent reaction
Calvin's cycle \longrightarrow Dark reaction

07 Respiration



Hints



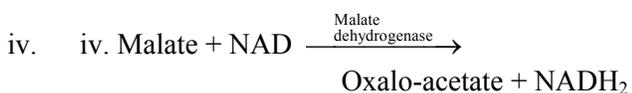
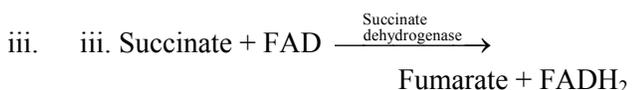
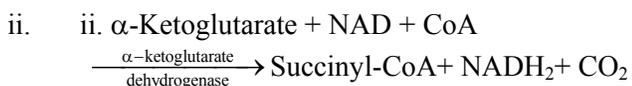
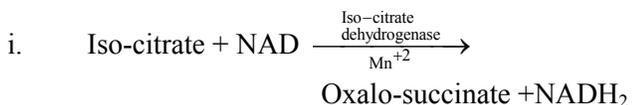
Classical Thinking

2. Chlorophyll, light and CO_2 are the requirements of photosynthesis, while O_2 is a byproduct. All living organisms use oxygen for the process of respiration.
9. Oxidative phosphorylation is nothing but synthesis of ATP during respiration.
10. The Krebs cycle of respiration takes place in the matrix of mitochondria.
14. F_1 particles or oxysomes are present on cristae or the inner membrane of mitochondria.
16. Oxysomes or elementary particles or F_1 particles are evenly distributed on the cristae of mitochondria. It contains enzymes necessary for electron transport chain. They are also known as subunits of Fernandez-Moran.
18. $\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \longrightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + \text{energy}$
21. Glycolysis does not use molecular oxygen to form pyruvic acid, hence it is the anaerobic phase of respiration. Oxidation reaction proceeds only in presence of O_2 , so it cannot be anaerobic. Pyruvic acid formed during glycolysis enters Krebs cycle only in presence of O_2 .
38. 2 NADH_2 molecules are formed during oxidation and phosphorylation of 2 molecules of PGAL to form 2 molecules of 1,3-diPGA.
41. During glycolysis, 2-PGA undergoes dehydration with loss of two water molecules in the presence of enolase and phosphoenol pyruvic acid (PEPA) is formed.
43.
$$\text{Phosphoenol pyruvate} + \text{ADP} + \text{H}_2\text{O} \xrightarrow{\text{Pyruvate kinase}} \text{Pyruvate} + \text{ATP}$$
44. ATP is used in the initial phosphorylation of glucose and fructose-6-phosphate.
46. Glycolysis is an anaerobic respiration as it is independent of oxygen. During oxidative phase of glycolysis 4 ATP molecules are formed while during preparatory phase 2 ATP molecules are utilized. Thus, in anaerobic respiration total 2 ATP molecules are formed.
48. All the reactions in EMP pathway take place in cell cytoplasm.
52. Pyruvic acid undergoes decarboxylation (removal of CO_2) and then oxidation by removal of H_2 .
54. The released hydrogen during oxidation of pyruvic acid is accepted by NAD^+ which is reduced to NADH_2 .
60. Sir Hans Krebs in 1937 discovered various reactions in TCA cycle. He was awarded Nobel prize in Biochemistry in 1953.
63. Aconitase catalyses the conversion of citric acid to iso-citric acid, via. aconitic acid in presence of Fe as an enzyme activator.
65. Oxalo-succinic acid undergoes decarboxylation in the presence of oxalo-succinate decarboxylase to form α -ketoglutarate.
70. Succinyl-CoA undergoes hydration and phosphorylation in the presence of succinate thiokinase to form succinate. The energy liberated during this reaction is used in the formation of GTP from GDP.
72. FAD takes up the hydrogen ion (H^+) and two electrons from succinic acid and gets reduced to FADH_2 .
73. Addition of one molecule of water (hydration) converts fumaric acid to malic acid.
75. Malate is dehydrogenated or oxidised through the agency of malate dehydrogenase to produce oxalo-acetate.
76. In the final step of TCA cycle, malic acid is oxidized by removal of hydrogen to 4C-oxalo-acetic acid. The hydrogen is taken up by NAD and NADH_2 is formed.
78. During various steps of the Krebs cycle, oxidation of substrates takes place by the removal of hydrogen from the substrate. It is accepted at each step by co-enzyme such as NAD or FAD to form reduced NADH_2 or FADH_2 .

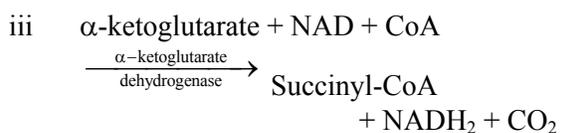
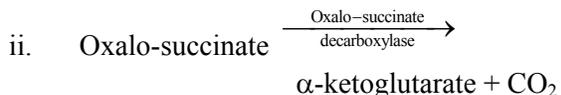
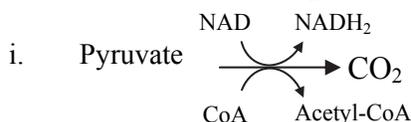


79. 6 molecules of NADH_2 is formed when 2 molecules of acetyl-CoA undergoes oxidation through Krebs cycle.

84. The 4 dehydrogenation reactions are as follows;



85. The three CO_2 molecules produced are



91. TCA cycle is called as 'Amphibolic' because it has dual role, being catalytic (two carbon compound acetyl-CoA produced from metabolism of carbohydrates, lipids and proteins are oxidized to produce CO_2 , H_2O and ATP) and anabolic (intermediates are utilized for synthesis of various compounds).

92. When fats are the respiratory substrate, they are first broken down into glycerol and fatty acids.

93. Oxidative phosphorylation is a process of electron transport system.

95. Free molecular oxygen is the final acceptor of electrons in electron transport system.

100. Cytochromes are proteins in which iron is present in a porphyrin ring. Because the iron porphyrin complex is called heme, the cytochromes are also called heme proteins.

101. NAD and FAD are hydrogen acceptors. Cytochromes are electron acceptors. These are classified into several groups e.g. cytochrome a_3 , a, b, c, c_1 etc.

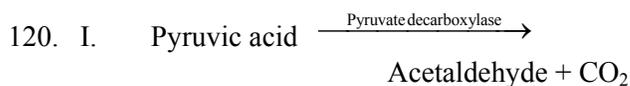
102. The oxygen (final acceptor) reacts with the proton (H^+) to form water molecule.

105. In respiratory chain, the NADH_2 undergoes oxidation and NAD is formed.

108. Various electron carriers are arranged on the body of the oxysomes in the order of their decreasing energy level in electron transport system.

112. ATPs produced through electron transport system are 34.

117. Pyruvic acid under anaerobic fermentation in the presence of enzyme pyruvate decarboxylase and dehydrogenase forms ethanol and CO_2 , whereas in the presence of lactic acid bacteria forms lactic acid and in the presence of acetogenic bacteria forms acetic acid.



Breakdown of pyruvic acid to ethyl alcohol takes place in two steps. In first step pyruvic acid breaks down to form acetaldehyde with the help of enzyme pyruvate decarboxylase and in second step acetaldehyde combines with NADH_2 with help of enzyme dehydrogenase to form ethyl alcohol.

122. Pyruvate directly undergoes reduction using NADH_2 to produce lactic acid

123. For production of vitamins, aeration is required. Thus, aerobic micro-organisms are used.

124. Buchner (1897) found that crushed yeast cells can ferment sugars and this conversion is brought about by enzyme zymase. Amylase and diastase help in breaking starch. Protease helps in breaking proteins.

129. Respiration rate are high at growing regions like floral and vegetative bud, germinating seedlings, young leaves, stem and root apices.



134. Respiratory quotient is $\frac{\text{amount of CO}_2 \text{ given out}}{\text{amount of O}_2 \text{ used}}$.

135. $\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \longrightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + \text{energy}$

$$\text{RQ} = \frac{6\text{CO}_2}{6\text{O}_2} = 1.0$$

144. EMP pathway or glycolysis occurs in cytoplasm, so it is also known as cytoplasmic respiration.

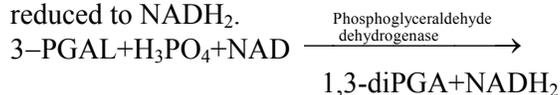


Critical Thinking

- The stored food in the form of starch and sugars is the source of energy in respiration.
- Respiration cannot be endothermic as energy is not absorbed and it cannot be anabolic as it is a breakdown process. Respiration is an intracellular process of oxidation – reduction reactions in which the complex organic food materials are broken down in a step wise manner to form simpler end products with the release of energy and CO_2 . Respiration is thus an exergonic process.
- AMP i.e. Adenosine monophosphate is a compound having only one phosphate bond between adenine and ribose.
- Energy released during respiration is in form of ATP. In ATP, energy is stored in the form of high energy phosphate bond. When high energy phosphate bond is broken, large amount of energy is released.
- The space enclosed by the inner membrane is called inner chamber and is filled with a colourless fluid called matrix which is rich in enzymes and co-enzymes.
- ATP is the energy currency of the cell. Breakdown of ATP produces energy which is utilized for carrying out various metabolic activities of the body.
- The process of respiration is completed in two phases. Reactions in phase I are called glycolysis and are common to both the types of respiration. Reactions in phase II depend upon whether O_2 is utilized or not.
- Glycolysis is the first step in aerobic respiration where one glucose molecule is converted into 2 molecules of pyruvic acid along with 2NADH_2 and 2ATP . Acetylation of pyruvate occurs to form Acetyl CoA. Acetyl CoA then enters Krebs cycle which is the second phase of aerobic respiration.

10. 2ATPs are formed in conversion of $1,3\text{-diPGA} \rightarrow 3\text{PGA}$ and further 2ATPs are formed during $2\text{PEPA} \rightarrow \text{Pyruvic acid}$.

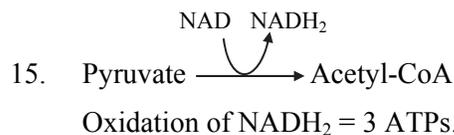
11. When 3-PGAL is oxidized during hydrolysis, co-enzyme NAD takes up hydrogen and gets reduced to NADH_2 .



13. The seven 3 carbon compounds formed during glycolysis are:

- Dihydroxyacetone phosphate (DHAP)
- 3-Phosphoglyceraldehyde (3-PGAL)
- 1,3-Diphosphoglyceric acid (1,3-diPGA)
- 3-Phosphoglyceric acid (3-PGA)
- 2-Phosphoglyceric acid (2-PGA)
- Phosphoenolpyruvic acid (PEPA)
- Pyruvate

14. Pyruvic acid is formed in the cytoplasm as a result of glycolysis and it enters the mitochondrion where it is converted to acetyl-CoA which enters Krebs cycle.



16. 2NADH_2 are formed which will help in formation of 6ATP molecules.

17. Pyruvate is converted to acetyl coenzyme – A in the perimitochondrial space. Acetyl CoA then enters Krebs cycle which occurs in matrix of mitochondrion.

18. As the 1st organic acid i.e. citric acid has 3 carboxylic groups, Krebs cycle is also known as Tricarboxylic Acid cycle or TCA cycle.

19. Each molecule of acetyl-CoA (2C) that enters the Krebs cycle first combines with 4C oxaloacetic acid to form a 6C citric acid. This is the first product of Krebs cycle.

20. α -Ketoglutaric acid undergoes oxidation and decarboxylation to form 4C succinyl-CoA. The reaction takes place in presence of CoA and NAD. Succinyl-CoA is then hydrolysed to succinic acid. GTP reacts with ADP to form ATP and GDP is recovered. This is called substrate level phosphorylation.

21. Succinic acid is oxidized to 4C fumaric acid in presence of co-enzyme FAD which gets reduced to FADH_2 .



22. Aconitase, Fumarase and malic dehydrogenase are the enzymes of Krebs cycle which are present in mitochondria. Hexokinase is the enzyme of glycolysis which is present in cytoplasm.
23. One turn of Krebs cycle produces 3 NADH₂ and 1 FADH₂. Through ETS;
 3 NADH₂ produces = 3 × 3 = 9 ATPs
 2 FADH₂ produces = 1 × 2 = 2 ATPs
 Total = 9 + 2 = 11 ATPs
24. Oxalosuccinic acid is decarboxylated (removal of CO₂) using decarboxylase enzyme.
25. In Krebs cycle, at the time of oxidation of succinate to fumarate, FAD (Flavin adenine dinucleotide) is utilized. FAD takes up the two hydrogen ions and two electrons from succinic acid and gets reduced to FADH₂. This FADH₂, on further oxidation through ETS gives two ATP molecules.
26. Before entering into Krebs cycle, 2 molecules of pyruvic acid are converted into 2 molecules of Acetyl CoA. 2 molecules of Acetyl CoA enters Krebs cycle and undergoes series of reactions in which 2 water molecules are used in each of the following reactions
1. Acetyl-CoA(2M) → Citric acid(2M)
 2. Cis-aconitate (2M) → Iso-citrate(2M)
 3. Succinyl-CoA(2M) → Succinic acid(2M)
 4. Fumaric acid (2M) → Malic acid (2M)
27. α-Ketoglutaric acid undergoes oxidation and decarboxylation to form 4C succinyl-CoA. The reaction takes place in presence of CoA and NAD.
28. In Krebs cycle,
- a. 2 × Iso-citrate → 2 × Oxalo-succinate
∴ 2 × NADH₂ = 6 ATP
 - b. 2 × α-Ketoglutarate → 2 × Succinyl-CoA
∴ 2 × NADH₂ = 6 ATP
 - c. 2 × Succinyl-CoA → 2 × Succinate
∴ 2 ATP
 - d. 2 × Succinate → 2 × Fumarate
∴ 2 × FADH₂ = 4ATP.
 - e. 2 × Malate → 2 × Oxalo-acetate
∴ 2 × NADH₂ = 6ATP.
∴ Total Number of ATP = a + b + c + d + e = 6 + 6 + 2 + 4 + 6 = 24.
29. 6 NADH₂ and 2 FADH₂ molecules are formed during Krebs cycle. When NADH₂ and FADH₂ enter respiratory chain, they produce 3 ATPs and 2 ATPs respectively.
 ∴ 6 NADH₂ = 6 × 3 = 18 ATPs and
 2 FADH₂ = 2 × 2 = 4 ATPs.
 Total ATPs produced = 18 + 4 = 22
30. a. Acetylation reaction:
- $$\begin{array}{ccc}
 & 2 \text{ NAD} & 2 \text{ NADH}_2 \\
 & \swarrow & \searrow \\
 2 \text{ Pyruvate} & \xrightarrow{\quad} & 2 \text{ CO}_2 \\
 & \swarrow & \searrow \\
 & 2 \text{ CoA} & 2 \text{ Acetyl -CoA}
 \end{array}$$
- It is a decarboxylation and oxidation reaction.
- b. Iso-citrate + NAD → Oxalo-succinate + NADH₂
It is a oxidation reaction.
 - c. Oxalo-succinate → α-Ketoglutarate + CO₂
It is a decarboxylation reaction.
 - d. α-Ketoglutarate + NAD + CoA → Succinyl-CoA + NADH₂ + CO₂
It is oxidation and decarboxylation reaction.
 - e. Succinate + FAD → Fumarate + FADH₂
It is oxidation reaction
 - f. Malate + NAD → Oxalo-acetate + NADH₂
It is oxidation reaction.
32. Substrate phosphorylation occurs during conversion of succinyl-CoA to succinic acid when GTP is converted to ATP.
33. One molecule of glucose forms 2 molecules of pyruvic acid through glycolytic pathway. In glycolytic pathway,
 Number of ATP molecules formed = 2.
 Number of NADH₂ formed = 2
 Two molecules of pyruvic acid undergo acetylation to form acetyl-CoA.
 Number of NADH₂ formed during acetylation = 2.
 During Krebs cycle,
 Number of NADH₂ formed = 3 × 2 = 6.
 Number of FADH₂ = 1 × 2 = 2.
 Number of ATP = 1 × 2 = 2
 ∴ Total number of NADH₂ = 2 + 2 + 6 = 10.
 ∴ Total number of ATPs = 2 + 2 = 4.
 ∴ Total number of FADH₂ = 2.



60. Respiration coupled with photosynthesis helps to maintain the balance between CO_2 and O_2 in the atmosphere.



Competitive Thinking

2. Radiant energy of sun $\xrightarrow{\text{photosynthesis}}$ Potential / chemical energy in food $\xrightarrow{\text{Respiration}}$ kinetic energy / heat.
6. The energy is usually released from ATP by hydrolysing the terminal phosphate groups.
8. Krebs cycle takes place in the matrix and ATP formation takes place on oxysome of cristae in mitochondria.
11. Oxysome acts as the unit of phosphorylation in respiration by the formation of ATP from ADP. These are present on cristae of mitochondria.
13. Cellular respiration is an enzyme controlled process of biological oxidation of food materials in living cell.
14. Glycolysis takes place in the cytoplasm and does not use oxygen.
16. Conversion of Glucose into glucose 6-phosphate is first step of glycolysis.
18. During, the breakdown of one molecule of glucose (via. glycolysis), ATP is utilized in the following steps:
- Conversion of glucose to glucose-6-phosphate
 - Conversion of fructose-6-phosphate to fructose-1,6-bisphosphate
22. Magnesium ion is a common activator of respiratory enzymes.
27. Glycolysis can be summarised in the following equation :
- $$\text{Glucose} + 2\text{NAD} + 2\text{ADP} + 2\text{iP} \xrightarrow{(6\text{C})} 2 \text{ pyruvic acid} + 2\text{NADH}_2 + 2\text{ATP}$$
- The end product of glycolysis is pyruvic acid – CH_3COCOOH .
28. Acetyl CoA produced in glycolysis enters in Krebs cycle through various steps in mitochondria. As a result of different reactions taking place in a cyclic manner, the complete oxidation of acetyl CoA takes place.

33. Krebs cycle occurs in the mitochondrial matrix. Cristae and F_1 particles are the site of ETS.
34. Pyruvic acid is converted into CO_2 and H_2O through Krebs cycle.
35. Krebs cycle of aerobic respiration takes place in matrix of mitochondria.
38. The first product of Krebs cycle is citric acid which is tricarboxylic acid and hence this cycle is also known as citric acid cycle or Tricarboxylic acid cycle.
43. Acetyl CoA combines with water and oxaloacetic acid to form citric acid.
55. Oxidative phosphorylation occurs in inner mitochondrial membrane.
63. NAD^+ is one of the electron acceptors in cellular respiration. It accepts electrons released during glycolysis and TCA cycle.
67. The oxidation of one NADH_2 yields 3 ATP and one FADH_2 yields 2 ATP molecules.
73. Fermentation of glucose by yeast gives ethyl alcohol and carbon dioxide.
75. In anaerobic respiration, O_2 is not used but CO_2 is removed.
78. Respiratory Quotient (R.Q.) in case of Proteins and Lipids is less than one.
79.
$$\text{R.Q} = \frac{\text{Volume of } \text{CO}_2 \text{ evolved}}{\text{Volume of } \text{O}_2 \text{ consumed}}$$
- In anaerobic respiration, CO_2 is evolved but O_2 is not consumed, therefore R.Q is always infinity.
89. Citric acid is the first metabolite of Krebs cycle.
90. ATP is not electron transferring molecule. It is a energy storing molecule. So, it is called as energy currency.
91. The complete oxidation of glucose forms 10 NADH_2 and 2 FADH_2 .
 2NADH_2 – Glycolysis; 2NADH_2 – Acetylation; 6NADH_2 – TCA cycle.



Evaluation Test

3. Citric acid $\xrightarrow{-\text{H}_2\text{O}}$ Cis-aconitic acid
(6C) (6C)

4. The intermediate products formed during Krebs's cycle are used in the synthesis of organic compounds like proteins and fats.

5.

Substrate	Respiratory Quotient (R.Q.)
Carbohydrate	1
Fats	< 1
Organic acid	>1

6. During glycolysis, DHAP(Dihydroxyacetone phosphate) undergoes isomerization reaction to form 2 molecules of 3-PGAL.

8. Alcoholic fermentation is anaerobic respiration.



Glucose Ethyl Carbon
alcohol dioxide

11. In TCA cycle, 2ATPs are generated.

13. Krebs's cycle is a stage of aerobic respiration which takes place in the matrix of the mitochondria.

15.

Substrate	Respiratory Quotient
Fats	< 1
Glucose	1
Organic acid	> 1

17. Glycolysis is an enzymatic breakdown of hexose sugar (glucose) into two molecules of Pyruvate (3C) in the cytoplasm.

18. The value of Respiratory Quotient (R.Q.) is different for different substrates.



Hints



Classical Thinking

10. Filaments of algae get broken into small fragments and each fragment develops into new individual.
18. *Albizzia* is a non-fleshy root.
34. Androecium is the male reproductive whorl, while gynoecium is the female reproductive whorl.
35. Anther produces pollen grains by process of microsporogenesis.
36. Ovule produces megaspores by megasporogenesis.
37. Androecium is the male reproductive whorl consisting of stamens. Each stamen is made up of a filament and anther.
44. Fibrous thickenings and hygroscopic nature of endothecium cells help in the dehiscence of anther at maturity.
45. One to three layers of parenchyma cells are present surrounding each pollen sac or microsporangium. They are called middle layers.
47. Each microspore mother cell ($2n$) undergoes meiosis to form four haploid microspores (n).
49. Each pollen grain is with double layered wall called sporoderm. Outer layer is called exine and inner layer is intine.
52. Pollen grains of monocots are uniporate, i.e. with single germ pore and triporate, i.e. with three germ pores in dicots.
55. The development of male gametophyte is endosporic, i.e. occurs within the microspore.
60. The two-celled stage consists of a tube cell and generative cell.
61. The fully mature 3-celled gametophyte is formed after pollination. It consists of two male gametes and a tube nucleus.
62. When pollen grain comes in contact with sugary stigmatic secretions, it absorbs the secretion and the volume of the cytoplasm of pollen grain increases and creates a pressure on the intine. Due to this, the intine of pollen grain comes out of the germ pore in the form of a tube called pollen tube.
63. The haploid generative cell of a microspore or pollen grain undergoes mitotic division to form two haploid male gametes.
76. Nucellus consists of many diploid parenchyma cells.
83. The mature embryo sac consists of an egg apparatus at the micropylar end, antipodals at the chalazal end and two polar nuclei which form the secondary nucleus situated inside the central cell.
84. The functional megaspore undergoes three successive mitotic divisions. Two nuclei formed after first mitotic division undergo two successive divisions and results into four nuclei at each pole and 8-nucleated structure is formed. One nucleus from each pole come to the centre and fuse with each other, thus 7-celled structure.
86. Outer integument forms the testa. Chalaza is a basal region of the body of the ovule. Perisperm is the remnant of the nucellus.
89. The diploid megaspore mother cell undergoes meiosis to form a tetrad of haploid megaspores (n).
96. When pollen grains are transferred from the anthers of one flower to the stigma of another flower produced on a different plant having dissimilar genetic makeup is called cross-pollination or allogamy.
100. Insects, birds, bees and bats are biotic agents.
102. In hydrophilous plant, pollen grains and other floral parts are unwettable, i.e. coated with mucilage.



107. The stigmas of anemophilous flowers are large, hairy, feathery to catch the pollen from the air.
108. *Ceratophyllum* is a hypohydrophilous plant.
117. In *Vallisneria*, both male and female flowers are submerged. At the time of maturity, the male flowers are detached from the male inflorescence and begin to float on water surface. Female flowers have a coiled long pedicel which undergoes uncoiling, so that flower can reach the water surface.
123. Ornithophilous flower lack fragrance because birds have poor sense of smell.
141. In ex-albuminous seeds, endosperm is totally consumed during embryo development, hence it is absent in ex-albuminous seeds.
147. The oospore divides transversely to form suspensor towards the micropyle end and embryonal cell towards the interior of embryo sac.
152. Pericarp is nothing but fruit wall which may or may not be differentiated into epicarp, mesocarp and endocarp.
159. Along with binary fission and budding, the other methods of asexual reproduction are sporulation and fragmentation.
160. Except angiosperms, all others are non flowering plants.
10. During microsporogenesis (i.e. development of microspores or pollens), the nucleus of each microspore mother cell undergoes meiosis giving rise to four haploid nuclei, these are the new microspores or pollens.
12. The germination of pollen tube takes place on the stigma. When fertile pollens are lodged on the receptive stigma, they germinate with the help of stigmatic secretion. The pollen tube emerges through a germ pore and grows down through the style to reach the ovary and fertilize the egg.
13. The meiosis produces the spores and mitosis produces male gametes.
15. The stigma is usually placed on the style. Sometimes if there is no style the stigma is placed on the top of the ovary. This is termed as sessile stigma. The stigma top is usually rough, papillose or even hairy and somewhat sticky due to secretions. This is the receptive surface where the pollens alight and germinate.
16. 4 microspore mother cells will undergo meiosis to give 16 pollen grains.
17. Each microspore mother cells undergoes one meiotic division. Hence, for 24 microspore mother cell, 24 meiotic divisions are required.
18. Each meiotic division produces 4 daughter cells. Hence, 16 pollen mother cells are required to produce 64 pollen grains.
19. After meiosis, daughter cell receives half the number of chromosomes as parent cell.
20. Pollen Mother Cells are diploid (2n). Pollen grains (n) are the first male gametophytic cells. Each PMC divides by meiosis to produce four pollen grains.
22. The functional megaspore divides and forms eight nuclei which migrate towards the two ends of the embryo sac. Three nuclei go to chalazal end forming antipodals, three move to the micropylar end forming egg cell and synergids and two nuclei (polar nuclei) remain in the center to form secondary nucleus.
23. The haploid polar nuclei fuse together to form diploid secondary nucleus
25. The female gamete, i.e. egg cell along with synergids and antipodal cells is present in embryo sac. Hence, it represents female gametophyte.



Critical Thinking

2. Many roots can develop adventitious buds and take part in vegetative propagation e.g. *Dahlia*, *Dalbergia*.
4. A stem tuber has many notches on its surface called 'eyes'. Each eye is actually a node and act as vegetative propagule.
5. Part of the other plant inserted on the rooted plant is called scion.
6. The cambium plays important role in grafting. The cambia of both stock and scion fuse together and make the union of two plants successful.
9. A typical anther consists of four microsporangia (tetra sporangiate) and such anther is called dithecous.



27. Tapetum is a part of stamen, while the other three belong to carpel.
28. One megaspore mother cell forms four megaspores, three out of four megaspores degenerate and only one megaspore takes part in the formation of female gametophyte. Hence, it is called monosporic.
29. In a very young ovule, a single hypodermal cell is differentiated as the archesporium. This archesporium cell becomes megaspore mother cell. The megaspore mother cell now undergoes meiosis or reduction division and a linear row of four haploid megaspore cells (linear tetrad) is formed. Of the linear tetrad of megaspores, the lowermost cell enlarges and becomes the functional megaspore, while the three on top degenerate. The functional megaspore now develops into the female gametophyte or the embryo sac.
30. As the synergids are haploid, they contain half the number of chromosomes than that of the parent.
32. In self-pollination, the stigma is pollinated by the pollen of the same flower, hence for self-pollination bisexual plants are important. Dicliny is unisexuality. Dichogamy is the maturation of androecium and gynoecium at different times. Dioecious plants are those in which male and female plants are different.
33. Geitonogamy involves transfer of pollen grains from one flower to the stigma of another flower of the same plant and hence they are genetically similar.
36. Heterozygosity means genetic variability. In xenogamy, transfer of pollen grains takes place between flowers of different plant which will produce flowers with different genetic makeup, thus favouring heterozygosity.
39. In entomophilous plants, pollen grains have spiny or rough exine.
40. Herkogamy is a physical barrier which prevents self pollination. Heterostyly is the different length of styles.
42. In Dioecious plants like papaya, male and female flowers are produced on different plants. Thus, it prevents autogamy as well as geitonogamy. Papaya shows xenogamy (cross pollination).
43. The ovule is enveloped by two integuments which leave an opening at the terminal end of nucellus. It is called micropyle. On reaching the ovary, a pollen tube mostly enters in an ovule through micropyle.
44. The two nuclei of male gametes and three nuclei of female gamete (2 nuclei of secondary nucleus and one nucleus of egg cell) are involved in double fertilization.
45. Siphonogamy is the passage of gametes through pollen tube.
47. An endosperm is triploid, while megaspore mother cell is diploid.
Endosperm $(3n) = 24$
 $\therefore n = 8$
megaspore mother cell $= 2n = 2 \times 8 = 16$
52. When seedless fruits (noble varieties) are produced without fertilization the process is known as parthenocarpy.
53. Bean is non-endospermic seed. Thus in bean, food is stored in cotyledons.
55. Megaspore mother cell is diploid $(2n) = 12$
 \therefore haploid (n) number will be 6
Endosperm is a triploid $(3n)$ tissue
 \therefore it will have 18 chromosomes.



Competitive Thinking

4. Simple fleshy tuberous roots occur in Sweet potato. Fasciculated fleshy roots occur in *Asparagus*.
6. *Oxalis* propagates by means of runner.
8. In *Bryophyllum*, the new plants are formed from the leaves, when leaves get separated from the parent plant and falls on wet soil.
9. Foliar (on the leaf) adventitious buds are formed at places other than nodes.
12. A small shoot of plant with superior traits is employed called graft or scion. The root system of another plant is allowed to remain intact called stock.
22. In an anther, microspore tetrad is covered by endothecium which shows characteristic fibrous thickening of callose.
28. The cells between middle layer and microsporogenous cells develop into tapetum. Tapetum plays an important role in pollen development by providing nutrition. It is a part of anther wall.



29. Microspore or pollen grain is initial cell of male gametophyte. Development of male gametophyte occurs within the microspore.
30. Meiosis occurs in pollen mother cells (2n) of anther to produce haploid pollen grains (n).
34. Intine is a continuous layer made up of cellulose and pectin. The exine is a discontinuous layer with germ pores.
36. Fibrous thickenings and hygroscopic nature of cells of endothecium help in dehiscence of anther at maturity.
44. A tetralocular anther consists of four pollen chambers.
Since there are 1280 microspores in the anther,
No. of microspores in each chamber
$$= \frac{1280}{4} = 320$$

1 microspore mother cell (2n) undergoes meiosis to form four haploid microspores (n).
 \therefore No. of microspore mother cells (MMCs) needed to produce 320 microspores
$$= \frac{320}{4} = 80$$

 \therefore 80 MMCs are present in each chamber.
49. When the funicle lies parallel to the body of the ovule and micropyle, the position of the body of the ovule is 180° , hence the ovule is called anatropous.
50. Synergids bear special cellular thickenings at the micropylar tip called filiform apparatus which guides pollen tube into egg apparatus.
51. In orthotropous ovule or erect ovule, chalaza lies above the funicle and attached at the hilum.
61. After meiotic division, four haploid megaspores are formed. Only one megaspore (haploid) divides mitotically to form embryo sac and the other three disappear or disintegrate.
69. Geitonogamy – pollination between two flowers of same plant.
73. Cleistogamous flowers are closed flowers in which only self pollination is possible.
80. Feathery stigma is characteristic of wind pollinated flowers.
82. In *Salvia* (Sage plant), a member of family Labiatae, pollination occurs by bees and there is a special mechanism called ‘Turn pipe mechanism’ or ‘Lever mechanism of pollination’.
88. Geitonogamy occurs in the same plant but between different flowers and so may require pollinators, but is genetically similar to autogamy.
89. *Salvia* is an entomophilous flower.
94. Gymnosperms, Bryophytes and Pteridophytes show single fertilization.
97. In mesogamy, pollen tube penetrates laterally through integuments (*Cucurbita*) and funiculus (e.g. *Pistacia*).
103. Egg is the part of embryo sac.
104. In porogamy, filiform apparatus of synergids secretes some chemotropically active substances, which direct the pollen tube towards micropyle of ovule.
105. Filiform apparatus present in synergid cells helps in guiding pollen tube into embryo sac.
106. Syngamy is the fusion of one of the two male gametes with egg to produce diploid zygote (oospore).
111. Syngamy is the fusion of first male gamete with egg. It results in formation diploid zygote which develops to form embryo. Triple Fusion is a fusion of second male gamete with secondary nucleus. It results in formation of triploid PEN (Primary Endosperm Nucleus) which develops to form endosperm. Since both male gametes participate in fertilization, it is called double fertilization.
114. Endosperm is triploid (3n).
118. Embryogeny is the development of mature embryo from zygote or oospore.
121. Because maize and lily are angiosperm plants, in which endosperm is formed by fusion of one diploid polar nucleus and haploid male gamete. Thus, this tissue is triploid.
129. In apomixis, diploid egg cell is formed without reduction division (meiosis) and it develops into an embryo without fertilization.
132. Angiosperms (citrus) have two or more than two embryos in one seed. It is called polyembryony.



137. Haploids can be obtained by culturing pollen grains. Only pollen grains are haploids. Root apex, shoot apex and embryo are diploid.
140. Pollen grains are haploid, while endosperm has triploid chromosome number and integument is diploid in nature.
141. The diploid pollen mother cells have 24 chromosomes, hence pollen grains will have 12 chromosomes. Thus, the male gametes will have 12 chromosomes. The female gamete being haploid will also have 12 chromosomes. Hence, syngamy will form diploid zygote with 24 chromosomes. Triple fusion will involve three haploid nuclei with 12 chromosomes each. Thus, the triploid endosperm will have 36 chromosomes.
142. Endosperm is formed by triple fusion of diploid secondary nucleus and haploid male gamete. Thus, when diploid secondary nucleus ($2n = 24$) fuses with haploid male gamete ($n = 6$), triploid endosperm ($3n = 30$) is formed.
144. Some angiosperms have bisporic and tetrasporic embryo sacs.
146. Tapetum is the innermost layer of anther which provides nutrition to developing microspores.
148. Parthenocarpy is the production of fruit without fertilization of ovule. The fruit is therefore seedless like in banana.



Evaluation Test

- Integument is a diploid cell.
 $\therefore 2n = 2 \times 14 = 28$
 Antipodal cells are haploid.
 $\therefore n = 14$
 Embryo is diploid. $\therefore 2n = 2 \times 14 = 28$
 Endosperm is triploid. $\therefore 3n = 3 \times 14 = 42$
 Nucellus is diploid. $\therefore 2n = 2 \times 14 = 28$
- Seeds are produced by fertilized ovule which is an outcome of fusion of male gametes and egg cell.
- The division of parental body into two nearly equal daughter individuals during favourable conditions is called Binary fission.
- Oxalis* is vegetatively propagated by runner.
- Vallisneria* shows adaptation for epihydrophyly.
- Self incompatibility is a phenomenon in which genetic mechanism of flower prevents the fusion of gametes of genetically similar plants. It is also called self-sterility.
- The antipodal cells are the part of embryo sac and hence they are haploid (n). Zygote is formed by the fusion of male and female gamete, hence it is diploid ($2n$). The endosperm is formed by fusion of secondary nucleus ($2n$) and one male gamete (n), hence it is triploid ($3n$).
- Angiosperms are flowering plants in which seeds are enclosed inside the fruit.



Hints



Classical Thinking

6. (A), (B) and (C) are natural ecosystems whereas (D) is an artificial ecosystem.
8. Climate is an abiotic component, while other three are biotic components of ecosystem.
10. The decomposers include bacteria, actinomycetes and fungi.
11. The decomposers such as bacteria, actinomycetes and fungi decompose the dead organic matter into simpler compounds and make it available in the environment.
18. The chlorophyll content is expressed as chl / g dry wt / unit area and photosynthetic number is expressed as CO₂ fixed / g chl / hour.
20. The amount of food energy not utilized by heterotrophs per unit area in a unit time is referred to as net productivity.
22. Micro-organisms like fungi and bacteria are decomposers.
28. Warm and moist conditions fasten the rate of decomposition.
29. The pyramid of number in forest is erect or upright as producers are maximum in number and top consumers are least in number.
30. The concept of biomass refers to organism's mass. Producers are always more in biomass than herbivores and herbivores are more in biomass than carnivores.
31. Pyramid of biomass is inverted in sea because biomass of fishes is more than that of phytoplanktons.
34. Out of the total sunlight reaching the earth, about 34% is reflected back, 10% is held by ozone layer, water vapour and other atmospheric gases.
37. In the path of energy flow, first trophic level is occupied by producers, second trophic level by herbivores, third trophic level by consumers and fourth trophic level by top carnivores or tertiary consumers.
39. As maximum amount of carbon is found in oceans, it is considered as the main reservoir of carbon.
41. Corals and algae encourage the reaction of precipitation of CO₂ and build up the calcium carbonate (limestone) reef.
45. Phosphorus never goes to atmosphere, it is always part of an organism or dissolved in water or in the form of rocks.
71. In sanitary landfills, wastes are dumped in a trench or depression after compaction and covered with soil everyday. It is used as a substitute for dumping grounds because on dumping grounds, waste is not burnt completely and it serves as the breeding place for rats and flies.
72. Polyblend has been used in development of roads in Bangalore.
76. The blanket of these gases (CH₄, Nitrogen oxides, CFC) in the atmosphere traps reflected infrared rays and produces heat on the earth's surface.
79. CFCs increase the temperature by 20% and methane increase the temperature by 15%.
80. Ozone formed in the stratosphere is considered as good ozone.
81. DNA and protein of living organisms absorb UV rays and its high energy breaks down the chemical bonds within these molecules and cause damage to skin cells causing skin cancer. High dose of UV rays cause inflammation of cornea, called snow-blindness cataract.
98. Spatial pattern arises in the ecosystem with respect to the space due to limiting factors such as air, temperature and rainfall.



Critical Thinking

2. Agriculture is a systematic process of growing plants which is produced by man.



4. According to the pyramid of numbers, the number of primary consumers are more than secondary consumers. Primary consumers are prey to secondary consumers. Similarly, secondary consumers are prey to the tertiary consumers which are more in number than tertiary consumers.
5. Productivity is determined by biomass.
6. The pyramid of number and pyramid of biomass shows the relationship between producers, herbivores and carnivores at successive trophic level.
7. Pyramids of energy are most fundamental and they indicate overall nature of ecosystem and it is a graphical representation of amount of energy trapped per unit time and area in different trophic levels of a food chain.
9. The transfer of food energy from the producers through a series of organisms (herbivores → carnivores → decomposers) with repeated eating and being eaten is known as a food chain.
10. The food chain always begins from green plants which synthesize organic food by photosynthesis using solar energy.
12. All the green plants having chlorophyll are considered as primary producers because they can synthesize food by trapping solar energy.
13. Lion is a top-level carnivore.
14. There are four trophic levels – Producers, Primary consumers, Secondary consumers and Tertiary consumers. Producers are always more in number than primary consumers and this rule applies to all the trophic level. The tertiary consumers are least in number.
15. As the energy moves from one trophical level to next, it goes on decreasing.
17. Carbon enters the biotic system through photosynthesis. In photosynthesis, green plants utilize CO_2 and incorporate the carbon of CO_2 in Glucose. In respiration, burning of biomass and fossil fuels release a lot of CO_2 . Burning of fossil fuels adds 6×10^{12} kg of carbon into atmosphere.
18. Phosphorus is obtained from soil as phosphate. Organic phosphorus circulates in nature from plants to animals. Phosphate is released by decomposers (Phosphatising bacteria) back to soil.
19. Usable energy is ATP (Adenosine triphosphate) in which phosphorus is present.
20. Marine birds like guano play a unique role in the phosphorous cycle. These birds eat marine fish, which is rich in phosphorous. Their excreta called “guano deposits” contain high level of phosphorous and thus marine birds return phosphorous from the ocean to the land.
26. In collaboration with Bangalore city corporation and R.V. college of engineering A.Khan proved that, if polyblend is mixed with bitumen and is used to lay roads, the road life is increased.
27. In green glass house, the glass panel lets the light in for photosynthesis to take place but does not allow heat to escape which helps the green house to get warmed up.
29. When CFCs reach the stratosphere, UV rays act on CFCs and Cl atoms are released. These chlorine atoms degrade the ozone.
32. By the process of mineralization, inorganic nutrients are released into the environment, thus helping in nutrient conservation.
33. Plants or producers are positioned at first trophic level. Organisms positioned at second trophic level (primary consumers), third trophic level (secondary consumers) and fourth level (top carnivores) are dependent on producers. Thus if plants or producers die, all other organisms will also die.



Competitive Thinking

5. Ecosystem is a structural and functional unit of biosphere consisting of community of living beings and their physical environment.
9. Gross primary productivity is the total rate of photosynthesis including the organic matter used up in respiration.
11. Net primary productivity refers to the amount of organic matter stored by the producers (green plants) after meeting the loss by way of respiration.
13. The rate of energy storage at consumer level is referred to as secondary productivity. Infact, it is the rate of re-synthesis of organic food by the consumers.



14. Secondary productivity is biomass assimilated by consumers. The consumers use the food material directly or indirectly from the producers and simply convert it into different forms.
20. Fragmentation is the first step of decomposition, which involves break down of detritus into small fragments by detritivores like earthworm.
21. Three types of ecological pyramids are pyramid of number, pyramid of biomass and pyramid of energy.
23. In an ecosystem, at each trophic level, only 10% energy is left. Thus, the amount of energy decreases and pyramid will be straight and cannot be inverted in any condition.
24. The given data represents inverted pyramid of biomass which is generally found in aquatic ecosystem as the biomass of primary consumers is more than that of producers.
25. In any ecosystem, the basic or ultimate source of energy is sunlight.
29. Plants represent the first trophic level and the herbivores make the second trophic level. The carnivores constitute the third trophic level, and large fish, man, etc. constitute the fourth trophic level of an ecosystem.
31. Herbivores they depend upon producers for food.
35.
$$\begin{array}{ccc} \text{Grass} & \longrightarrow & \text{Lamb} \\ \text{(Producer)} & & \text{(Primary consumer)} \\ & & \downarrow \\ & & \text{Wolf} \\ \text{Tiger} & \longleftarrow & \text{(Secondary consumer)} \\ \text{(Tertiary consumer)} & & \end{array}$$
42. Phosphorus cycle is an example of sedimentary cycle having its main reservoir not in atmosphere but in the form of rocks.
44. In the phosphorus cycle, weathering makes phosphate available to the soil from where plants or producers get them first.
46. Newly exposed sea floor, igneous rocks, sand dunes, lava sediments or newly submerged areas are some of the examples of primary bare area. It is quite hostile to first life or pioneer community. Primary succession takes a very long time.
47. The first biotic community which develops in a bare area is called pioneer community. It has very little diversity. This stage takes the longest time to change the environment for invasion of the next community.
51. Secondary succession occurs on deforested site, as secondary succession follows primary succession.
52. Climax community is the stable, self perpetuating and final biotic community that develops at the end of biotic succession and is in perfect harmony with the physical environment.
54. Hydrarch succession is also known as hydrosere succession. It begins with small phytoplanktons replaced by rooted submerged plants followed by submerged and free floating plants and then reed swamp stage, marsh meadow stage, scrubs and finally the trees.
59. Ozone formed in the lower atmosphere i.e troposphere is known as bad ozone as it is harmful for plants and animals. Ozone formed in the upper part of the atmosphere is i.e stratosphere is known as good ozone.
60. UV rays act on chlorofluorocarbons, causing release of Cl atoms which react with ozone.
64. Due to depletion of stratospheric ozone, there is increased risk of skin cancer, damage to cornea, conjunctiva, etc. It damages the immune system as well.
66. These gases cause global warming of atmosphere which is called 'green house effect' and these gases are called green house gases.
67. The recommended forest area is about 33% of the total land area.
69. Habitats of a large variety of organisms would be destroyed and food chains would be disturbed leading to population and ecological imbalance.
71. Slash and burn agriculture (commonly known as Jhum cultivation) was the main cause of deforestation in the north-eastern states of India.
72. Chipko movement is a movement initially meant for protecting trees, but now meant for preservation of environment including habitat and wildlife.
75. Reforestation is the restoration of a degraded forest.



80. An ecosystem should always maintain a balance, if primary consumers in an ecosystem are absent, then producers will increase in number and will create overcrowding. It results in competition and consequently number of producers will decrease to near normal.
83. Pesticides occur in increasing concentration in top members of the food chain.

88. Bioaccumulation (deposition of pesticides) is seen as we move upwards in trophic level. Thus, in aquatic food chain it will be more in seagull.
90. DDT and mercury are both pollutants that can be biomagnified through the aquatic food chain and cause a decline in bird population (tertiary consumers). SO_2 and NO_2 are air pollutants.



Evaluation Test

1. Green plants (Producers)
↓
Grasshopper (Herbivore)
↓
Frog (Primary carnivore)
↓
Snake (Secondary carnivore)
↓
Hawk (Tertiary carnivore)
2. Lake is an example of natural ecosystem since it operates under natural conditions without any major interference of man.
6. The Montreal Protocol was a treaty signed in 1987 to control the emission of ozone depleting substances, mainly CFCs.
7. The Chipko movement was initially meant for protecting trees, but now meant for preservation of environment.
8. Greenhouse gases are CH_4 , CO_2 , N_2O and CFCs.
9. At every trophic level in a food chain, only 10% of energy is available.
Grass → Insect → Frog → Snake
30 J 3 J 0.3 J 0.03 J
So, energy available for Snake is 0.03 J.
11. Production and respiration rates of the community and nutrient cycles are considered as the function of the ecosystem.
12. The sequence given in Option (B) is an example of Xerarch succession, while others are examples of Hydrarch succession.



Hints



Classical Thinking

27. Proteinoids aggregated into spherical colloidal droplets which were called microspheres.
33. Organic evolution is a slow, gradual, continuous and irreversible changes through which the present day complex forms have descended from their simple pre-existing forms of the past.
40. Intra-specific struggle is observed between two cows or two horses for getting grass.
47. Hugo de Vries proposed the “Mutation theory” by studying the plant called evening primrose (*Oenothera lamarckiana*).
53. Population is considered as a unit of evolution because new species are evolved from population and not from a single individual
58. The homologous chromosomes exchange genetic material by the process of crossing over which results into genetic recombination.

63.

Organism	Scientific name
Silkworm	<i>Bombyx mori</i>
Honey bees	<i>Apis dorsata</i>
Frog	<i>Rana tigrina</i>

67. The geographical isolation leads to progressive genetic divergence. The separated population develop distinct gene pool and they do not interbreed.
76. An organism buried in the earth or rocks by natural causes in past geologic time is called as fossil.
84. Huxley called birds as glorified reptiles because birds have evolved from reptiles.
87. The reptilian characters of *Archaeopteryx* also include abdominal ribs and hand limbs with four digits terminating in clawed digits.

92. In both the organisms, wings are useful in flight, but they are structurally different.
98. Molecular evidences also include presence of endoplasmic reticulum, Golgi bodies, mitochondria as cell organelles and similarities in proteins and genes in diverse organisms which proves common ancestry.
99. Saltation is a single step large mutation.
102. Geological time scale is the tabulated form showing the sequence and duration of the eras and the periods with their dominant form of life since the beginning of life on the earth. In the geological time scale, the duration of the earth’s history has been divided into 6 palaeoarctic geological time-spans called the eras which are – Azoic, Archaeozoic, Proterozoic, Palaeozoic, Mesozoic and Cenozoic.
103. Palaeocene, Miocene and Pliocene are epochs of the tertiary period of cenozoic era, whereas triassic is a period of mesozoic era.
106. Thomas Huxley (1863) in his book “Man’s Place in Nature” established the close similarities among monkey, ape and man.
108. The order Primates includes the Genus - *Homo* and species-*sapiens*.
109. The order Primates is divided into sub-orders: Prosimii and Anthropoidae. The sub-order Prosimii includes lemurs, lorises and tarsiers. The sub-order Anthroidea includes Ceboidea (New world monkeys), Cercopithecoidea (Old world monkeys) and Hominoidea (Apes and man).
110. Sub-order Prosimii includes tree shrews, tarsiers, lemurs and lorises.
113. Apes are included in two families. Pongidae includes large size apes-chimpanzees, gorillas and orangutans; Hylobatidae includes small sized apes-gibbons.
114. Anthropoid means ‘man-like’. Apes are the closest kin of humans in size, form, physiology and behaviour.



118.

Features	New world monkeys	Old world monkeys
Nose	Flat	Narrow
Tail	Long prehensile	Short prehensile
Location	South and Central America	Tropical regions of Africa and Asia
Examples	Squirrel Monkey, Spider monkey	Baboons, Macaques, Langurs

120. All *Homo sapiens* and others belonging to the genus *Homo* are placed in one family Hominidae.

123. The other characters which show phylogenetic relationship between apes and man are larger head, molar teeth with five cusp, highly developed facial musculature for expression and the remarkable similarity in the DNA, haemoglobin and albumin molecules.

129. *Dryopithecus* fossils were first discovered by L.S.B. Leaky in 1930 from Lake Victoria of Africa.

131. The earliest fossils of prehistoric man are *Ramapithecus* and *Shivapithecus* found from the late miocene of India. (Siwalik hills of Himalayas)

135. The first fossil *Australopithecus africanus* in the form of skull cap of a child (called Taung baby) was discovered in a lime quarry by workers of Taung, South Africa.

137. *Australopithecus* lived in Africa between 4 million years ago which was the end of Pliocene period and the beginning of the Pleistocene epoch.

142. The fossils of *Homo habilis* was discovered in Olduvai George, Tanzania in Africa by Dr. L.S.B. Leakey.

144. *Australopithecus* gave rise to *Homo habilis* about two million years ago in Africa. They were rough tool makers, and probably first fossil forms of *Homo*.

145. The cranial capacity of *Homo habilis* was about 650 cc – 800 cc

152. *Homo erectus* was considered to be the first true species of man. The skull was rather massive and flat. Jaws jutted forward (prognathous). The teeth and dental arcade were as in modern man.

163. The cranial capacity of Neanderthal man was 1450 cc.

166. About 50,000 years ago, people of essentially modern character, the so called Cro-Magnon, abruptly replaced the European Neanderthals. They used sophisticated stone tools. They were expert hunters and knew the use of fire. They had developed art and have left paintings and carvings in the caves.

175. It was proposed in 1858 and published in 1859 by Charles Darwin.

178. Vestigial organs are non-functional in the possessors, but were functional in the ancestors and in related animals.

Tail bone or coccyx is a small triangular bone formed by fusion of 4 reduced caudal vertebrae, and it became vestigial due to bipedal gait and sitting posture of man.

180. Apes and man have a common ancestry, Hominoidea.

181. Baboon is a large long Arabian monkey, while others are apes.

182. Neanderthal man was early man inhabiting Southern Europe and Central Asia during the late Pleistocene era, while *Australopithecus* existed during Pliocene era. *Zizanthropus* (a type of *Australopithecine*) is an extreme primate found in Tanzania.



Critical Thinking

- Oparin Haldane theory explained the chemical evolution of life.
- The active element hydrogen at the time of primitive earth combined with nitrogen, oxygen and carbon to form ammonia, water and methane. These were the first chemicals formed on the earth.
- According to the 'Theory of Chemical evolution', the highly reactive free radicals – CH and CH₂ condensed to form a variety of both saturated and unsaturated hydrocarbons.
- Today, there is an enormous number and diversity of living organisms. These are explained in organic evolution. It is a gradual process of change by which, different kinds of organisms develop from a few simple forms of life over a long period of time.
- The increase in the number of individuals, but limited food and space leads to the competition called struggle for existence.



11. When an organism gets adapted to a new environment, it produces variations for existence.
12. The organisms provided with favourable variations succeed in the struggle for existence.
14. Because of the absence of knowledge about genetics (Genetics as a subject was not still taken with) how variations (observed and appreciated) come about and how they improve in quality and quantity through generations could not be explained. Other salient points in Darwin's theory are not disputed.
16. Mutation is a sudden change in the structure of a gene changing the genotype of an organism. Mutations provide the raw material for organic evolution by which new species originate.
17. Mutations are characterized by the statements made in (A), (B) and (C) but not made in (D), since mutations, once occurred, pass on to next generations without undergoing again, immediate mutational changes, i.e. mutations breed true.
18. Organic evolution provided the palaeontological evidence which was the result of genetic variations.
19. The sum of genes of all the members of population is known as gene pool. Combinations of all the gene pools of its population constitute the gene pool of a species.
20. Once a species gets isolated or separated from the old species, a new species develops.
21. Homologous structures refer to similar structures with dissimilar function, but with similar origin and architecture, i.e. forelimb of higher vertebrate (a bird, a whale, a horse, a monkey).
22. The doctrine of organic evolution is supported by study of different branches of biology which provide evidences of anatomy and morphology, physiology and embryology, etc.
24. In mesozoic era, the progressive reptiles evolved.
25. Mesozoic era which started about 250 million years ago is noted as the era of reptiles. Later, about 200 million years ago, primitive and earliest mammals emerged from reptilian stock.
27. Palaeozoic, Proterozoic and Mesozoic followed the Archaeozoic which is the oldest era of geological time scale.
29. Africa is the home of numerous fossils of primitive man.
30. Order Primates has nails over the digits, thus *Homo sapiens* (man), Orangutan (apes) and Macaque (a kind of monkey) are all primates.
31. These animals have very elongated hind limbs which have tarsals which are the ankle bones.
33. The nearest relatives of man are apes. In tribe catarrhina, the sequential placement of animal groups is old world monkeys (*Cercopithecidae*), Apes (*Simiidae*) and Hominidae (Man). Apes thus come close to man.
36. The ancestry of man is arranged as follows :
Ramapithecus → *Australopithecus* → *Homo habilis* → *Homo erectus* → Modern man
Thus, earliest prehistoric man is *Ramapithecus*.
37. *Australopithecus* walked completely straight and had a distinct lumbar curve. Java Ape man, Peking man and Cro-Magnon were found after *Australopithecus*.
38. *Homo habilis* lived in Tanzania, Africa. Thus, *Homo erectus* evolved from *Homo habilis*.
40. The scientific name of Ape-man is *Australopithecus africanus*, while others are *Homo heidelbergensis*, *Homo erectus pekinensis* and *Homo neanderthalensis* (Heidelberg man, Peking man and Neanderthal man respectively).
41. The cranial capacity of *Homo neanderthalensis* was about 1450 cc which is same as that of modern human.
42. *Homo erectus* had heavy bony eye brow ridges, whereas Cro-Magnon man had thin eye brow ridges. The cranial capacity of *Homo erectus* was from 850 to 1200 cc and the cranial capacity of Cro-Magnon man was about 1600 cc.
43. Cro-Magnon man who neatly represents modern man (*Homo sapiens*) in almost all respects (physical, mental and social, etc.) and he was prevailing all over Europe and other places about 20,000 years ago.



44. Cro-Magnon man had developed thinking abilities. They used clothes made of animal skin and had developed art. Coloured painting and carvings were found from their caves.
45. Cranial capacity of Cro-magnon man → 1600 cc
Cranial capacity of Modern man → 1450 cc.
46. *Homo sapiens*, the modern man developed the cranial capacity followed by the skillful use of their fingers.
47. As human beings developed, their cranial capacity increased and the ability to use them still increased.
49. “Struggle for existence” or competition always happens when two individuals have the same needs like food and shelter.
52. In ordovician, silurian and devonian period of palaeozoic era, many fishes of various types originated.



Competitive Thinking

1. Theory of abiogenesis is also called as theory of spontaneous generation. According to this theory, life originated from non-living material spontaneously without any interruption.
4. J.B.S Haldane described the sea containing bio molecules like monosaccharides, amino acids, purines, pyrimidines, fatty acids and glycerol in abundance as “the hot dilute soup” or “primitive broth”. The “hot dilute soup” was without oxygen.
5. The nucleic acid along with inorganic and organic molecules formed the first form of life called protobionts or precells.
7. The first cell or primitive cells were marine and heterotrophic in nature. These heterotrophs later transformed into autotrophs by mutation.
9. Coacervates are the colloidal aggregates of large complex organic molecules capable of growth and division.
15. Enzymes were called as protoproteins.
16. According to Darwinism, interspecific competition results in divergent evolution, hence helpful in organic evolution.
19. Any alteration in allele frequency in natural population by chance is called genetic drift.
23. Industrial melanism is an evidence of Natural Selection but industrial pollution acted as the selective factor.
26. They are the organs with common origin but perform different function.
34. *Dryopithecus* was an ape that lived in Miocene epoch.
36. Dinosaurs were present during Jurassic period of Mesozoic era.
44. Hardy-Weinberg equilibrium principle states gene (allele or genotype) frequencies remain same from generation to generation thus maintaining the genetic equilibrium unless disturbed by factors like mutation, non-random mating, etc.
45. Selective mating alters Hardy-Weinberg equilibrium. Random mating maintains the equilibrium.
47. According to Hardy – Weinberg equation $p^2 + 2pq + q^2 = 1$
Where, $2pq$ represents the percentage of heterozygous individuals.
Since frequency of $A = 0.6$
and frequency of $a = 0.4$
∴ $2pq$ (Frequency of heterozygous individuals)
 $= 2(0.6 \times 0.4)$
 $= 2(0.24)$
 $= 0.48$ (48%)
49. Pliocene is the epoch of tertiary period of coenozoic era. Man originated in this era.
55.

	Human ancestor	Cranial capacity
(A)	<i>Homo erectus</i>	940 cc
(B)	<i>Homo sapiens</i>	1600 cc
(C)	<i>Homo neanderthalensis</i>	1450 cc
(D)	<i>Homo habilis</i>	650 – 800 cc
57.

Human ancestors	Cranial capacity
Neanderthal man	1450 cc
Australopithecus	450 – 600 cc
Cro-magnon man	1600 cc
Java man	940 cc
60. Actual name of this fossil was *Pithecanthropus erectus*. This was classified under *Homo erectus*.



67.

Human ancestors	Cranial capacity
Neanderthal man	1450 cc
Cro-magnon man	1600 cc

72. The first chemicals formed during prebiotic environment of the earth were CH_4 , NH_3 , H_2O .
73. Darwin's finches is a classical example of geographical isolation. Darwin's finches living on Galapagos islands differ not only among themselves but also from mainland finches in size, colour, beak and food habits.

81. Sympatric speciation occurs within the same geographical area when two species occupy different ethological or ecological niche and are reproductively isolated by the development of biological isolating barriers. Allopatric speciation occurs when the original population becomes separated spatially because of geographical barriers. Phyletic speciation is a model of evolution that is uniform and gradual, occurring over a long period of time.



Evaluation Test

- The spark discharge glass apparatus was designed by Miller and Urey to show that simple organic compounds could be formed in nature from the inorganic molecules.
- Nature selects the organisms which are provided with favourable variations and those are fit to survive. This is called as 'Natural selection' or 'Survival of the fittest'.
- Upto 1845, in England, the species *Biston betularia* was a light coloured moth. However, after industrial revolution, more and more black peppered moths were observed and by 1895, they comprised 99% of the moth population.
- Hardy-Weinberg equilibrium principle states gene (allele or genotype) frequencies remain same from generation to generation, thus maintaining the genetic equilibrium unless disturbed by factors like mutation, non-random mating, etc.
- Darwin observed many varieties of finches (a group of small-sized and black coloured passerine birds) on Galapagos Islands. Many varieties of these birds were found on same island with alteration in beaks, some insectivorous and some vegetarians. They radiated to different geographical areas. They have undergone adaptive radiation especially in their type of beak.
- Darwin gave Natural selection theory, Hugo de Vries proposed mutation theory of evolution, Lamarck proposed theory of inheritance of acquired characters and Huxley said that the birds are glorified reptiles.
- Most of the ape fossils of human evolutionary line have been excavated from African rocks.
- The condition in which members of the same species fail to interbreed is called geographical isolation.
- The organs of the body which are non-functional to the possessor but were functional in ancestor and are also functional in related animals are called vestigial organs.



Hints



Classical Thinking

2. William Bateson coined the term 'genetics'. Johannsen coined the term 'gene'. Griffith discovered transformation.
15. Chromatid represents a half chromosome during duplication in early prophase and metaphase of mitosis and between diplotene and the second metaphase of meiosis. After these stages, it is called as daughter chromosome.
17. Centromere is also called as primary constriction.
18. Nucleolar organizers are necessary for formation of nucleolus.
26. Acrocentric chromosome has one arm shorter, while other arm is long. Thus, it appears 'J' shaped.
33. The number of linkage groups is equal to the haploid number.
34. Genes showing complete linkage are transmitted together in their parental combination to the same gametes. Genes showing complete linkage are closely located in the chromosome, and do not segregate at all during crossing over.
41. The term 'crossing over' means the exchange of material between homologous chromatids by the formation of chiasmata. In this process, separation of linked genes occurs.
44. Genes present on non-homologous part of sex chromosomes, i.e. both X and Y are called as sex linked genes. Sex linked genes are not involved in sex determination.
45. There are two types of sex chromosomes 'X' and 'Y'. The Y-chromosome is present only in males and the genes present on non-homologous part of Y-chromosome will be restricted to males only. Such genes are called as holandric genes or Y-linked genes.
46. Genes which are situated on sex chromosomes, i.e. X and Y-chromosomes and are transmitted along with sex are called sex-linked genes.
48. In human beings, several sex linked genes are shown. Some of them are red green colourblindness, haemophilia and hypertrichosis. Genes for these diseases are present on X and Y-chromosomes.
50. Holandric genes are present on Y-chromosome.
52. The allele for colour blindness is recessive to the allele located on X-chromosome for normal vision.
53. Colour blindness is a condition of faulty vision. A colourblind person cannot identify some colours. The most common type is the red-green colour blindness. This fault of colour vision is due to the inheritance of recessive X-linked gene. There is a gene on X-chromosome which is responsible for the formation of colour sensitive cells in the retina, i.e. cones. The cells are essential for the distinction of red and green colours.
54. Criss-cross inheritance helps in establishing relationship between genes and sex chromosomes. It provides evidence that sex-linked genes are located on X-chromosomes.
55. In criss-cross inheritance, the defect is carried from mother to son and from son to his daughter. e.g. haemophilia, colour blindness
57. In haemophilia, the blood of the person fails to clot and the persons bleeds to death. The recessive gene for haemophilia is present on X-chromosomes.
58. Haemophilia and colourblindness both show sex-linked inheritance. They are X-linked diseases showing criss-cross inheritance. Total blindness is called as xerophthalmia and it is not a sex-linked disease. A cataract is a clouding that develops in the crystalline lens of the eye varying in degree from slight to complete opacity and obstructing the passage of light.
59. Haemophilia is a sex-linked recessive trait known as Bleeder's disease because the exposed blood does not readily clot due to deficiency of plasma thromboplastin.



60. Down's syndrome is the trisomy of 21st chromosome which is an autosome.
61. The heterosomes in human female is XX.
62. The diploid number of chromosomes in man is 46, i.e. 23 pairs. Of these, 22 pairs are autosomes and one pair is of sex chromosomes.
67. Human male has two sex chromosomes – X and Y. Y-chromosome is contributed by his father. X-chromosome is donated by his mother only.
68. In human beings, each cell contains 46 chromosomes. Of these, in male, 44 are autosomes, while remaining two which are dissimilar and designated as XY chromosomes are sex chromosomes. The males are heterogametic, i.e. sperms contain autosomes and either X or Y-chromosome.
72. In most animals, the chromosomes are in diploid condition, but in honey bee, the male is haploid in number and female has diploid number of chromosomes.
77. In birds and butterflies, males are homogametic and have 'ZZ' pair of sex chromosomes and females are heterogametic with ZW pair of sex chromosomes.
99. At the time of fertilization, if X-sperm fertilizes X-ovum, XX pair is formed and the zygote will develop into a female child. If the X-ovum is fertilized by Y-sperm, the XY combination will result in male child. It is clear that the sex of child depends upon the type of sperms fertilizing the ovum, and hence the male parent is responsible for the determination of sex of the child.
9. In case of linkage, the genes are inherited together, so the chances of recombination are lost.
10. Distance between the genes and number of chiasmata along the length of chromosomes influence crossing over. More the distance between the genes, higher is the percentage of crossing over and when two genes are situated very close together in a chromosome, no crossing over can take place between them.
11. When there is absence of crossing over, the genes are completely linked. These genes tend to be inherited together.
14. Crossing over is the exchange of corresponding segments between chromatids of paired homologous chromosomes during first meiotic division.
15. Morgan proposed that chiasmata lead to crossing over by breakage and reunion of homologous chromosomes.
16. During crossing over, non-sister chromatids of homologous chromosomes exchange genes.
19. Sex determination in man is chromosomal. In females, the chromosome complement is (44 + XX), whereas males have chromosome complement as (44 + XY). In females, since XX complement is present, the recessive gene gets suppressed by the dominant gene while in males, there is presence of Y-chromosome because of which the recessive gene on X-chromosome in male expresses itself.
20. X-chromosomes linked genetic diseases is never passed on from father to son. It is a sex-linked trait or disease which is never transmitted from male to male, i.e. from father to son. The inheritance of recessive sex-linked characters from F₁ male to F₂ males (grandson) through F₁ female is called criss-cross inheritance, i.e. from male to female and again to male.

**Critical Thinking**

1. In prokaryotic cell, e.g. bacteria, cyanobacteria organized nuclei are not present. As a result, the hereditary material occurs in the cell cytoplasm as nucleoid without the nuclear envelope.
4. A Sub-metacentric chromosome appears 'L'-shaped in Anaphase.
5. X and Y are two chromosomes which differ in length, i.e. X chromosome is larger than Y. They differ in number of genes present on them and also the pattern of inheritance.
6. Y-chromosome has less DNA, hence genetically less active.
8. All the genes which are linked with one another, form a linkage group.
21. Holandric genes show straight inheritance.
22. In human beings, males are heterogametic with 'XY' sex-chromosomes, while females have XX sex-chromosomes. So, the sex-linked gene on Y-chromosome will be transmitted to male offsprings only.
23. A man transmits sex-linked genes on Y-chromosomes to his son and not X-chromosomes, as son receives Y-chromosome from father.

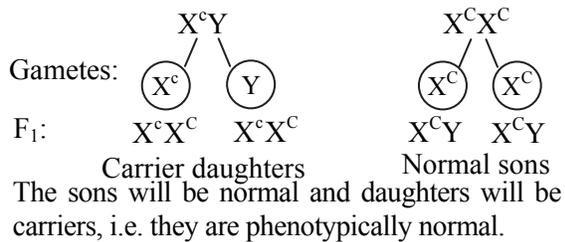


24. All the daughters will be normal. Females do not have the Y-chromosome. They are homogametic, i.e. 'XX'. Moreover, hypertrichosis shows a straight inheritance from grandfather to father to son. This Y-linked disease is observed specifically in males and not in females.

25. Colour blindness is caused by recessive gene present on X-chromosome and shows criss-cross type of inheritance. Hence, the man carries the recessive gene for colour blindness from his carrier mother. The mother is phenotypically normal as a female requires two recessive genes for the expression of the disease.

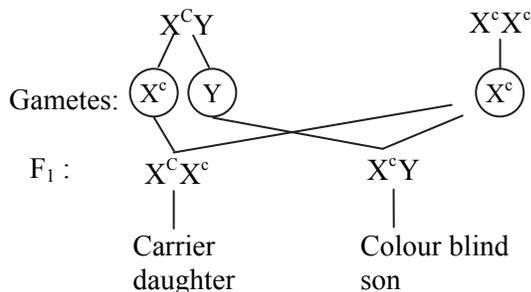
26. The defective gene is present on the X-chromosome. It is expressed in a single recessive condition in males due to a single X-chromosome, but in females, two recessive genes are essential for expression of the disease.

27. Parents: Colour blind man × Normal female

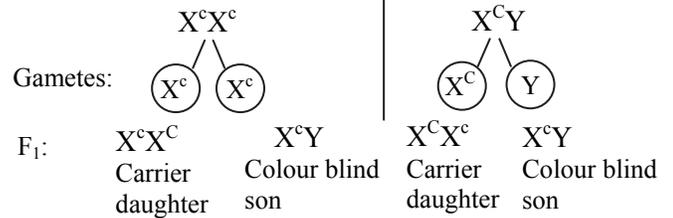


28. In case of sex-linked disease like colour blindness, the defective X-chromosome of the father is passed on to his daughter who becomes a carrier for the gene. She then transmits it to her son who manifests the disease. Thus, the defective X-chromosome passes from father to his daughter and to his grandson where it is expressed. Thus, sex-linked genes follow a criss-cross pattern of inheritance.

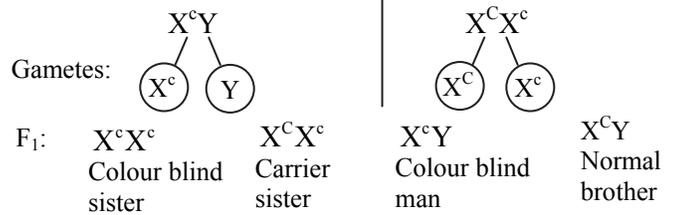
29. Normal visioned man × Colour blind woman



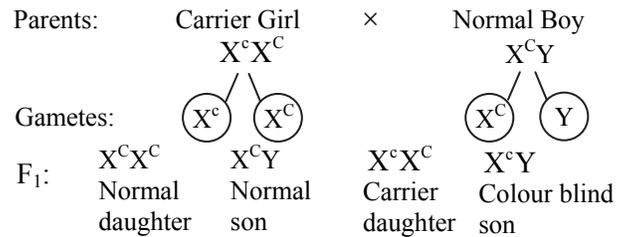
31. Parents: Colour blind woman × Normal man



32. Parents: Father × Mother



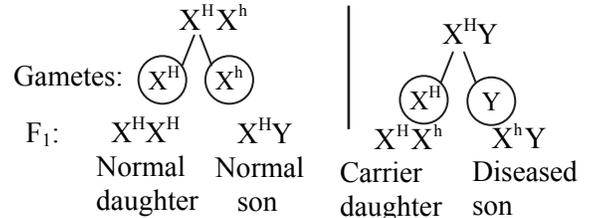
33. The girl will be a carrier of colour blindness, while the boy will be normal as he receives Y-chromosome from his father.



34. The father cannot be a carrier. He has to be either normal or colourblind. The mother can be a carrier or colourblind. If she is a carrier, the male child will be colourblind and the female child will be a carrier.

35. Haemophilia is caused by a mutant allele of a gene present on X-chromosomes. Hence, the total number of chromosomes is same as that of normal man, i.e. 46.

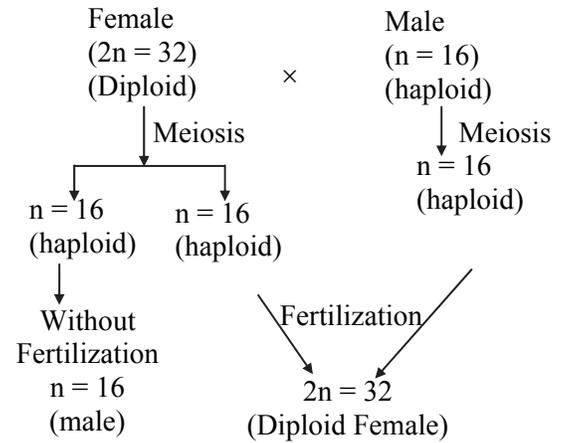
36. Parents: Carrier woman × Normal man



37. Haemophilia is a sex-linked disease, also called as bleeder's disease. Since Mary's father has haemophilia, according to the inheritance, Mary will be a carrier daughter containing a single recessive gene for haemophilia. When such a carrier female marries a normal person, then 50% of sons will be normal while 50% of sons will have haemophilia. Similarly, 50% of daughters will be normal while 50% will be carrier daughters.



38. As the woman has a haemophilic brother their mother has to be a carrier of the disease. She would then pass the recessive gene to her children. A single recessive gene is enough in males to express the disease, so the brother is haemophilic. In females, a double recessive condition is necessary to express the disease. Therefore, as the woman receives only one recessive gene, she is only a carrier.
39. A cell generally contains two types of chromosomes, i.e. autosomes and heterosomes. Heterosomes are sex chromosomes, whereas autosomes are chromosomes other than sex chromosomes. In diploid organisms with separate sexes, the chromosomes associated with the determination of sex are called sex chromosomes.
40. In human beings, sex is determined by chromosomes. Out of 46 chromosomes, 44 are autosomes and two are sex chromosomes. The XX chromosomes determine female sex, whereas XY determine male sex.
41. A female child receives X-chromosomes from both parents because X-chromosome is present both in female as well as male chromosomal complement.
42. The total number of chromosomes in man is 23 pairs or 46 and are heterogametic, i.e. X and Y. Women are homogametic (XX).
- ∴ Sperm produced by man are of two types.
(A) 22 + X (B) 22 + Y
Whereas the ovum produced by female contains only 22 + X-chromosome.
45. The chance of fusion of 'X' 'X' and 'X' 'Y' is equal.
46. In humans, ovum is of only one type, i.e. 22 + X. Sperms are of two types – 22 + X and 22 + Y. Thus, sex of the baby is determined by the type of sperm fertilizing the ovum.
47. In honey bees, there is an unusual method of sex determination. The unfertilized eggs develop into males while fertilized eggs develop into females. Hence, haploid males and diploid females are formed.



48. In Honey bee, males are haploid and hence possess half the number of chromosomes present in diploid females.
49. Down's syndrome is due to trisomy (i.e. presence of extra chromosome) of 21st pair of chromosome and hence the total number of chromosomes in each cell is 47.
50. Turner's syndrome is caused by absence of one of the X chromosomes in females. Such females have genotype as 44 autosomes + only one X chromosome.
∴ 2n = 44 + XO
51. Klinefelter's syndrome is caused by the presence of an extra X chromosome in males. The genotype of the person having this syndrome is 44 + XXY. (Trisomy of sex chromosome)
52. Crossing over is directly proportional to the distance between the linked genes, i.e. more the distance between genes on the chromosomes, more will be the chances of crossing over.
53. Parents: Colour blind man (X^cY) × Carrier female (X^cX^C)
Gametes: (X^c, Y) × (X^c, X^C)
F₁: X^CX^c (Carrier daughter), X^cX^c (Colour blind daughter), X^CY (Normal son), X^cY (Colour blind son)
54. Parents: Carrier woman (X^HX^h) × Normal man (X^HY)
Gametes: (X^H, X^h) × (X^H, Y)
F₁: X^HX^H (Normal daughter), X^HY (Normal son), X^HX^h (Carrier daughter), X^hY (Haemophilic son)



55. Turner's syndrome is caused by monosomy of X-chromosome, i.e. the individuals have only one 'X' chromosome. Such individuals are always females. Down's syndrome is due to trisomy of 21st chromosome, whereas Patau's syndrome is due to trisomy of 13th chromosome. Klinefelter's syndrome is trisomy of sex chromosome, i.e. the individuals are XXY type and are males.
57. Sex ratio is the number of females per 1000 males.

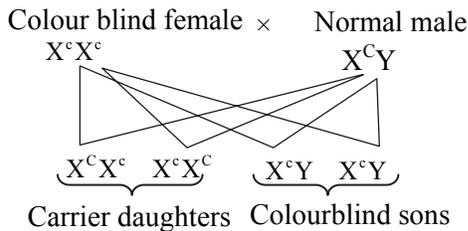


Competitive Thinking

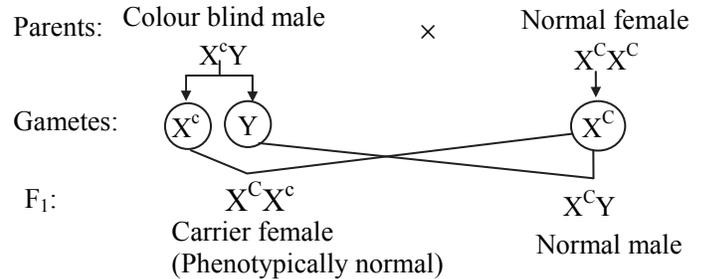
- The genetic system of bacteria contains only DNA molecule but no histones. Histones are main structural protein found in eukaryotic cells.
- Genetics is the study of heredity, the process by which characters are passed from parents to their offsprings, so that all offsprings resemble their parents.
- Centromere (Kinetochore) lies in the region of primary constriction where two chromatids are connected at the centromere.
- Based on the location of centromere, the chromosomes are categorized into
 - Telocentric
 - Acrocentric
 - Submetacentric
 - Metacentric
- Sperm is haploid structure in which twenty two autosomes and one X or Y chromosome is present.
- Centromere is a region of chromosome which holds sister chromatids together and the area where chromosomes are attached to spindle fibres during cell division.
- Metacentric are V-shaped chromosomes in which centromere lies in the middle of the chromosome so that the two arms are almost equal.
- Acrocentric → Chromosomes with centromere near the end.
Metacentric → Chromosomes with centromere at the center.
Sub-Metacentric → Chromosomes with centromere near the center.
Telocentric → Chromosomes with centromere at end.
- In metacentric chromosome, centromere is present in the middle. So, these chromosomes are isobrachial. In anaphase, the chromosomes appear V-shaped.
- 22 pairs of chromosomes are called autosomes, which decide the somatic characters in both sex, while 23rd pair of chromosomes are called heterosomes or allosomes.
- Number of linkage groups in an organism is equal to the haploid number of chromosomes. In *Drosophila melanogaster*, $2n = 8$, hence $n = 4$ linkage groups.
- The genes for white eye and miniature wings are loosely linked hence show higher percentage of recombination (37.2%).
- In zygotene stage of prophase-I of meiosis, two homologous chromosomes lie side by side which is known as pairing of homologous chromosomes or synapsis.
- Synapsis is a process of crossing over in which, pairing of homologous chromosomes takes place during zygotene. Synapsis results in the formation of bivalents during zygotene. After zygotene stage, cell enters the pachytene stage in which the two non-sister chromatids break and exchange segments leading to recombination.
- Crossing over is a process by which chromatids of homologues exchange portions of genetic material, usually during tetrad formation of meiosis.
- Crossing over always takes place between nonsister chromatids of two homologous chromosomes.
- Number of linkage group corresponds to the haploid number of chromosomes of a particular species. In case of honey bees, females have 16 pairs of chromosomes. Thus, the linkage groups in them are 16.
- Frequency of crossing-over is directly proportional to the distance between two genes.
- If the genes are tightly linked they will not allow crossing over. They cannot show 50% recombination frequency. So, statement (B) is not true.
- | | | | | |
|------------------|------------------|------------------|-----------------|-----------------|
| | $X^C X^c$ | | $X^C Y$ | |
| | (Carrier mother) | | (Normal father) | |
| Gametes: | X^C | X^c | X^C | Y |
| | $X^C X^C$ | $X^C X^c$ | $X^C Y$ | $X^c Y$ |
| F ₁ : | Normal daughter | Carrier daughter | Normal son | Colourblind son |



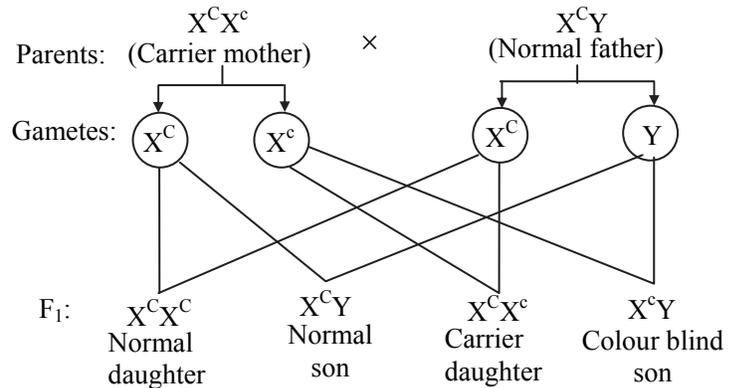
32. Whenever mother is homozygous colour blind, all her sons will be colour blind irrespective of their father's nature.
33. Colour blindness is a X-linked recessive disease, influencing man in heterozygous condition and woman in homozygous condition.
35. Colour blindness is a recessive sex-linked disease, genes of which are present exclusively on non-homologous segment of X chromosome. So, males need only one affected chromosome to express the character, whereas females need both the affected chromosomes to exhibit the same.
36. Genes for sex linked characters occur on both segments of X and Y-chromosomes. Many sex linked characters (about 120) are found in man. Such characters are mostly recessive.
37. Colour blindness and Haemophilia are the two main sex linked or X-linked diseases found in man.
38. Carrier mother is heterogametic for recessive colour blindness gene.
39. Colour blind sons and carrier daughters are formed.



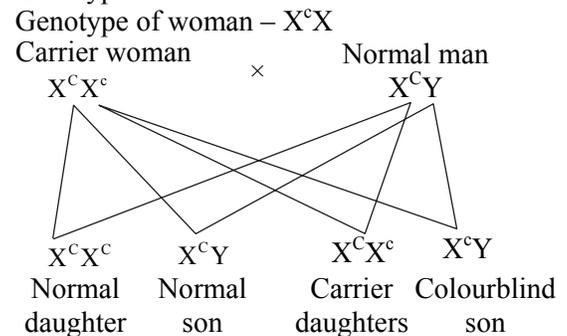
40. Colourblindness gene is located on X-chromosome.
41. All the sons of a colourblind mother are colourblind.
42. A son receives X chromosome from his mother and Y chromosome from his father.
43. Although all the daughters will be genotypically carriers, but phenotypically they will be normal.
44. Colour blindness is an X-linked recessive disorder. Since their fathers were colour blind, the gene for colour blindness would be passed on to the female (carrier female) whereas the male will be normal.



The probability of their daughter becoming colour blind would be 0% as their daughter would atleast receive one normal X gene from the father.



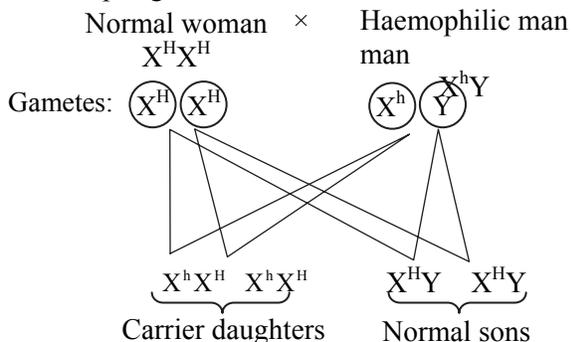
45. Sex linkage is the transmission of characters and their determining genes alongwith sex determining genes which are found on the sex chromosomes. Y chromosome of male carries a few genes, but X chromosome, which is common to male and female, carries a number of genes.
46. For a woman to be colour blind, both her X chromosomes should bear genes for the disease; which is possible only when her father is colourblind and her mother is either colourblind or a carrier of disease.
47. Red-green colour blindness is inherited as a sex-linked recessive gene on the X-chromosome in human beings.
48. Gene for colour blindness is located on the non-homologous part of X-chromosome. It is a sex-linked recessive disease.
50. Genotype of normal man – XY
Genotype of woman – X^cX





52. When both the chromosomes bear genes for disease, i.e. in homozygous condition, only then the character will be expressed. Otherwise, the individual will act as a carrier.

54. All offsprings will be normal.



55. Haemophilia is a sex-linked disease. It is genetically due to the presence of a recessive sex linked gene h, which is carried by X-chromosome.

56. The recessive gene for haemophilia which is located on X-chromosome suppresses the synthesis of factor VIII, which is necessary for the normal blood clotting.

57. Since woman is normal and her father was a bleeder means she is a carrier as she marries a haemophilic man, only half of their children will be diseased.

59. All sons are haemophilic because this disease is caused by X-linked mutant gene.

60. Haemophilia is a sex-linked recessive disease.

61. A man possesses only one gene for colour vision, whereas woman possesses two. The normal colour vision is dominant over colour blindness. Therefore, only woman will be carrier when she has gene for colour blindness in one X-chromosome.

67. Unfertilized human egg is a haploid structure in which 22 autosomes and one X-chromosome is present.

69. Man is heterogametic because it has X and Y chromosomes.

73. Haplodiploidy is a type of sex determination in which the male is haploid, while female is diploid. It occurs in some insects like honey bees, ants and wasps.

76. Thalassemia is a quantitative problem of synthesizing less globin chains whereas sickle cell anaemia is a qualitative problem in which mutant haemoglobin molecule is produced.

78. The condition of chromosomal change which involves the loss or gain of a single chromosome is called aneuploidy. Genotype "22 + XXY" shows the condition of Klinefelter's syndrome.

79. Down's syndrome is an autosomal aneuploidy.

82. Trisomic condition of Down's syndrome arises due to failure of separation of chromosome or non-disjunction during meiosis.

83. Down's syndrome is due to trisomy of 21st chromosome was first reported in 1866 by Langdon Down.

84. Down's syndrome is caused due non-disjunction of 21st chromosome.

85. Hyper aneuploidy is an increase in the number of chromosomes (e.g. Trisomy). Down's syndrome arises due to gain of an additional copy of chromosome 21 (i.e. trisomy) and does not involve the sex chromosomes. Hence, it is an example of autosomal hyper aneuploidy

86. Trisomy of 21st pair of chromosome.

88. Individuals with Turner's syndrome have one X chromosome (44 + XO) due to non-disjunction of sex chromosome in their parents.

89. The number of chromosomes in Turner's syndrome is 45, with only one sex chromosome. i.e. X-chromosome Hence, referred to as X-monosomy.

94. XXY genotype is found in Klinefelter's syndrome. In this chromosomal disorder, male individuals show female secondary sexual characteristics and are usually sterile.

97. Loss of one chromosome from a homologous pair ($2n - 1$) is called monosomy. Increase of one chromosome in any homologous pair ($2n + 1$) is called trisomy.

99. Phenotypically these individuals are males, but they can show some female secondary sexual characteristics and are usually sterile.

101. Males with Klinefelter's syndrome have 47 chromosomes with XXY condition.

102. Since daughter of a colour blind person will be a carrier of the disease and only one of the two X chromosomes will bear the recessive gene for the disease. So, half of their sons will be colourblind.



106. Nephritis – Incomplete sex-linked inheritance
Haemophilia, Myopia, Night blindness – Complete sex-linked inheritance
109. Sickle cell anaemia is an autosomal recessive disorder.
110. Sex-linked traits appear more frequently in males as they have only one 'X' chromosome so the recessive gene gets a chance to express itself. Colour blindness is caused due to defect in gene that prevents the proper formation of colour sensitive cells in the retina. Drone bees produce sperms by mitosis.
111. Spliceosomes help in removal of introns during post-transcriptional processing of hnRNA in eukaryotes. Split genes are absent in prokaryotes. Franklin Stahl demonstrated semi-conservative mode of replication.
T. H. Morgan coined the term linkage.
Transduction was discovered by Norton Zinder.
113. T. H. Morgan coined the term linkage.
 $F_2 \times$ Recessive parent - test cross.
Gregor Mendel performed experiments on pea plants to study inheritance pattern.

**Evaluation Test**

1. The number of linkage groups in a species corresponds to its haploid number of chromosomes.
Hence, number of linkage groups in maize are 10 (10 pairs of chromosomes) as chromosome number is 20.
2. i. The individual suffering from Klinefelter's has 47 chromosomes instead of 46 and chromosomal make up will be $44 + XXY$.
ii. When an abnormal egg with XX chromosomes is fertilized with normal Y sperm, the resulting baby gets XXY.
4. Myopia is an example of complete sex-linked inheritance.
6. Y-chromosome contains small amount of euchromatin and large amount of heterochromatin.
7. ZZ-ZW type of sex determination is seen in birds. Male has genotype (ZZ) and female has genotype (ZW).
8. The chromosomal make-up of an individual suffering from Turner's syndrome is $44 + XO$.
10. Haemophilia is inherited from father to his grandson through his daughter. This is called 'Criss-cross inheritance'.



Hints



Classical Thinking

11. Many copies of DNA is obtained from available material by Polymerase Chain Reaction.
29. *Methanococcus jannaschii* – 1660 Kb
Haemophilus influenzae – 1830 Kb
Mycobacterium genitalium – 569 Kb
33. Insulin is produced by cells in the pancreas called Islets of Langerhans.
- 39.

Name of gene	Use
Tissue plasminogen activator (TPA)	Prevent or reverse blood clots.
Tissue Growth Factor (TGF)	Wound healing and burns.
Factor VIII	Treatment of haemophilia



Critical Thinking

1. Variable number of tandem repeats or VNTRs are short repeating sequences which are used as genetic markers during DNA fingerprinting.
2. All persons show 99% similarity in their nucleotide sequence. Only some short pieces of nucleotides differ from person to person and these nucleotides are teamed as VNTRs.



Evaluation Test

1. In somatic gene therapy, healthy genes are introduced into somatic cells like blood cells, bone marrow cells.
2. Vaccine is an antigenic preparation developed from attenuated bacteria and viruses.
3. The cutting of DNA by restriction endonucleases results in the fragments of DNA. These fragments can be separated by a technique known as gel electrophoresis.
4. PCR is a gene amplification technique in which multiple copies of known DNA sequence is obtained.

4. Erythrocytes do not have nucleus, hence cannot be used in DNA fingerprinting.
6. DNA is negatively charged. Thus, the movement of DNA sample will be from negative (cathode) to positive pole (anode).
20. During DNA profiling, the DNA sample is subjected to fragmentation by the action of restriction endonuclease. Thus, the DNA obtained after fragmentation is termed as RFLP (Restriction fragment length polymorphism) which is used for analysis.
21. Bovine growth hormone is used to increase cattle and dairy yield.



Competitive Thinking

9. DNA fragments are negatively charged due to the presence of phosphate group.
11. Ethidium bromide is a dye used to stain the DNA fragments which appear as orange coloured bands under UV light.
23. First human hormone produced by recombinant technology.
35. Hyper ovulation occurs during estrous cycle. Re-implantation of embryo is relatively easy in mice. It can carry upto 20 offsprings at one time.



Hints



Classical Thinking

14. Skin is an anatomical barrier.
16. Macrophages are large irregular shaped cells that engulf microbes and cellular debris.
25. Vaccine develops artificial immunity by stimulating the production of antibodies.
31. Immature lymphocytes destined to become thymocytes migrate via the blood, to the thymus where they mature as T-lymphocytes.
35. T-lymphocytes generate cell mediated immunity and B-lymphocytes generate humoral immunity
36. Sensitized helper T-cells produce lymphokines which are responsible for the proliferation of T-cells, stimulation of B-lymphocytes and attraction of macrophages.
40. Killer T-cells directly attack and destroy invading microbes, infected body cells and cancer cells.
43. Opsonisation is coating of bacteria to facilitate their subsequent phagocytosis by macrophages.
44. APC cells deliver co-stimulatory signals which are necessary for helper T-cell activation.
48. The four polypeptide chains of an antibody are held together by disulphide bonds (-S-S-) to form a 'Y' shaped structure.
52. The paratope present on the variable region recognizes and binds to the specific antigen forming an antigen-antibody complex.
54. Since most antibodies carry two antigen binding sites, they are said to be bivalent.
61. Individuals with blood group 'O' lack A and B antigens on the surface of their RBC's.
66. Rh factor was first discovered by Landsteiner and Wiener in 1940 on the surface of RBCs of Rhesus monkey; Hence, it was named as Rhesus or Rh factor.
68. Any disease producing agent or micro-organism is termed as pathogen.

98. In treatment of filariasis, 100 mg of diethyl carbamazine is used twice a day for 3 weeks and for 5 days every six months.
100. Man is the definitive host for *Ascaris*.
123. World Health Organization has recommended live oral Ty 21a vaccine (sold as *Vivotif Berna*) for typhoid.
128. RSV causes viral pneumonia.
166. Lysergic acid diethyl amide (LSD) is derived from ergot fungus *Claviceps purpurea*.
173. When mosquito bites a person, sporozoites enter the blood stream and migrate to the liver. They infect liver cells, where they multiply into merozoites.



Critical Thinking

1. Mucous membrane secretes mucus and the mucus coating of the epithelial lining of the respiratory, gastrointestinal and urinogenital tracts help in trapping microbes entering the body.
2. The epithelial lining of the respiratory tract helps in trapping microbes entering the body, thus acting as an anatomical barrier.
3. Cells when infected with virus, release interferons (glycoproteins). Interferons make the surrounding cells resistant to viral infection.
4. Lysozyme is a bacteriolytic enzyme present in tears which digests bacterial cell wall, thus preventing invasion of pathogenic micro-organisms.
5. Antibodies belong to Acquired Immunity.
8. Phagocytosis is an important mechanism of innate immunity. Phagocytes engulf and destroy invading microbes.
9. The resistance or immunity that an individual acquires during lifetime is called acquired immunity. It is specific for each type of pathogen.
14. Humoral immune system is an antibody-mediated system.



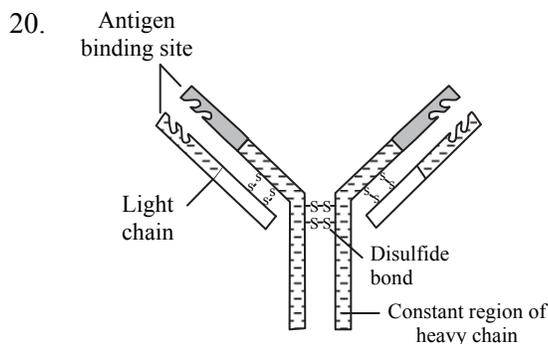
18. Antigen presenting cells engulf invading pathogens and process the antigens. The processed antigens are presented on their surface.
19. Antibodies are specialised serum glycoproteins that are produced by lymph in response to an antigen. They are formed for self-defence against the antigens.
20. Antibody is not an organism. It is a complex chemical substance.
21. A person with blood group 'B' can receive blood from person with blood group 'B' or 'O'. Blood group 'AB' is 'Universal recipient'.
25. As *E. histolytica* is resistant to chlorination, therefore sedimentation and filtration are the processes used for treatment of water.
29. Lipopolysaccharide (LPS) protects the typhoid bacteria from environment.
32. Epistaxis (bleeding nose) is seen in case of typhoid.
33. During typhoid, victim suffers from leukopenia. Leukopenia is a clinical condition in which number of circulating WBCs decrease.
34. Influenza is a viral disease caused by *Haemophilus influenzae*. Typhoid is a bacterial disease. Ascariasis and filariasis are caused by roundworms.
36. The bacterium *Streptococcus pneumoniae* is the common cause of pneumonia. *S. typhi* is the causative agent of typhoid.
38. Onychomycosis is the infection of nail in which nails become thick, discoloured and finally crumble and fall off.
39. Metastasis is a stage wherein the cancerous or malignant tumor starts spreading to other regions of the body to form secondary tumors. It is usually fatal.
40. Adenomas are cancers that arise in the thyroid, pituitary, adrenal and other glandular tissues.
41. Glaucoma is a group of eye diseases characterized by damage to the optic nerve.
44. Cancer is a non-communicable disease. Cancer cells show uncontrolled growth and multiplication.

45. Cancerous growth can be prevented through all the given options like surgical method which means removal of cancerous tissue. Radiation therapy is burning and destroying cancerous tissue. Chemotherapy – drug treatment and new cancer treatment is administration of interferon to a cellular molecule, which prevents viral reproduction, slows cell division and regulates the activities of immune system.
49. Bhang, Marijuana and Hashish are produced from the plant *Cannabis sativa* and are hallucinogens. Heroin is a depressant and extracted from *Papaver somniferum*.
58. Carcinomas are cancers of internal and external body parts such as lungs, breast and colon.
59. HAART is an antiretroviral drug therapy used in the treatment of HIV. It has been very effective in reducing the number of HIV particles.



Competitive Thinking

1. Interferons are glycoproteins.
4. Artificially acquired passive immunity is developed by injecting previously prepared antibodies using serum from humans or animals.
6. Oral polio vaccine consists of attenuated pathogens.
7. Colostrum is mother's first milk which is rich in immunoglobulins. It provides naturally acquired passive immunity.
9. Passive immunity is acquired when ready-made antibodies are received by the body.
10. Lymphatic tissue (Lymphocytes) are the chief cells of specific immune system of the body.
14. Rejection of graft or transplanted organs or tissues takes place due to cell mediated immune response.
17. MALT is Mucosa Associated Lymphoid Tissue and it constitutes about 50 percent of the lymphoid tissue in human body.
18. Antibodies are glycoproteins which are highly specific to specific antigens.
19. Antigen binding site (paratope) in an antibody includes variable regions of both heavy and light chains.



Structure of Antibody

25. Amoebiasis or amoebic dysentery is caused by the ingestion of quadrinucleate cyst of *Entamoeba histolytica* along with contaminated food and drinks.
26. By washing the hands, we can avoid the ingestion of cysts. Cysts are responsible for infection.
27. Malignant tertian malaria (severe malaria) is caused by *Plasmodium falciparum*. The fever is often fatal to the patient as it affects the brain.
41. Widal's test is the test for the presence of agglutinins to O and H antigens of *Salmonella typhi* and *Salmonella paratyphi* in the serum of patients with suspected *Salmonella* infection.
51. Cancerous cells have high telomerase activity. Telomerase inhibitors are used in cancer treatment.
54. HIV infection affects CD₄ T-cells (T-Helper cells). The T-cell count reduces below 200 cells/m³.

57. HIV reduces natural immunity of the body by destroying T-lymphocytes which matures in thymus.
69. LSD is used as a medicine which helps the patient to cope up with mental illness like depression and insomnia
70. Heroin is a depressant and slows down body functions.
71. Smack – Heroin
Crack – Cocaine
74. *Wuchereria bancrofti* requires female *Culex* and *Plasmodium ovale* requires female *Anopheles* to complete their life-cycle.
78. In autoimmune diseases, the immune cells are unable to distinguish between self cells and non-self cells and thus attack self cells.
79. According to recent studies, vitiligo and psoriasis may be classified as autoimmune diseases.
Rheumatoid arthritis is considered as an autoimmune disorder since antibodies are produced against the cartilage and synovial membrane.
Alzheimer's disease is caused due to deficiency of neurotransmitter acetylcholine and current research links Alzheimer's to autoimmune disease.
80. α -Interferon is used for the treatment of cancer, whereas oncogenic viruses, proto-oncogenes and UV rays can cause cancer.



Evaluation Test

1. Hashish and Charas are hallucinogens and products of the hemp plant *Cannabis sativa*.
2. Saliva and tears are examples of Physiological (Chemical) barriers that constitute the first line of defence.
3. Development of swelling is a local inflammatory response.
4. In malaria, classical waves of fever arise from simultaneous waves of merozoites escaping and infecting red blood cells.
7. T and B-lymphocytes develop from haemopoietic stem cells that originate in the red bone marrow. The process of their production is called haematopoiesis.
10. The O-antigen present on the cell wall of *Salmonella typhi* is responsible for its pathogenicity.
12. Suppressor T-cells suppress the activity of Killer T-cells. Antibodies are produced by B-cells.
13. B-lymphocytes (Plasma cells) produce antibodies.
14. Erythroblastosis foetalis is a disease in which Rh-ve mother produces antibodies against Rh+ve foetus. It is also called haemolytic disease of the newborn (HDN).

14 Animal Husbandry



Hints



Classical Thinking

6. The six breeds of buffaloes found in India are Jaffarabadi, Mehsana, Murrah, Nagpuri, Nili and Surti.
11. Broilers and Plymouths are meat producing male chicken breeds.
32. In MOET technology, cow is administered with FSH to induce follicular maturation to bring about super ovulation.
34. The blastocysts at 8-32 cell stage are recovered non-surgically and transferred to surrogate mothers.
52. Lac is produced by dermal glands of the female insect.
57. Fishery – Rearing of fishes
Dairy – Rearing of cattles for milk
Pisciculture – It refers to rearing and harvesting of fishes



Critical Thinking

7. Hisardale is a new breed of sheep developed in Punjab by cross-breeding Bikaneri ewes and Marino rams.
8. Mule is a hybrid animal developed by interspecific hybridization between horse and donkey.
10. Economically, man is much benefitted by honey bee as we get honey, which has medicinal value. Flowers are pollinated by honey bees.
15. Life history of silk moth passes through four stages: Eggs, Caterpillar, Pupa and Adult.
16. Silk produced by different species of silkworms differ in quality and texture. Tassar silk (*Antheraea mylitta*) is less shiny and difficult to bleach. Eri silk (*Attacus ricini*) is creamy white. The best silk of the four silkworms is the silk of *Bombyx mori*.
21. *Drosophila* is an insect, while others are fishes.



Competitive Thinking

3. *Nagpuri* is a buffalo breed.
11. Super-ovulation and embryo transplantation are the new techniques for cattle and other livestock improvement.
- 14.

Common name of bee	Scientific name
Rock bee	<i>Apis dorsata</i>
Little bee	<i>Apis florea</i>
Indian bee	<i>Apis indica</i>
European bee	<i>Apis mellifera</i>

17. *Stromateus* (Pomfret) is a marine fish, while others are fresh water species.
18. *Cirrhinus* is a freshwater fish.
19. *Bombyx* is a silk producing organism.
20. Eri silk and Tussar silk are considered as inferior silk.
21. Silk is produced by silk worm insect called as silk moth.
23. Lac is the secretion of dermal glands of *Tacchardia lacca*.
24. Lac is secreted as pink coloured resin which hardens on coming in contact with air forming lac.
26. Isinglass is a by-product of fishery.
28. Inbreeding results in increase in the homozygosity. Thus, mating of the related individuals of same breed will increase homozygosity.
29. Intra-breeding refers to mating between individuals of the same species.
Inter-breeding refers to mating between individuals belonging to different species.
Inter-generic breeding refers to mating between individuals from two different genera.
Inter-specific breeding refers to mating between individuals from two different species.



Evaluation Test

1. Aseel is an indigenous (desi) breed of fowl, rest all are exotic breeds.
2. Ranikhet disease is a viral disease affecting poultry.
3. Rohu is a fresh water fish, while others are marine water fishes.
5. *Catla* is a fresh water fish.
7. Multiple Ovulation Embryo Transfer Technology (MOET) is an artificial breeding method for herd improvement. It is done in cattle, sheep, rabbits, etc.
8. The mating of more closely related individuals within the same breed for 4-6 generations is called inbreeding. It increases homozygosity.

15 Circulation



Hints



Classical Thinking

10. Plasma contains 90-92% water.
28. The average life span of WBC cells is about 3 to 4 days.
45. The size of the platelets is 2.5-5 μm .
76. The right atrium receives deoxygenated blood, via. superior vena cava, inferior vena cava and coronary sinus.
80. The two veins which open into right auricle are superior vena cava and inferior vena cava.
82. Left atrium receives oxygenated blood from lungs through pulmonary veins.
83. Each atrium (upper chamber) opens into the ventricle (lower chamber) through atrio ventricular aperture.
88. All the valves are attached to papillary muscles of ventricles by chordae tendinae.
116. The right ventricle on contraction pumps the impure blood into the pulmonary trunk which later branches into right and left pulmonary arteries that carry the blood to the lungs for purification.
122. The heart beat of a person suffering from tachycardia is 100 beats per minute.
123. The heart beat of a person suffering from bradycardia is 60 beats per minute.
152. Lymph is blood minus RBCs, platelets and some plasma proteins.
160. pH of blood is 7.4 which is slightly alkaline.
166. Accumulation of cholesterol in the arterial wall results into swelling and thickening of wall. It is a kind of necrotic, degenerative change in the arterial wall.
167. ECG is useful to detect abnormal functioning of heart during various heart diseases such as angina pectoris, bradycardia, heart block, etc.



Critical Thinking

1. Blood is a fluid connective tissue derived from mesoderm.
2. Haemoglobin acts as a buffer which helps in maintaining the pH of blood.
4. WBCs produce antibodies and are responsible for the immune response of the body.
6. Basophils release histamines which are involved in inflammatory and allergic reaction.
9. WBCs are of 2 types: granulocytes and agranulocytes. Each one of them has different nucleus and different size.
12. Fibrin is a blood protein which enmesh platelets, blood cells and plasma to form the clot.
14. The two grooves present in the heart are atrioventricular groove or coronary sulcus between atria and ventricles and interventricular groove between two ventricles.
16. Two arches (pulmonary trunk and systemic aorta) are connected by ligamentum arteriosum that represents remnant of ductus arteriosus of foetus.
18. The atrioventricular aperture (present between right atrium and right ventricle) is guarded by tricuspid valve which has three valves.
19. Mitral valve or bicuspid valve is present between left auricle and left ventricle which controls the back flow of blood in left auricle.
20. The chordae tendinae prevents the valves from turning back into the atria during the contraction of ventricles, thus preventing the back flow of blood.
22. Because, the right ventricle has to pump the deoxygenated blood into the lungs only through pulmonary artery, whereas the left ventricle has to pump the oxygenated blood through aorta and its branches to all the parts of the body. For this, there has to be sufficient force and pressure on the output of blood, to enable the blood to reach to various parts of the body.



23. The heart beat is stimulated and regulated by SA node, AV node, Bundle of his and Purkinje fibres.
24. The impulse or heart beat initiates in the SA node which is located in right atrium.
25. The wave of contraction or cardiac impulse generated by SA node is conducted by cardiac muscle fibres to both the atria causing their contraction (atrial systole).
30. The three phases of cardiac cycle are atrial systole, ventricular systole and joint diastole.
31. Deoxygenated blood enters right atrium through superior vena cava, inferior vena cava and coronary sinus. The right atrium contracts and blood enters right ventricle. Thus, cardiac cycle begins with auricular systole.
32. Systole refers to contraction of atria (atrial systole) which propels blood into ventricles and contraction of ventricles (ventricular systole) expels blood into aorta and pulmonary artery.
36. During complete cardiac diastole, right atrium receives deoxygenated blood from all over the body and left atrium receives oxygenated blood from lungs.
37. Sinoatrial node receives sympathetic nerves which secretes adrenaline.
38. Sympathetic nerves secrete adrenaline which stimulates and increases the heart beat.
39. Parasympathetic nervous system secretes acetylcholine which decreases the heart beat.
41. Capillaries are the thinnest of blood vessels and hence the velocity of blood flow is minimum in capillaries.
45. Each heart beat pumps = 70 ml blood.
∴ 60 heart beats will pump = 70×60
= 4.2 litres of blood.
46. The amount of blood pumped by heart per minute is called cardiac output or heart output.
47. Pulse wave is the contraction of left ventricle (systole), which forces the blood into arteries and the elastic wall of the arteries rises to accommodate the blood flow. In diastole, the arterial wall falls to regain its original condition. This rise and fall of the arterial wall is evidently the pulse wave mediated by ventricular systole.
54. The systolic blood pressure is 120 mm Hg and diastolic blood pressure is 80 mm Hg.
63. Blood platelets and thrombocytes aggregate at the site of injury and form a platelet plug. They release thromboplastin which helps in clotting of blood.
67. Pulmonary artery carries deoxygenated blood.
68. The path of flow of blood shown here is correct because arteries start from heart. Arteries carry oxygenated blood and go on dividing and redividing into capillaries. Capillaries unite to form veins and veins carry deoxygenated blood to heart.

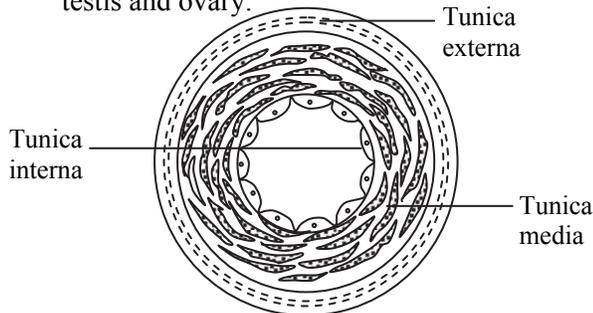


Competitive Thinking

2. pH of plasma is 7.4 which is slightly alkaline/basic.
3. Blood plasma – clotting factors = Serum
5. The old and worn out RBCs are destroyed in spleen and also in liver.
7. Neutrophils and monocytes are the major phagocytic cells of immune system.
9. Mature RBCs in adult humans lack nucleus (enucleated). The nucleus of RBCs degenerates during maturation to provide more space for oxygen carrying pigment-haemoglobin. They lack mitochondria along with many cell organelles hence, respire anaerobically.
13. In blood coagulation, prothrombinase in presence of Ca ions converts prothrombin into thrombin which converts fibrinogen to fibrin which forms clot.
16. Monocytes and Lymphocytes are agranulocytes. Erythrocytes are RBCs.
19. Monocytes and Neutrophils are phagocytic in function.
23. Pericardium (Protective covering) and pericardial fluid protects the heart from shocks, mechanical injuries and keeps it moist and also allows free movements of the heart.
24. The wall of heart has three layers – epicardium, myocardium and endocardium.
27. Opening of coronary sinus is guarded by Thebesian valve. Semilunar valves are present at the base of systemic aorta and pulmonary aorta. Mitral valve is also known as left atrioventricular or bicuspid valve. Opening of inferior vena cava is guarded by Eustachian valve.



29. AV node is located in the lower left corner of the right atrium. SA node is located in the upper right corner of the right atrium near the opening of superior vena cava.
30. SA node is called 'Heart of heart' because it initiates the heart beat and has the power of generation of wave of contraction.
32. The fossa ovalis which represent the remnant of foramen ovale is present on the right side of interatrial or interauricular septum.
33. 'X' - Bundle of His
37. Within the lateral walls of ventricles.
38. The wall of ventricles are thicker than those of auricles. Thickest wall is found in the left ventricles.
40. Adrenaline increases the heart beat normally during active and stress conditions.
45. Arteries are thick walled, carrying oxygenated blood from heart to various parts of body at high pressure.
46. Tunica albuginea is a layer of tissue formed in testis and ovary.



T.S. of an Artery

47. The wall of arteries are thick and muscular.
48. Vein contains valves to prevent back flow of blood.
49. Veins bring blood from the body to the heart.
50. The left atrium receives oxygenated blood from the lungs through two parts of pulmonary veins.
54. 70 ml blood is ejected by left ventricle during each ventricular systole, called stroke volume.



Evaluation Test

1. Monocytes, Lymphocytes and Neutrophils are types of WBCs.
2. In lymphocytes, the nucleus is single, large and spherical.
4. Cardiac output is defined as the amount of blood pumped by each ventricular contraction per minute.

55. The amount of blood flowing from the heart over a given period of time is known as the cardiac output. It depends upon the heart rate and stroke volume.
56. Cardiac output = stroke volume \times ventricular systole/minute
 $= 70 \text{ ml} \times 72 \text{ (min)}$
 $= 5040 \text{ ml/min}$
 $= \text{about } 5.5 \text{ litres}$
57. The normal systolic and diastolic pressures are 120 mm Hg and 80 mm Hg respectively.
61. Normal diastolic pressure is 80 mm Hg.
64. B.P. in aorta will be maximum when left ventricle pumps the stroke volume into its lumen during its systole.
68. Purkinje fibres are found in the lateral walls of ventricles and help in conduction of cardiac impulse.
69. Cardiac impulse (Heart beat) normally originate from the pace maker.
71. Bundle of His is a network of muscle fibres found in between two ventricles.
75. Blocking of arteries due to deposition of fat and calcium is called atherosclerosis. Emphysema is choking of breath.
76. Atherosclerosis is narrowing of arteries and arterioles due to deposition of fats on their lining.
85. Lymphatic vessels unite to form two main vessels called thoracic duct and right lymphatic duct.
87. Since the flow of lymph is unidirectional but all other options have this statement, therefore (B) is the correct one.
91. Emphysema is a respiratory disease.
92. Frog has myogenic heart which is auto excitable due to the presence of self contractile system. This feature will keep the heart working outside the body for sometime.



Stroke volume is the amount of blood pumped out by the left ventricle at its each contraction.

The heart (left ventricle) contracts 75 times/minute.

$$\therefore \text{The stroke volume} = \frac{\text{Cardiac output/minute}}{\text{ventricular contraction/minute}} = \frac{5250\text{ml}}{75} = 70 \text{ ml}$$

5. P-wave indicates impulse of contraction generated by SA node which causes atria depolarization.
8. Thrombocytes are blood platelets that play an important role in blood clotting.
9. Bundle of HIS is present within the basal part of interatrial septum.
10. The inferior vena cava, radial vein and pulmonary artery carry deoxygenated blood, while the radial artery carries oxygenated blood.
12. The pH of blood varies between 7.36 and 7.45, the average is about 7.4
17. ECG (Electrocardiogram) = Apparatus which record waves of auricular and ventricular activities and cardiac cycle.
18. The two pairs of pulmonary veins bring oxygenated blood from lungs to left atrium.
19. Right auricle receives deoxygenated blood from three veins:
 - i. Superior vena cava (pre-caval)
 - ii Inferior vena cava (post-caval)
 - iii. Coronary sinusThe right ventricle receives deoxygenated blood from right atrium.



Hints



Classical Thinking

25. Excess of uric acid gets deposited in the joints which causes painful arthritis called gout.
41. The striations of the medulla converge and form 6 to 20 conical structures called as renal pyramids.
48. Urinary bladder has thick, muscular, distensible wall lined by transitional epithelium.
51. The sphincter muscles are present at the base of the urethra to keep urination under voluntary control.
60. The outer wall of the Bowman's capsule, called the parietal layer, is made up of a single layer of simple squamous epithelial cells.
88. Active reabsorption occurs against concentration gradient with the help of ATP. Diffusion is the phenomena referred to movement of molecules from high conc. to low conc. along the concentration gradient.
89. Active transport is the movement of ions across the cell membrane against the gradient with the use of ATP.
93. Water is reabsorbed by osmosis in PCT, DCT and descending limb of loop of Henle, except in the ascending limb loop of Henle. It is called obligatory absorption of water
99. Potassium ions are secreted by tubular secretion whereas amino acids, sodium ions and chloride ions are reabsorbed by ultrafiltration.
124. Renin changes plasma protein, called angiotensinogen to a peptide called angiotensin.
126. Angiotensin – II is a vasoconstrictor, i.e. brings about constriction of blood vessels and raises the blood pressure.
135. Urethra is a duct that extends from urinary bladder and discharges urine outside in mammals.
139. The Malpighian corpuscle is attached to renal tubule by the neck. The Renal tubule consists of PCT, Henle's loop which constitutes descending limb and then, ascending limb connected to DCT, which is further connected to Collecting duct.

142. Absence of ADH reduces the reabsorption of water in DCT causing dilute and increased urine, a pathological condition called diabetes insipidus.



Critical Thinking

2. The elements carbon, hydrogen, oxygen and nitrogen are present in waste products CO₂, H₂O and urea.
6. NH₃ is promptly released into the surrounding water by diffusion, whereby it is much diluted and carried away.
7. Ammonia is highly soluble in water and it is also very toxic. Therefore, its elimination requires lot of water, but very less energy is consumed in the formation of NH₃ compared to urea, uric acid and guanine.
8. In ureotelic animals, ammonia combines with CO₂ to form urea.
9. In uricotelic animals, uric acid is eliminated in the form of solid pellets or thick paste.
10. Uricotelic animals are mostly desert and terrestrial animals which cannot afford to lose water.
12. Birds are uricotelic because they live in air and dry habitats, so they have to conserve water for their survival.
14. Kidneys are the excretory organs, which carry out the filtration of blood along with the elimination of nitrogenous wastes. It also maintains osmotic balance of salts and water.
15. The pelvis is the upper expanded funnel shaped portion of the ureter. It lies partly in the renal sinus and partly along the median border of the kidney.
17. Columns of Bertini are the extensions of cortex into the medullary zone, separating the calyces. Ducts of Bellini are the ducts formed by the fusion of a number of straight collecting tubules.



18. The large funnel shaped space of the calyx is continued into pelvis situated near the hilus.
21. The pyramidal region present in kidney is called renal medulla. The limbs of Henle's and loop are present in medulla region and the collecting tubule opens at the apex of the medullary pyramid.
22. In each kidney, 1.2 million nephrons $\approx 10^6$ nephrons are present. Hence, the number of glomeruli is equal to number of nephrons.
25. Henle's loop is largely responsible for concentration of the urine. It is found that for greater ability of an animal to excrete hypertonic urine, longer are the Henle's loops in its kidneys.
26. The efferent arteriole which carries blood away from kidney breaks up into capillaries forming peritubular capillaries which further join to form venules and venules join to form a renal vein.
27. A kidney receives the blood by a renal artery that arises from the dorsal aorta. In the kidney, the renal artery divides and subdivides to send an afferent arteriole into each Bowman's capsule. Blood from glomerulus is drained by the efferent arteriole. Blood leaves the kidney by the renal vein.
29. Proximal convoluted tubule shows the cells with brush border formed of microvilli.
30. The functional units of kidney (nephron) perform the function of ultrafiltration, selective reabsorption and tubular secretion which is under the voluntary control of urinary bladder.
33. Inner wall of Bowman's capsule is lined by squamous epithelium with specialized cells called podocytes.
34. The inner wall of the Bowman's capsule is formed of specialised cells, the podocytes. A podocyte meets the basement membrane by several foot-like processes. The gaps between these processes are filtration slits.
36. High pressure of blood in the glomerular capillaries filters $1/5^{\text{th}}$ of the volume of blood. Thus, a severe fall in blood pressure reduces glomerular filtration.
39. Filtrate does not contain plasma proteins.
40. Reabsorption is a combined effect of diffusion, osmosis and active transport. Thus, useful substances are lost from the plasma through Bowman's capsule by ultrafiltration and regained by blood through the cells of tubules during reabsorption.
41. Glucose is reabsorbed by active transport against concentration gradient using ATP.
43. Glucose, even in normal body, is usually not expected in the urine. It is absorbed and sent back to the body, being a vital substance. However, if it rises in the blood beyond the threshold level, it is thrown out through the urine, whatever is in excess. This leads to diabetes mellitus.
45. Ultrafiltrate after undergoing chemical changes, turns into a concentrated watery solution of only nitrogenous excretory products in the collecting tubule. Further, from the collecting tubule it passes to the renal pelvis and then carried down by the ureters by peristaltic waves into the urinary bladder.
46. Absorption of water, sugar, amino acids, nutrients occurs mainly in PCT.
47. PCT is primarily concerned with reabsorption. Henle's loop carries out osmoregulation through counter current mechanism. DCT, particularly distal part of DCT is surrounded by peritubular blood vessels, which is required in tubular secretion.
50. From the network of blood capillaries, the cells of tubules by active absorption absorb the substances like ammonia, urea, potassium, hydrogen ions and creatinine and discharge or secrete them into the filtrate of the tubule.
51. The glomerular filtrate contains a large amount of water and other dissolved substances such as urea, uric acid, amino acid, glucose, sodium, potassium, vitamins, etc.
54. ADH (anti diuretic hormone) acts on DCT and collecting ducts of nephrons and increases their permeability for water.
56. ADH or vasopressin released by the neurohypophysis regulates the amount of water excreted in urine. It increases the reabsorption of water in the distal convoluted tubule and the collecting duct. Thus, urine becomes concentrated.



61. Dialysis is considered as imperfect treatment because it does not correct the endocrine system.
64. High concentration of body fluid activates osmoreceptors to release ADH which increases the permeability of renal tubules for absorption of water.
65. ADH (Antidiuretic hormone) released from neurohypophysis prevents excess loss of water from the body by increasing permeability of renal tubules for absorption of water.
72. Sebaceous glands are linked with the hair follicles and not the sweat glands.
74. Kangaroo is a mammal. It is ureotelic.
75. Snake is a reptile.
76. Bowman's capsule, proximal and distal convoluted tubule is present in the cortex region of the kidney.
77. The Henle's loop plays a major role in the reabsorption of 20% of the glomerular filtrate. Its function is critical to maintain hypertonicity in the renal medulla, which allows the concentration of urine.
78. Renal artery is the blood vessel bringing blood to kidney. This blood contains many toxic substances including urea. Renal vein drains purified blood from the kidney and hence the amount of urea is less. The blood returning in renal vein is already filtered by kidney.
82. Lacteals are associated with the lymphatic system, while the others are associated with the kidneys.
83. ECG is used to detect abnormalities of the heart.
10. The animals which excrete mainly uric acid are uricotelic. Terrestrial reptiles (lizards and snakes), birds, most insects are uricotelic animals.
13. Whale is ureotelic. It is a mammal.
15. Frog is ureotelic whereas larval form of frog i.e. tadpole is ammonotelic.
16. *Labeo* is ammonotelic. Turtle, camel are ureotelic and lizard, snakes are uricotelic.
17. Snake is uricotelic.
23. The renal Columns of Bertini is the part of cortex continued inside medulla between pyramids.
24. Nephron is the structural and functional units of kidney, which extract wastes from the blood. It is also called renal tubules or tubule. Each nephron is about 6 cm long and is formed of two parts, i.e. Bowman's capsule and body of renal tubule.
25. The wall of urinary bladder shows thick layer of smooth muscle called Detrusor. Dartos is present in scrotal wall. Deltoid is present in arm.
29. Duct of Bellini opens at the apex of renal pyramid (renal papillae).
34. PCT (Proximal Convoluted Tubule) of the nephron is the main site for reabsorption of Na^+ , K^+ , glucose and amino acids through active transport. Here, 70-80% of electrolytes and water are reabsorbed.
35. L – Afferent arteriole
M – Efferent arteriole
N – Glomerulus
O – Proximal convoluted tubule
Blood filtration occurs in glomerulus. Afferent arteriole is the blood vessel leading to glomerulus. Efferent arteriole carries blood away from the glomerulus. Proximal convoluted tubule is involved in reabsorption of useful substances from the filtrate.
36. Urea is formed in the liver by utilizing ammonia and CO_2 . The hepatic vein drains blood from liver into the inferior vena cava.
Hepatic vein – Maximum urea.
Renal vein – Minimum urea.
39. Ultrafiltration takes place through semipermeable walls of glomerulus and Bowman's capsule.



Competitive Thinking

1. Excretion involves the processes in which substances of no further use or those present in excess quantities are thrown out of the body.
2. *Hydra* is an aquatic invertebrate. *Hydra* has no organ of excretion, therefore, excretion of waste nitrogenous matter occurs directly by diffusion.
4. Ornithine cycle is a cyclic process of urea formation which operates in the mitochondria of liver cells and has been studied by Krebs and Henseleit.



40. During selective reabsorption, high threshold substances e.g. glucose, amino acids, potassium and calcium ions, etc. are completely reabsorbed from PCT. Urea and uric acid are low threshold substances. They are reabsorbed negligibly.
44. The glomerular hydrostatic pressure is the blood pressure in the glomerular capillaries. It is the chief determinant of effective filtration pressure, i.e. the main driving force to cause filtration.
45. Proteins are not filtered through glomerulus and glucose is totally reabsorbed in renal tubule.
46. PCT of nephron is the main site for selective reabsorption of glucose, amino acids, water and different ions.
48. The part labelled as 'W' is Malpighian body which does not absorb water but carries out ultrafiltration. Water reabsorption is done by PCT, DCT, collecting tubule and descending limb of loop of Henle.
49. Complete reabsorption of glucose by active transport takes place in the PCT.
51. The descending limb of Henle's loop is permeable to water, but nearly impermeable to salts where the filtrate becomes hypertonic.
52. Descending limb of loop of Henle is permeable to water but impermeable to electrolytes. While ascending limb of loop of Henle is impermeable to water and permeable to electrolytes.
56. Aldosterone causes increase in Na^+ reabsorption from DCT by active process.
58. Water is reabsorbed in distal convoluted tubules under the influence of antidiuretic hormone (ADH) secreted by posterior lobe of pituitary gland.
59. ADH or vasopressin is effective in reabsorption of water by changing permeability of terminal part of DCT (distal convoluted tubules) and collecting ducts.
60. ADH constricts the blood vessels and increases blood pressure. Due to this, glomerular filtration rate increases. ADH controls the permeability of DCT and collecting duct to water.
61. Decrease in blood pressure or volume stimulates the release of renin, aldosterone and ADH. ANF is released when blood pressure increases or blood volume increases. Release of ANF causes vasodilation and also inhibits renin-angiotensin mechanism that decreases blood pressure and blood volume.
70. Renin is an enzyme released by the juxtaglomerular cells into plasma, where it converts angiotensinogen into angiotensin I.
72. If liver is removed, ammonia will not get converted to urea and hence the level of ammonia will increase in blood.
73. A nephron is made of two parts: malpighian corpuscle and tubule. Tubule consists of proximal convoluted tubule (PCT), loop of Henle and distal convoluted tubule.
75. Due to large size, proteins can't be filtered through the filtration slits. So, they are absent in glomerular filtrate.
77. Henle's loop – Does not reabsorb glucose.
Podocytes – lines the visceral layer of Bowman's capsule.
JGA – Release renin due to low glomerular blood pressure.
78. Renin released by JG apparatus in response to control increased GFR, while alcohol, caffeine and ANF are directly or indirectly diuretics.
81. ADH is secreted under water stressed condition. It helps in reabsorption of more water in kidney and maintains body fluid volume.
82. Urea is less toxic and can be eliminated with lesser amount of water. Ammonia is highly toxic and requires lots of water in order to be eliminated from the body.

**Evaluation Test**

1. Whale is a mammal, hence it is ureotelic. Other aquatic fishes and animals show ammonotelic excretion.
2. The filtrate is isotonic to blood plasma (in proximal convoluted tubule) and the filtrate becomes hypertonic to blood plasma (in descending limb of loop of Henle). The filtrate is hypotonic to blood plasma (in ascending limb at loop of Henle) in distal convoluted tubule. ADH makes the filtrate isotonic to blood plasma.



3. Distal convoluted tubule is another segment of selective secretion and reabsorption. It helps in regulation of blood pH by the reabsorption of HCO_3^- an important buffer. The distal tubule also functions in K^+ and Na^+ homeostasis.
4. Urea and Uric acid are the ultimate products of protein catabolism.
5. Uric acid is insoluble in water and can be stored for a very long time and excreted in a crystalline form and hence it requires minimum amount of water for its dispersal and also requires less energy for elimination.
8. Presence of blood or blood cells in urine is called hematuria.
9. The 'Juxtaglomerular apparatus' is responsible for production and release of Renin.
12. Kidneys are retroperitoneal (retro-behind) in position, i.e. present behind the peritoneum.
13. The yellow colour of urine is due to the presence of pigment Urochrome, which is a breakdown product of haemoglobin from worn out red blood corpuscles.
14. Bright's disease (Nephritis) is inflammation of kidney that involves glomeruli and caused by infection of streptococci bacteria. In this case, blood cells and proteins are also filtered. Such a stage is called haematuria. Glomerular filtration rate is also reduced.



Hints



Classical Thinking

5. The brain is ectodermal in origin. It consists of both grey mater and white mater and is covered by three meninges – Pia mater, Arachnoid mater and Dura mater.
7. Arachnoid is a middle connective tissue surrounding the brain and has a web-like appearance.
18. CSF also helps in exchange of nutrients and wastes between blood and brain tissues. It protects the brain from dessication.
24. Human brain is divided into three parts: forebrain, midbrain, hindbrain
35. More than half part of the brain in any animal is occupied by large cerebral hemispheres, i.e. cerebrum. Diencephalon, cerebellum and medulla oblongata are very small portions of the brain.
38. Corpus callosum is a thick band of transverse nerve fibre which joins the two cerebral hemispheres. It is the largest commissure in human brain.
51. Broca's area is the motor speech area and translates thoughts into speech and controls the movement of tongue, lips and vocal cord.
60. Pineal body and epithalamus function as an endocrine gland which secretes two hormones called serotonin and melatonin.
66. Corpus striatum is the ventrolateral wall of cerebrum.
70. Optic chiasma is the part of hypothalamus which is formed by the crossing over of two optic nerves.
76. Crura cerebri are longitudinal tracts of fibres that connect cerebellum with cerebrum and transmit more impulses to limb muscles (longitudinal band) from cerebrum. It contains reflex centres.
78. Cerebellum is the centre for equilibrium and speaking. Hence, its injury would result into unbalanced movement and defective speech.
82. Medulla oblongata contains important centres like cardiac, peristalsis, respiration, etc. Hence, damage to medulla oblongata results in death.
83. Medulla is a part of cerebellum which controls the non-vital activities like sneezing, coughing, swallowing, salivation and vomiting.
90. Central canal is a narrow canal which passes through the spinal cord.
93. Two dorsolateral horns and two ventrolateral horns give H-shaped appearance.
94. The three funiculi are dorsal funiculi, lateral funiculi and ventral funiculi.
99. Peripheral nervous system includes nerves originated from brain, i.e. cranial nerves and from spinal cord, i.e. spinal nerves.
104. Olfactory nerves originate from olfactory lobe and innervate the nose and control sense of smell.
107. Oculomotor is the III nerve which originates from cerebrum; innervates eye muscles and are responsible for movement of eyeball.
108. Pathetic cranial nerve is a IV cranial nerve which innervates the eye muscles and are responsible for rotation of the eye ball.
110. Mixed nerves include both sensory and motor nerves. V (Trigeminal) nerve is the first mixed nerve encountered, which innervates to face and teeth and are responsible for movement of jaw and tooth.
111. Abducens is the VI cranial nerve which originates from ventral surface of medulla oblongata and innervates the lateral rectus muscles of eye ball. They are responsible for movement of eye.
113. Facial nerve (VII) innervates muscle of face, neck, taste buds or salivary glands and are responsible for facial expressions, movement of neck and saliva secretions.



116. Glossopharyngeal nerve is the IX cranial nerve which innervates muscles of mucosa of pharynx, tongue and parotid salivary gland. They are responsible for the taste, pharyngeal contraction and saliva secretion.
123. 1st = Olfactory nerve
2st = Optic nerve
8st = Auditory nerve
124. 11th and 12th cranial nerves are also purely motor nerves.
147. Na and K ions play an important role in the transmission of nerve impulses.
152. The nerve cell which contributes to the generator region is called post-synaptic neuron.
162. Glands and smooth muscles generate visceral reflexes.
163. When one sensory and one motor neuron are involved, the reflex is termed as monosynaptic.
164. Skin, eye, ear, tongue are receptor organs.
169. Spinal reflex contains 5 components/elements:
Receptor organ (Sense organ) → Afferent (sensory) neuron → Adjustor / connector / Association Neuron → Motor / efferent neuron → Effector organ.
Effector organ is skeletal muscle fibre or gland cells.
173. Pavlov demonstrated conditioned reflex for the first time by performing an experiment with a dog, where he offered food to a dog and observed its reaction.
178. Chemoreceptors are exteroceptors, whereas proprioceptors, enteroceptors and baroreceptors are interoceptors.
180. Mechanoreceptors are located in the corpuscles of skin and free nerve endings.
188. Statoacoustic receptors are responsible for hearing, balance and equilibrium.
198. Choroid is bluish in colour and contains many blood vessels.
201. Retina consists of three sub-layers – ganglion cells, bipolar cells and photoreceptor cells.
202. The two types of photoreceptor cells are rods and cones.
203. There are three types of cones containing three different visual pigments. The visual pigment for colour vision are; erythropsin (sensitive to red), chloropsin (sensitive to green) and cynopsin (sensitive to blue).
211. Anatomically, the ear is composed of three divisions – external ear, middle ear and internal ear.
212. Auditory canal contains few hairs and specialized sebaceous gland called ceruminous gland. Ceruminous glands secrete cerumen.
219. Organ of Corti lies on basilar membrane, which contains auditory receptors.
230. The pituitary gland is situated at the geometrical centre of the skull. It is attached by a short stalk, called the infundibulum, to the base of the brain behind the optic chiasma.
231. The pituitary gland lies in the sella turcica, which is a depression in the sphenoid bone on the floor of the cranial cavity (diencephalon).
234. Pituitary gland is divided into two lobes – adenohypophysis and neurohypophysis.
237. The anterior lobe and intermediate lobe arise from a diverticulum of the roof of embryonic buccal cavity known as Rathke's pouch.
241. Pars distalis is the largest anterior region of pituitary gland made up of loose cords of epitheloid secretory cells.
246. Infundibulum is a hypophyseal stalk which helps in attachment of pituitary gland.
247. Pars nervosa is the lower most, larger region of neurohypophysis and contains axons in between pituicytes.
248. Herring bodies are densely staining pools of stored neurosecretory substance present in the local regions along axons terminating in the posterior lobe of the pituitary gland.
254. Frohlic dwarfs are mentally abnormal.
261. ACTH stimulates the adrenal cortex to produce glucocorticoids and mineralocorticoids.
262. ACTH is regulated under the control of hypothalamic corticotropin releasing factor, i.e. hypothalamic CRF.
263. Addison's disease (adrenal failure) affects carbohydrate metabolism leading to weakness and failure.
267. The other names of prolactin as per their functions are development of mammary glands (mamotropin), milk secretion by mammary glands (lactogenic hormone), maintenance of corpus luteum (leuteotropin).
273. FSH stimulates follicular cells for secretion of oestrogen.



277. The anterior pituitary gland secretes LH. It is responsible for release of ovum from ovary, i.e. LH is involved in the process of ovulation.
278. LH = luteinizing hormone stimulates interstitial cells of the testes to produce the male hormone testosterone. For this reason, LH sometimes is called interstitial cell stimulating hormone (ICSH) in males.
288. Oxytocin causes contraction of uterine myometrium at the end of gestation to initiate labour pains for normal delivery.
289. Oxytocin stimulates myoepithelial cells of mammary glands for milk ejection during breast feeding.
296. Position of the thyroid gland is ventrolateral to trachea, just below the larynx.
298. Two lateral lobes of thyroid gland are connected by isthmus which is at 2nd to 4th tracheal cartilage
308. Thyroxine secreted by thyroid gland regulates various metabolic activities such as physical growth, development of gonads, respiration rate and heart rate.
310. A person suffering from myxoedema shows thickening and puffiness of skin and low BMR.
313. Deficiency of iodine in the diet or drinking water causes goitre.
316. Cretinism is caused by extreme hypothyroidism during foetal life, infancy or childhood. This condition is characterized especially by failure of body growth and by mental retardation.
318. Thyrocalcitonin stimulates bones to take up Ca from the blood, thereby decreasing calcium blood level. Thus, increased Ca level stimulate the secretion of thyrocalcitonin
320. PTH is a parathyroid hormone.
328. Glucocorticoid, mineralocorticoid and androgenic steroids are hormones of adrenal cortex collectively called corticoids.
337. Adrenaline is secreted by adrenal medulla during stress condition. It is a hormone of fight or flight.
338. Adrenaline and noradrenaline also stimulates the breakdown of glycogen, lipids and proteins, thereby increasing blood glucose level.
341. Glucagon is a hyperglycemic hormone which acts on liver cells where it stimulates hepatocytes for glycogenolysis and also stimulates gluconeogenesis.
344. Prolonged hyperglycemia leads to diabetes mellitus due to insufficient insulin level. In this condition, blood is unable to utilize glucose and high level of glucose is excreted in urine.
348. Androgens are basically secreted by male gonads, i.e. testes.
354. Gastrin stimulates gastric glands for the secretion of HCl and pepsinogen.
359. The juxta glomerular cells of the kidney produce a peptide hormone known as erythropoietin which stimulates bone marrow for production of RBCs.
363. Cerebellum or metencephalon is a well-developed part, present below the occipital lobe of cerebral hemisphere. It coordinates the voluntary movements and also controls equilibrium and posture of the body.
368. Pars nervosa is found in posterior lobe of pituitary gland.
369. TCT is a hormone of thyroid gland, whereas all others are hormones of pituitary gland.
370. Deficiency of thyroxine in adults causes myxoedema. Excessive secretion of thyroxine cause Graves disease. Deficiency of thyroxine in children causes cretinism. Hyposecretion of corticosteroids causes Addisons disease.
375. Cricoid is a single signet ring-like cartilage of larynx.
376. Intermediate neuron receives sensory impulse, interprets it and generates motor impulse.

**Critical Thinking**

1. Right and left hemisphere are coordinated by a band of transverse modulated nerve fibres called corpus callosum.
6. Central sulcus is present between the frontal and parietal lobes of the cerebral hemispheres. Motor area is in front of frontal lobe and sensory area behind parietal lobe.
7. Area of parietal lobe controls general sensations like pain, touch and temperature.
8. General sensory area concerned with sensation of touch is located in parietal lobe.
9. Olfactory area lies in the cerebral cortex of the temporal lobe and controls the smell.



10. The cerebrum is the seat of intelligence because it is the centre for intelligence, memory, judgement and problem solving ability.
11. Cerebrum is the centre for memory, hence cerebrum would be affected if a person loses his memory in an accident.
12. A vascular region of anterior choroid plexus is located near the roof of third ventricle in diencephalon.
13. Hypothalamus is the co-ordinator between nervous system and endocrine system. It secretes neurohormones (stimulating and inhibiting factors) which influence the pituitary gland.
15. All sensory impulses except olfactory impulses pass through thalamus which is located in diencephalon.
17. It is the hypothalamus, which is the seat and the source for the regulation of body temperature and water balance, i.e. homeostasis
18. Itter runs through midbrain and connects the III ventricle to IV ventricle.
19. Superior colliculi control and co-ordinates movement of head in response to visual stimulus. Inferior colliculi controls and co-ordinates head movement in response to auditory stimulus.
20. Cerebrum and cerebellum both contain the outer layer of grey matter and the inner layer filled of white matter. Grey matter in the cerebrum is called cerebral cortex, which is the highest centre for many sensations and activities and has a number of sensory areas. The upper surface of the cerebellum is formed of grey matter and forms cerebellar cortex, while its deeper central part, the medulla, is formed of white matter called arbor vitae.
21. Activities like walking, running, working and speaking involves hand-eye co-ordination. All these activities are controlled by cerebellum.
24. Pons varolii and medulla oblongata has outer white mater and inner grey mater, whereas cerebrum and cerebellum have outer grey mater and inner white mater.
25. Corpus callosum interconnects the two cerebral hemispheres, while pons varolii connects and co-ordinate the activities of cerebellar hemisphere.
29. About 8 pairs of cranial nerves arise from medulla.
30. Cerebrum has grey matter on the outside and white matter inside, while spinal cord has grey matter on the inside and white matter on the outside.
32. Olfactory and optic nerves are exclusively sensory in function. Olfactory nerves function for sense of smell, whereas optic nerves function for sense of light and vision.
33. Trigeminal cranial nerves are distributed in lips which are involved in whistling.
34. The V cranial (Dentist nerve) is distributed in lower jaw which is responsible for mastication.
35. Facial nerves are distributed in taste buds.
36. Auditory nerves arise from lateral side of medulla oblongata.
37. The ninth cranial nerve, i.e. Glossopharyngeal is located in mucosa of pharynx which helps in swallowing of food through pharyngeal contraction.
38. Vagus nerve is responsible for movement of visceral organs such as heart, stomach, lungs and intestine.
40. Sympathetic nervous system works during stress, pain, anger and fear which causes secretion of sweat, tears and saliva.
41. Heart beat accelerates during fear, anger or stress. All these emotions are controlled under sympathetic nervous system. It also secretes adrenaline hormone during these situations as an emergency hormone.
42. Parasympathetic system consist of nerve fibres which run along cranial nerves and sacral nerves.
43. Sympathetic nervous system works during stress, pain, anger, fear or emergency. Parasympathetic nervous system works during rest and brings about relaxation, comfort and pleasure. Thus, sympathetic and parasympathetic nervous system are antagonistic.
49. The dorsal root of the spinal cord contains fibres which brings sensation from somatic area.
50. The conditional reflexes are acquired throughout the life by learning or experience. These are of temporary nature and may disappear and reappear again.
52. Receptors are the different types of doors and windows of the body receiving various stimuli and keep the body updated with the environment.



53. Gustatory nerves relay the impulse of chemical stimulus produced by the taste organs to the brain, while changes of light intensity is related with thermoreceptors, touch and pressure with mechanoreceptors and sound waves related with sound receptors.
57. Cones are one of the two photo-receptor cells present in retina.
58. The purple red protein called rhodopsin is present in the rods which is a vitamin A derivative.
59. The three types of cones contain their own characteristic photo-pigments which respond to red, green and blue lights. Various combinations of these cones and their photo-pigments produce sensation of different colours.
61. A yellowish pigmented spot called macula lutea is present lateral to the blind spot with a central pit termed as fovea which is a thinned out portion of the retina.
62. The tectorial membrane overhangs the sensory hair in the scala media. Its properties are to determine the patterns of vibration of sound waves.
63. The change in the permeability of retinol is responsible for the formation of image. The change in permeability generates action potential which is carried, via. bipolar neurons and ganglion cells and further conducted by the optic nerves to the visual cortex of the brain. The neural impulses are analyzed and the image formed on the retina is recognized.
65. Growth hormone releasing factor (GHRF) stimulates the secretion of STH or GH.
66. Growth hormone inhibiting factor (GHIF) inhibits the secretion of STH or GH.
68. The hormone responsible for growth is GH (Growth hormone) which is secreted by anterior pituitary.
69. Leuteotropic hormone (LTH) is responsible for development of mammary glands.
70. ADH is apparently stored and released by the posterior lobe of the pituitary gland. It is a peptide hormone, synthesized in the hypothalamus.
71. Diabetes insipidus is caused due to deficiency of ADH which is a hormone of pituitary gland.
72. Deficiency of ADH causes loss of large quantity of water through urine.
74. Vassopressin facilitates ultrafiltration which helps in concentration of urine.
76. Oxytocin (birth hormone) is responsible for contraction of uterus which is secreted by posterior lobe of pituitary.
77. Oxytocin (Pitocin) brings about the contraction of the uterine muscle during parturition. At the time of parturition, large amount of oxytocin is secreted by the neurohypophysis. The release of this hormone from the neurohypophysis induces labour pain during child birth.
78. Prolactin stimulates milk secretion from mammary glands after child birth. Oxytocin stimulates release of milk from mammary glands.
79. Thyroid is located in the anterior region of the neck just below the larynx which is a voice box.
81. Thyroid gland secretes thyroxine which maintains basal metabolic rate (BMR) by increasing glucose oxidation and energy production known as calorigenic effect.
82. In cretinism, child is mentally abnormal. In pituitary dwarfism, child is mentally fit.
83. Synergistic means supplementary with each other. Somatotrophic hormone and thyroxine both are responsible for general growth of body, hence they are synergistic.
84. Myxoedema (or Gull's disease) strikes adults when there is deficiency of thyroxine. The affected person is fatty and lethargic with bradycardia and lower BMR.
85. Hypersecretion of thyroxine results in exophthalmic goitre. Acromegaly is caused due to hypersecretion of GH in adults.
86. Thyroid hormone (thyroxine) is required for the tissue differentiation and metamorphosis in amphibians. In absence of thyroxine or in presence of an anti-thyroid substance (e.g. thiourea), the tadpole remains in the larval stage indefinitely.
87. Gigantism is caused due to hypersecretion of GH. Simple goitre, cretinism and myxoedema is caused due to hyposecretion of thyroxine.



88. Parathormone is a hypercalcemic hormone which increases the level of Ca^{++} in blood, thus developing the bones.
89. PTH is the peptide hormone of parathyroid glands which helps in controlling the calcium balance of the blood. Its release is triggered by the falling blood calcium levels. Thyrocalcitonin decreases the blood calcium level. Increased calcium level in blood stimulates 'C'-cells to secrete thyrocalcitonin.
90. Thymus is the organ from where T-lymphocytes originate. Hence, it is involved in immunological reactions.
91. The thymus gland is the primary centre for formation of T – lymphocytes and antibodies. This gland is prominent at the time of birth, but gradually degenerates in adults.
93. Aldosterone is the mineralocorticoid secreted by adrenal gland which maintains blood pressure.
94. Aldosterone is a potent mineralocorticoid hormone secreted by the adrenal glands of mammals from the cells of the outer cortex (glomerulosa zone). The primary action of aldosterone is to promote the uptake of sodium from the filtrate in the distal renal tubule back into the blood and excretion of potassium.
95. Insulin is responsible for decreasing the blood glucose level. Hence, it is involved in glycogenesis, i.e. conversion of glucose to glycogen. Glycogenolysis is the hydrolysis of glycogen to glucose. Glyconeogenesis is the conversion of amino acids, fatty acid or any other nutrient to glucose, while glycolysis occurs in cytoplasm to generate energy from glucose and has no association with insulin.
97. Pancreas is a dual gland – exocrine as well as endocrine. It shows both hyperglycemia (increased level of blood glucose) and hypoglycemia (decreased level of blood glucose).
98. Insulin reduces the blood glucose level, while glucagons increase the blood glucose level. Hence, their action is antagonistic.
99. Thyroxine maintains basal metabolic rate (BMR) by increasing glucose oxidation. Adrenal cortex secretes glucocorticoids which are involved in carbohydrate metabolism.
100. Adrenal medulla and pancreas secrete their hormones independently since there are no trophic hormones of the pituitary to regulate or control them.
103. When hormone binds to receptor, a hormone-receptor complex is formed. This complex leads to biochemical changes in the target tissue. Thus, the hormones act as chemical messengers which bring change in the target tissue.
104. Otoconia helps in balancing the body during the change of posture when the body is imbalanced and tilted onto one side.
105. The degeneration of thymus gland occurs in old individuals leading to decreased production of thymosins, thereby weakening the immune response.
106. In general, adrenaline of adrenal gland prepares the body to face emergency conditions of physical and emotional stress like fall in blood pressure, fear, etc. So, adrenaline is also called emergency hormone and adrenal glands are called “Glands of Emergency”.
107. The 7th cranial nerve is responsible for the functioning of tongue and secretions of salivary gland. The 9th cranial nerve is responsible for taste.
108. 8th (Auditory) is sensory, while 7th, 9th, 10th are mixed.
109. Salivation is a unconditioned reflex as it is seen in a small baby. It is conditioned also, as proved by Pavlov's dog experiment.
111. Pars intermedia is the part of adenohipophysis which is reduced, less developed and non-functional in human being.
112. Testosterone is a male reproductive hormone, while others are female reproductive hormones.
113. Acetylcholine is neutralized by acetylcholine esterase when impulse reaches the dendrites of association neuron.
114. Erythropoietin is released by kidneys.



Competitive Thinking

1. Nervous system and endocrine system communicate with each other to achieve co-ordination and integration.
2. Brain and spinal cord are surrounded by three meninges – dura mater, pia mater, arachnoid in mammals.
4. Arachnoid mater lies between the duramater and piamater.



5. Thermoregulation centre of body is present in hypothalamus of brain.
7. The cerebrum is the largest and most complex of all the parts of the human brain.
9. The area concerned with sense of hearing is located in temporal lobe of fore brain.
12. Interpretation of speech (understanding speech) takes place in Wernicke's area of temporal lobe.
17. The primary function of cerebellum is to maintain posture, orientation and equilibrium of body by co-ordinating and regulating tone and contraction of voluntary muscles.
19. Cerebellum in hind brain is primarily responsible for maintaining body posture and equilibrium (not for language comprehension).
20. The limbic system along with hypothalamus is involved in regulation of sexual behaviour, expression of emotional reactions (e.g. excitement, pleasure, rage and fear) and motivation.
22. Medulla oblongata of hind brain contains centres that regulate heart beat, blood pressure, breathing, swallowing, salivation, sneezing, vomiting and coughing and other involuntary movements.
27. In human beings, 12 pairs of cranial nerves, 31 pairs of spinal nerves and 12 pairs of ribs are present.
39. Oligodendrocytes (neuroglial cells) form myelin sheath around the axon in CNS, while the Schwann cells form myelin sheath around the axon of PNS.
41. The depolarisation of nerve membrane takes place through influx of Sodium ions, whereas repolarisation takes place due to efflux of Potassium ions.
42. Nerve impulse is a self propagating wave of depolarization and repolarisation.
43. Axons are modified for the conduction of impulses away from CNS.
44. Transmission of nerve impulse, across a synapse is accomplished by neurotransmitters.
45. Acetylcholine is the neurotransmitter that helps in neuromuscular transmission.
47. At the chemical synapse, pre-synaptic membrane is involved in the release of neurotransmitters. The receptor sites for neurotransmitters are present on the post-synaptic membrane.
48. Reflex arc is the basic functional unit of nervous system.
50. Unconditioned reflexes are inborn, inherited, species specific, stable and controlled by spinal cord. Conditioned reflexes are acquired by learning and experiences and controlled by cerebral cortex of brain.
51. Chemoreceptors respond to chemicals. They are of two types – olfactory (respond to smell) and gustatory (respond to taste).
54. Tactile, Frigido and Tango receptors are sensitive to touch, cold and pressure respectively.
59. The pigmented part of ciliary body is called iris and it is the visible coloured portion of the eye.
64. Photosensitive pigment rhodopsin in human eye is made up of opsin protein and retinal [aldehyde form of vitamin A (Retinol)].
65. Carotene is the source of retinal (aldehyde of vit A). Retinal, is the light-absorbing part of all visual photopigments. Retinal is involved in the formation of rhodopsin of rod cells.
67. Pupil is an aperture through which light enters the eyes. Other parts are refractive media.
69. Ear drum is also known as tympanic membrane which separates middle ear from external ear.
72. An Eustachian tube is present in the middle ear which connects the middle ear cavity with the pharynx.
73. Membranous labyrinth of ear acts as statoacoustic organ and controls hearing and equilibrium or balancing.
75. Organ of Corti is the auditory sensory part in the cochlea.
82. Vestibular apparatus (otolith organs i.e. utricle and sacculus and semicircular canal) help in maintaining body posture, equilibrium and balancing the body. Thus, it will help a gymnast to balance his body upside down even in total darkness.



89. The labelled part 'X' in the given diagram is adrenal medulla. It secretes catecholamines. Calcitonin is secreted by thyroid gland. Adrenal cortex secretes cortisol and mineralo corticoids along with small amounts of androgenic steroids.
96. Melatonin secreted by pineal gland controls diurnal rhythms (Sleep and wake cycle).
99. Growth of bones is due to epiphyseal plate. Epiphyseal plate closes after adolescence. Thereafter, even if growth hormone is secreted in excess, it does not cause further increase in height. Rather excessive secretion of growth hormone in adults lead to Acromegaly.
106. Oxytocin and ADH are synthesized and secreted directly from hypothalamic nuclei without involvement of releasing hormones.
114. Atrial Natriuretic Factor (ANF) is responsible for lowering of blood volume and blood pressure by promoting salt and water excretion in the urine.
116. Activity of pineal is regulated by light. Melatonin regulates diurnal rhythm.
118. Hypothalamus secretes gonadotropin releasing factor (GnRF), which stimulates the anterior lobe of pituitary gland (Adenohypophysis). Adenohypophysis under the influence of GnRF stimulates the secretion gonadotropins (FSH and LH).
119. High level of estrogen and progesterone gives negative feedback to hypothalamus for the release of GnRH.
120. Cyclic AMP act as intracellular mediators and affect the cell metabolism in various ways.
126. Oxytocin helps in contraction of smooth muscles of uterine myometrium.
130. Insulin stimulates glycogenesis and decreases blood glucose levels (Hypoglycemia).



Evaluation Test

3.

Name of nerve	Nature
Vagus	Mixed
Olfactory	Sensory
Trigeminal	Mixed
Abducens	Motor

4. The axon of a nerve fibre is covered with a myelin sheath made up of lipids and proteins and is white in appearance.
7. The hypothalamus located in the diencephalon acts as thermoregulatory centre of the body in warm-blooded animals.
8. Centre for pain and pressure is located in Parietal lobe.
10. ICSH is secreted by the anterior pituitary (adenohypophysis).
15. Hypothalamus – Temperature regulation.
16. Adrenaline is a stress hormone that participates in fight, fright and flight mechanism.
20. Insulin is secreted by the β -cells of Islets of Langerhans in the pancreas. It decreases the blood glucose level.



Hints



Classical Thinking

33. Formation of sperms is called spermatogenesis.
36. Interstitial cells are present between the seminiferous tubules which produce testosterone.
50. Ejaculatory duct carry seminal fluid and spermatozoa to urethra.
53. Membranous urethra is present between the end of prostate gland and root of penis.
55. The urethra has two sphincters—internal sphincter of smooth muscle and external sphincter of striated muscle.
87. Bartholin's gland is homologous to Cowper's gland as both secrete lubricating fluid.
100. There are about 13 menstrual cycles per year, so $32 \times 13 = 416$ eggs.
108. Mesosalpinx is a double fold of peritoneum which supports the oviduct.
125. Mammals other than primates show estrous cycle, while primates only show menstrual cycle.
136. Follicular phase extends from 5th to 13th day of menstrual cycle.
143. Ovulation occurs under the influence of LH from pituitary gland.
144. A rise in LH stimulates ovulation which occurs on 14th day of menstrual cycle.
164. Primordial follicle cells undergo mitotic division to produce diploid spermatogonia.
173. Acrosome secretes hyaluronidase which helps sperm to penetrate into egg during fertilization.
174. Neck of sperm contains two centrioles—proximal centriole and distal centriole.
182. The primary oocyte undergoes Ist meiotic division to form haploid secondary oocyte.
196. Corona radiata is made up of radially elongated follicular cells around the oocyte which are glued together by hyaluronic acid.
209. The surface of the sperm adheres with the oocyte due to fertilizin—anti-fertilizin reaction.
212. The entry of sperm into female gamete, stimulates secondary oocyte and second polar body is released. This ends the process of oogenesis.
213. Polar bodies are smaller cells produced during oogenesis that do not develop into egg cells.
252. Muscles, spinal cord and epidermis of skin develop from ectoderm.
257. The placenta has two parts, the part contributed by the foetus, i.e. chorionic villi is called foetal placenta and the part shared by the mother, i.e. part of uterine wall is termed as maternal placenta.
258. Umbilical cord is a tubular connection covered with a connective tissue sheath through which the foetus with the chorion of placenta.
265. Glucose, antibodies and vitamins move from maternal blood to foetal blood and foetal waste, such as CO₂ and urea from foetal to maternal blood.
279. These structures are referred as “after birth” because they are expelled after infant's birth (during third stage) by series of uterine contractions.
291. IUCD, an intra-uterine device is a loop, spiral or ring of copper or stainless steel inserted into the cavity of the uterus.
306. The children born to affected mothers suffer from eye infection called gonococcal ophthalmia.
314. The success rate of GIFT is about 30 percent.
333. Lens arises from ectoderm layer.



Critical Thinking

1. Asexual reproduction is a method of reproduction which produces genetically identical clones.
5. During seventh month (28th week) of embryonic development, testes descend permanently into respective scrotal sac through inguinal canal.
8. Each seminiferous tubule is lined by a germinal epithelium formed of two types of cells germ or spermatogenic cells and sertoli or nurse cells. Sertoli cells are a few pyramidal shaped cells which provide nutrition to developing sperms.
11. The prostaglandin in the semen stimulates the contraction in female reproductive tract to help the process of fertilization, thus increasing the mobility of sperms.
13. Seminal vesicles contribute about 60% of the total volume of the semen.
14. Fructose is present only in seminal fluid. Its presence in the female genital tract confirms sexual intercourse. Hence, it provides a proof for forensic test in case of rape.
16. The secretion of Cowper's glands lubricates the passage of sperms in urethra and also neutralizes the acidity in urethra due to previous micturition. It makes the medium alkaline to keep the sperms alive. So, its removal may affect sperms.
18. The inner medulla of ovary contains connective tissue called stroma in which Graafian follicles are embedded.
19. The outer cortex of ovary is lined by germinal epithelium which gives rise to Graafian follicle.
21. In cortex, at the beginning, the single layer of follicular cells surrounding each oocyte forms primordial follicle.
22. Under the influence of follicle stimulating hormone and luteinising hormone, primary follicle undergoes meiosis I and meiosis II and develops into Graafian follicle.
29. Glycogen present in vagina is fermented by lactobacilli, thus making the vagina mucous acidic. This acidic medium prevents vagina from fungal infection.
30. The ovary remains attached to the abdominal wall by a ligament called mesovarium. The uterus lies in the fold of peritoneum called mesometrium.
31. Uterus opens into an elastic muscular tube called vagina. Vagina is lined by a stratified squamous epithelium without any glands.
35. Corpus luteum is formed in the luteal or secretory phase which begins immediately after ovulation and lasts for about 14 days, i.e. days 15 – 28 (till the end of menstrual cycle). If fertilization does not occur, corpus luteum degenerates and the unfertilized egg passes through the vagina as menstrual flow.
36. After ovulation, the ruptured follicle develops into yellow body called corpus luteum which secretes progesterone. Corpus luteum is active till the placenta take up the secretion of HCG hormone.
37. During follicular phase, estrogen causes repair of endometrium and increase the thickness. During luteal phase, when pregnancy occurs corpus luteum secretes progesterone which maintains the thickness of endometrium.
38. The corpus luteum is considered as temporary endocrine gland because
 - i. if fertilization occurs, corpus luteum secretes progesterone.
 - ii. if fertilization does not occurs, corpus luteum degenerates to corpus albicans.
40. During differentiation, Sertoli cells provide nourishment to spermatids.
41. Germinal cells (primordial germ cells) which line the seminiferous tubules undergo repeated mitotic division to produce spermatogonium.
44. During spermatogenesis, primary spermatocyte undergoes 1st meiotic division to form secondary spermatocyte which undergoes 2nd meiotic division to form four haploid spermatids. These four haploid spermatid undergo spermiogenesis to form mature male gamete, i.e. sperm
46. The primary spermatocyte undergoes first meiotic division during maturation phase. During this phase, each homologous chromosome pairs and splits longitudinally leading to chiasma formation which results in exchange of genetic material.



47. 50 primary spermatocytes undergo two divisions to produce 200 secondary spermatozoa.
48. 100 secondary spermatocytes undergo meiotic divisions to form 200 spermatozoa.
50. The ovum possesses three coverings—inner plasma membrane, middle glycoprotein zona pellucida and outer cellular corona radiata with radially elongated follicular cells.
51. During maturation phase, second meiotic division gets arrested at metaphase. Thus, releasing the secondary oocyte.
52. Primary oocyte undergoes 1st meiotic division to form secondary oocyte and polar bodies. Secondary oocyte and polar bodies undergo IInd meiotic division to form ovum.
55. Hyaluronidase is a hydrolytic enzyme which helps in penetration of the egg during fertilization.
57. Polar body is a component of female sex gamete, ovum.
59. Fertilizin is a glycoprotein secreted by unfertilized egg called oocyte.
60. The penetration of the sperm through the zona radiata is supported by enzymatic substance called hyaluronidase. (mucopolysaccharide hyaluronic acid)
61. Hyaluronidase enzyme of acrosome hydrolyses the hyaluronic acid of follicular cells. Zona lysine or acrosin digests zona pellucida.
64. After cleavage, there is no time for cells to grow in size and they become progressively small.
65. The zona pellucida which surrounds the morula prevents the implantation of the blastocyst at an abnormal site.
66. Cells covering the free surface of the embryonal knob (embryonic pole and abembryonic pole) become flat and form first endodermal cells.
67. Two ova are fertilized by two different sperms.
69. During third trimester, as the foetus grows, the uterus expands causing the compression and displacement of mother's abdominal organs which leads to the problems.
70. Placenta is the only organ in animals formed of the tissues derived from two different individuals, the foetus and the mother.
72. Oxytocin stimulates the uterine muscles to contract and prostaglandins increase the force of contraction. This provides force to expel the baby from the uterus, causing birth.
73. The hormone relaxin secreted by corpus luteum relaxes the ligament of the pelvic girdle for easy birth of the baby.
74. Combined pills are drugs that prevent the releases of pituitary hormones (FSH and LH) that lead to ovulation. These pills contain synthetic progesterone and estrogen.
78. The prenatal diagnosis of amniotic fluid to determine the genetic disorders is termed 'amniocentesis'.
79. Bartholin's glands are present in female reproductive system which is homologous to the Cowper's glands of the male reproductive system.
80. Fallopian tubes in female reproductive system are supported by double fold of peritoneum called mesosalpinx.
83. Lining layer of uterus called endometrium (mucous membrane) is richly supplied with blood vessels and tubular gland. Actual wall of uterus is myometrium. It is covered on the outside by perimetrium.
84. Vagina, Ovaries, Oviduct – Internal genitalia
Mammary gland – External genitalia.
85. The secretory phase extends from 15th – 28th day of the menstrual cycle.
88. Aminocentesis is a technique to determine the sex of developing baby, genetically controlled congenital diseases and metabolic disorders in the foetus.
89. Neuron – Structural and functional unit of the brain.
92. Mammary gland is a modified sweat gland.

**Competitive Thinking**

8. Testes are located in scrotum which provides a low temperature (of 2°C) for maintenance of spermatogenetic tissue and formation of sperms.
9. Each testis is held in its position within its scrotal sac and is supported from posterior scrotal wall by means of a small cord of fibro muscular mesodermal tissue called Gubernaculum.



11. Cells of Leydig or interstitial cells are stimulated to secrete male hormone testosterone by the interstitial cell stimulating hormone (ICSH) from anterior lobe of pituitary gland.
12. Leydig cells secrete the hormone testosterone after puberty.
13. Vas deferens is the larger duct that arises from cauda epididymis and reaches upto seminal vesicles.
14. Function of vasa deferentia is conduction of sperms by peristalsis of its highly muscular coat. If it is disconnected in man, semen will be without sperms.
24. The greater vestibular glands (Bartholin's glands) are paired glands situated one on each side of the vaginal opening. These glands are homologous to the bulbourethral (Cowper's) gland of male and secrete viscous fluid that supplements lubrication during sexual intercourse.
27. Theca interna is a highly vascularised internal layer of secretory cells encircling the basement membrane on which the granulosa rest.
28. The cavity of graafian follicle is antrum or follicular cavity having liquor folliculi and an eccentrically placed oocyte.
29. Corpus luteum is a mass of cells present in ovary. The luteal cells secrete progesterone hormone to maintain pregnancy. It also secretes relaxin.
32. Cessation of menstrual cycle is called menopause. Menopause occurs in females at the age of 45-58 years.
34. The ovum is ejected from the follicle near the end of proliferative phase, i.e. 14th day or midway during menstrual cycle.
40. Corpus luteum secretes pregnancy hormone progesterone.
42. The ruptured follicle show proliferation of cells of membrana granulosa, deposition of yellow pigment or lutein and formation of yellow body called corpus luteum. Corpus luteum secretes progesterone. If ovum is not fertilized, corpus luteum loses its yellow colour and changes to whitish scar, corpus albicans and degenerates.
44. FSH is secreted during proliferative phase which leads to development of Graafian follicle. Oestrogen is secreted by follicular cells of ovary which repair endometrium. After rupture of Graafian follicle during ovulation, the remaining cells of Graafian follicle develops into corpus luteum which secrete progesterone.
47. Spermatogonia/oogonia are produced by mitotic cell division, while spermatids and ova are produced after meiotic cell division.
48. Acrosome forms a cap in front of the nucleus containing lytic agent (lysin) which penetrates egg membrane during fertilization.
55. Spermiation is the process of release of the sperms from Sertoli cells into the lumen of seminiferous tubule whereas spermiogenesis is transformation of spermatids into spermatozoa.
58. The process of formation of haploid ova from diploid germinal cells (2n) of the ovary called oogenesis.
59. Oogenesis is the process of formation, development and maturation of haploid ova from diploid germinal cells of ovary. Oogenesis comprises of three phases (i) Multiplication phase (ii) Growth phase (iii) Maturation phase.
62. Discharge of a mature ovum from Graafian follicle is known as ovulation.
65. Entry of sperm stimulates the secondary oocyte to start the suspended meiosis - II resulting in the formation of one ootid and 2 to 3 polar body. Ootid changes to become ovum, male and female pronuclei get mixed up. The process is called amphimixis.
66. Fertilization membrane prevents polyspermic fertilization by preventing further entry of spermatozoa.
67. On fertilization, egg becomes diploid (2n).
68. **Note:** The statement given in option (D) is partially correct because fertilisation of the ovum takes place in the ampullary part of the fallopian tube.
69. Hyaluronidase dissolves hyaluronic acid (cementing material) of corona radiata around ovum.
70. The increase in fertilising capacity of sperms is termed as capacitation. It occurs in female reproductive tract.



- 76. Trophoectoderm forms placenta which help to draw food for the developing cells.
- 80. Gastrulation is the process of the embryonic development during which cell movements establish the three primary germinal layers namely ectoderm, mesoderm and endoderm.
- 82. A three layered larva, gastrula is formed and cell mass move from surface of blastula by morphogenetic movements.
- 85. The archenteron is primitive gut lined by the endoderm.
- 89. Eye (retina, lens and cornea) derived from embryonic ectoderm.
- 91. Connective tissue, bone and cartilage, heart, blood, muscles and gonads are formed from mesoderm.
- 97. Placenta is universally present in eutherian mammals.
- 98. Oxytocin is released from the neurohypophysis of pituitary gland of mother.
- 100. Relaxin is produced by the ovary and the placenta during pregnancy.
Oxytocin / Pitocin: It is secreted by neurohypophysis.
Glucocorticoids are secreted by adrenal gland.
- 104. Release of prolactin has no direct role in expulsion of foetus during parturition.
- 106. MMR stands for Maternal mortality rate.
- 111. The active ingredient of Saheli – ormeloxifene is a selective estrogen receptor modulator. In some parts its action is estrogenic, (e.g. bones) and in other parts of the body its action is anti-estrogenic (e.g. uterus).
- 112. Intra uterine device (Copper MIT) inhibit fertilization and help in birth control.
- 113. LNG - 20 is a Levonorgestrel releasing IUD.
- 114. Cu ions released through copper releasing IUDs suppress sperm motility and the fertilising capacity of sperms.
- 115. Tubectomy is a method of female sterilization.

- 118. In vasectomy, a small part of the vas deferens is removed or tied up through a small cut on the scrotum. This prevents sperm transport. Seminal vesicles join vasa deferentia to form ejaculatory duct. They secrete seminal fluid which contains fructose, prostaglandins and clotting proteins, but no sperms. Thus, in a male who has undergone vasectomy, the ejaculatory duct will receive seminal fluid but due to cut in vasa deferentia sperms will not be transported from epididymis hence, will lack sperms.
- 122. Amniocentesis involves the analysis of amniotic fluid. It contains foetal skin cells and a number of proteins, especially enzymes. The cells can be cultured in vitro for further examination.
- 124. Cleft palate is a developmental abnormality and can be detected by sonography. Amniocentesis is a foetal sex determination test and is banned in India for sex determination to legally check increasing female foeticides.
- 127. Artificial insemination (AI) technique is utilized when the male partner is unable to inseminate the female or has very low sperm count in ejaculate.
- 130. Following are the sexually transmitted diseases and their causative agents:

Sexually transmitted diseases	Causative agent
Gonorrhoea	<i>Neisseria</i> (Bacteria)
Syphilis	<i>Treponema</i> (Bacteria)
Genital warts	Human papillomavirus (Virus)
AIDS	Human Immuno-deficiency Virus (Virus)

- 131. Each testicular lobules of testis contains two to three seminiferous tubules. Wall of each seminiferous tubule is formed of a single layered germinal epithelium.
- 132. Corpus luteum is formed after release of ova from Graafian follicles and secretory in nature.
- 141. In follicular phase of menstrual cycle, LH and FSH increase gradually.



Evaluation Test

2. In the caput (head) epididymis, sperms undergo maturation acquiring increased motility and fertilization capacity.
4. Both Penis and Clitoris show the presence of erectile tissues called corpora cavernosa.
5. Tunica albuginea is the covering of the testis.
7. Saheli is a weekly oral contraceptive pill that checks ovulation by inhibiting the secretion of FSH and LH hormones.
9. The seminal fluid contains citric acid, fructose, fibrinogen and prostaglandins. Fructose provides energy to sperms for swimming.
10. During each menstrual cycle of 28 days, only 1 ovum from either ovary is released.
∴ On an average, 13 eggs / year.
11. In external budding, a small projection or bud is formed on the outer surface of the parental body. eg. *Hydra*
13. In mammals, the testes are located in the extra abdominal scrotal sac. Failure of the testes to descend into the scrotum is called Cryptorchidism. This leads to sterility.
17. Early child marriage is a cause of population explosion.
18. Parturition is the process of expelling fully formed young one or baby from the mother's uterus after the gestation period.
20. Clitoris present in females is homologous to the penis in males.



Hints



Classical Thinking

15. Left ovary and oviduct are present in birds to reduce body weight.
25. It is an example of mutualism, in which ungulates benefit from the cellulase produced by bacteria and the bacteria benefits from the supply of nutrients by ungulates.
36. Female *Anopheles* mosquito is a vector which carries malarial parasite.
69. *Osmunda regalis* is an endangered species. Rest all are vulnerable species.
125. The rats have strong and stout forelimbs provided with claws which help in digging. These features of rat are fossorial adaptation.
127. Lichen is a symbiotic relationship between algae and fungus.
131. Musk deer is a vulnerable species. Rest all are endangered species.
132. Great Indian Bustard is a rare species of bird found in Gujarat and Rajasthan. Rest all are indeterminate species.
133. Option (A), (C) and (D) are manmade causes of extinction of species.
139. Patalganga river is in Panvel.



Critical Thinking

1. Cockroaches show presence of three thoracic legs with presence of claws and adhesive pads which help in running.
9. When new individuals come into the population from outside, it is described as immigration. It results in increasing the density of the population.
11. For a declining population, number of individuals in post-reproductive age group is greater than the number of individuals in pre-reproductive age group.
14. Endangered species of mammals are about 81, while endangered species of birds and amphibians and reptiles are about 38 and 18 respectively.

17. CO combines with haemoglobin to form carboxyhaemoglobin preventing O₂ from combining with haemoglobin. However, CO₂ forms a loose compound with Hb, so that Hb can break away easily to combine with O₂.
20. Defoliation of leaves occur due to exposure to H₂S gas.
21. The emission of finer particles (particulate matter) is controlled by “electrostatic precipitators” and fabric filters”. The larger particles are removed by “wet scrubbers” and “cyclone separators”.
22. Normally rains, even heavy rains cannot cause water pollution. On the contrary, a good supply of water is produced.
23. The industrial effluents with many injurious or hazardous chemicals must be treated before they are released in river, lake, pond or sea.
25. Integrated organic farming adopted by Ramesh Dagar includes bee-keeping, dairy management, water harvesting, composting and agriculture. All these processes support each other and is an ideal, economical, extremely useful and sustainable process.
31. All human beings belong to the species *Homo sapiens sapiens*.



Competitive Thinking

7. The interaction between *Sacculina* and crab is an example of parasitism.
11. Interspecific interactions arise from interactions of populations. In parasitism, one species is benefited while the other species is harmed. Hence the sign, ‘+’, ‘-’.
15. First population count in India was done in 1872 but due to many irregularities in it, 1891 census is considered as the country’s first census.
18. Natality is defined as the number of births per unit time, per unit area, per 1000 individuals of a population. In immigration, new individuals are added to existing population from outside thus, both these factors increase the population density.



24. IUCN publishes the Red data book.
25. IUCN (International Union for Conservation of Nature and Natural Resources) maintains a red data book in which list of endangered species of plants and animals has been given.
27. Red list of red data book IUCN (New name WCU) includes threatened species of plants and animals
33. Protected areas within the biosphere reserve are divided into three zones: Zone with no human interference is the core zone. The zone with limited human activity is the buffer zone. The zone where human settlement, grazing, cultivation, etc., are allowed is known as transition zone.
36. Kaziranga National Park situated in Sibsagar and Nowgong districts of Assam which covers approximately 430 sq.km. area and is famous for one - horned rhinoceros of India.
41. The wildlife is protected in their natural habitat. This is called as in-situ conservation. But, when wild life is protected, in areas, other than natural habitats such as zoos, botanical gardens, etc. it is called as *ex-situ* conservation.
43. Conservation of endangered species in zoological parks is an *ex situ* method of conservation of biodiversity.
44. Sacred groves development is a cultural tradition that emphasized protection of nature. It is *in-situ* type of conservation.
50. Methyl isocyanate reacts quickly with water and caused swelling of lungs and development of cataract in the eyes.
51. The number of automobiles in big cities is very high and automobile exhaust has many atmospheric pollutants like CO, SO₂, oxides of lead, etc.
54. Carbon monoxide when inhaled combines with haemoglobin more rapidly than oxygen. It blocks the oxygen transport by forming stable compound carboxyhaemoglobin. Its prolonged inhalation may lead to death.
57. Water pollution is mainly caused by industrial wastes, sewage, insecticides, herbicides, etc.
60. Mercury is very persistent effluent. Higher concentration of Hg causes a serious disease called Minamata disease.
62. CO is a major pollutant in air released by various automobiles.
63. Aerosols through its direct or indirect effects on plants can cause different problems to agriculture. However, constantly increasing air pollution may represent a continual and largely irreversible hazard to agriculture in the future.
66. CO is more toxic than CO₂ because it combines with haemoglobin resulting in less amount of haemoglobin to carry oxygenated blood.
67. Acid rain is a secondary pollutant, whereas SO₂, CO and CO₂ are primary pollutants.
68. SO₂, CO₂ and CO are primary pollutants. Tropospheric ozone is considered as a secondary pollutant formed when primary pollutants like hydrocarbons and nitrogen oxides combine in presence of sunlight.
75. *r* - selected species exhibit high fecundity small body size, early maturity onset, short generation time and the ability to disperse offspring widely. These species emphasize high growth rates, exploit less-crowded ecological niches and produce many offspring.
77. Amensalism is an association between organisms of two different species in which one is destroyed and the other is unaffected. In antibiotic production, one organism produces antibiotics against another organism.
78. Exotic species are non-indigenous species that are growing in a non-native environment.



Evaluation Test

1. Mycorrhizae is a mutualistic association between certain species of fungi and roots of higher plants. It is a positive inter-specific interaction.
2. Water potential is a term associated with plant water relations and not population.
3. Addition of new individuals by reproduction, i.e. natality and entry of individuals from outside, i.e. immigration contributes to population growth.

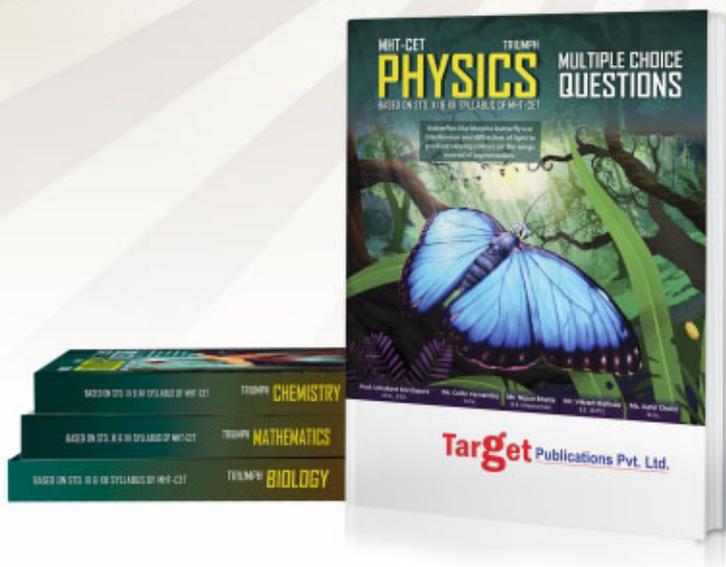


4. A population is said to be in the declining phase when,
Mortality (Death rate) > Natality (Birth rate)
5. Sand and dust storms are caused because of various environmental factors like temperature, wind, air pressure, etc. The sand and dust storms produce natural pollution.
6. Particulate matter of polluted air can be separated by two types of devices – Arrestors and Scrubbers. Arrestors include electrostatic precipitators, cyclone separator, gravity settling chamber and filters.
Incineration involves aerobic burning of the combustible constituents of solid wastes like garbage, rubbish and dead animals. This is an ideal method for medical waste management as it eliminates the infectious organisms.
7. Natality = 250, Immigration = 20
Mortality = 240, Emigration = 30
Net Increase in Population
= [(Natality + Immigration) – (Mortality + Emigration)]
= [(250 + 20) – (240 + 30)]
= 0
8. A rapidly growing population has high birth rate and low death rate. Hence, the contribution of reproductive members (15 – 49 years) is the highest.
9. Fossorial adaptation is a terrestrial adaptation for digging. e.g. The fore-limbs of rat are strong and stout which are provided with claws for digging.
10. An increase in natality and decrease in mortality leads to increase in population.



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