Mineral Nutrition

- **Nutrition** is defined as the sum total of processes by which a living organism receives and utilises raw materials for building its structure and maintaining body functions.
- The chemical substance that works as a raw material for body building and maintaining its functions is referred to as **nutrient**.
- Nutrient can be simple or complex organic molecule or inorganic as mineral ions.
- Mineral nutrition refers to the study of source, mode of absorption, distribution and metabolism of various inorganic substances or minerals by plants for their growth, development, physiology and reproduction.
- The first study in inorganic mineral nutrition was carried out by Van Helmont in 1648. Later, De Saussure (1804) concluded that a plant receives its mineral content from soil but Liebig (1840) depicted the essentiality of mineral nutrition and proposed law of minimum.
- Law of minimum states that productivity of soil depends upon proportionate amount of deficient mineral.

**ESSENTIAL MINERAL ELEMENTS**

- Chemical analysis of plants reveals that it comprises about 60 different elements. All of these elements are not required for the growth of plants.
- An **essential element** is described as the one which plays a specific structural or physiological role and in absence of which plants cannot complete their life cycle.
- 17 elements are found to be essential in plants i.e., C, H, O, N, P, K, S, Mg, Ca, Fe, B, Mn, Zn, Cu, Mo, Cl and Ni. Rest are called non-essential elements.
- **Non-essential elements** are required by some plants but not all. Their absence does not produce any major deficiency symptoms in plants e.g., cobalt, silicon, sodium etc.
It is indispensable for growth of plants.

- A component of either a structural or functional molecule directly involved in metabolism of plants.
- The plant is unable to complete its vegetative or reproductive phase in the absence of element.

Deficiency of an element leads to disorder or disease.

- An element cannot be replaced by another element.
- The element itself can correct the disorders caused by its deficiency.

### Classification of Essential Mineral Elements

#### Based on source from which they are derived

- **Mineral elements**
  - Elements derived from soil

- **Non-mineral elements**
  - Derived from air or water e.g., C, H, O and N.
  - Forms building blocks of macromolecules that form bulk of plant body.
  - Though nitrogen (N) is abundantly present in atmosphere but plants obtain it from soil as nitrate or ammonium ion.

#### Based on the amount required by plants

- **Macroelements**
  - These are essential elements present in plants in easily detectable quantities i.e., 1-10 mg/gm of dry matter.
  - They are usually involved in the synthesis of organic molecules and development of osmotic potential.
  - There are nine macroelements – C, H, O, N, P, K, S, Mg and Ca.
  - They do not cause toxic effects when present in excess.

- **Microelements**
  - Essential elements required by plants in small amounts i.e., less than 1.0 mg/gm of dry matter.
  - They are mostly involved in the functioning of enzymes, as cofactors or metal activators.
  - There are eight microelements e.g., Fe, Zn, Mn, B, Cu, Mo, Cl and Ni.
  - They came to be known only when extra pure salts were used in culture experiments.
  - Cause toxicity when present even in slight excess.

### Functions of Essential Elements

#### Components of biomolecules

They are constituents of biomolecules as nitrogen in amino acids, proteins, nucleic acids, chlorophyll, auxin, vitamins, etc. Depending on the organic compound formed, they are **framework elements** which produce cell walls and storage products of plants, e.g., C, H and O and **protoplasmic elements** which produce protoplasmic constituents like proteins, nucleic acids, cytochromes, ferrodoxin, etc. E.g., C, H, O, N, S, P, Mg.

#### Components of energy related compounds

Magnesium forms the components of chlorophyll which takes part in conversion of light energy into chemical energy. Similarly, phosphorus forms a component of ATP, the energy currency of living systems.

#### Oxidation reduction system

Metals with variable valency act as electron carriers e.g., iron (Fe$^{2+}$ and Fe$^{3+}$) and copper (Cu$^{+}$ and Cu$^{2+}$).

#### Catalytic effects

Certain mineral elements act as cofactors of many enzymes e.g., Mg$^{2+}$ is activator of respiratory enzymes i.e., hexokinase, phosphofructokinase as well as photosynthetic enzymes i.e., RUBP carboxylase etc. Zinc acts as activator of carbonic anhydrase and alcohol dehydrogenase, etc. K$^+$ is a cofactor of about 40 enzymes.

#### Regulator of osmotic potential and permeability

Osmotic potential of cell sap in plants is due to inorganic salts. It is required for water absorption and maintenance of cell turgidity. Elements like Na$^+$, K$^+$ and other monovalents increase membrane permeability while divalents like Ca$^{2+}$ decrease the permeability.

#### Oxidation reduction system

Metals with variable valency act as electron carriers e.g., iron (Fe$^{2+}$ and Fe$^{3+}$) and copper (Cu$^{+}$ and Cu$^{2+}$).

#### Toxic and balancing effects

Some elements become toxic when present in higher concentration than normal e.g., Cu, B, Mn, Mo, Zn while some are toxic even at smaller concentrations e.g., Pb, Ni, Se, Al, Hg. However some elements minimise the toxic effect of heavy elements e.g., Ca$^{2+}$, Mg$^{2+}$ and K$^+$.

#### Movements and buffer action

Certain elements e.g., K$^+$ takes part in stomatal and other turgor movements, while some weak acids and their salts function as a buffer against changes of pH.
Deficiency Symptoms

- Deficiency symptoms are externally visible pathological conditions (morphological and physiological deformities), produced due to absence or deficiency of some essential nutritive substance. Hence, they are also called as hunger signs.
- Deficiency symptoms appear when the availability of essential nutrients fall below critical concentration.
- Critical concentration is limited concentration of essential element below which growth of plant is reduced.

Toxicity of Micronutrients

- Toxic concentration is the concentration of nutrient in tissues which reduces its dry weight by 10%.
- Critical toxic concentration is different for different micronutrients as well as different plants.
- The toxic effects exerted may be due to direct excess of micronutrient or its interference in the absorption and functioning of other nutrients.

Table: Mineral elements and their deficiency symptoms

<table>
<thead>
<tr>
<th>Element</th>
<th>Obtained as</th>
<th>Constituent and major functions</th>
<th>Deficiency symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macroelements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen (N)</td>
<td>NO₃, NO₂ or NH₄⁺</td>
<td>Required for the synthesis of amino acids, proteins, nucleic acids, vitamins, hormones, coenzymes, ATP and chlorophyll.</td>
<td>Stunted growth, chlorosis appears first in older leaves.</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>H₂PO₄⁻</td>
<td>Constituent of cell membrane and some proteins. Required for the synthesis of nucleic acids, phospholipids, ATP, NAD⁺ and NADP⁺.</td>
<td>Poor growth especially of roots, leaves appear dull green, premature leaf fall.</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>K⁺</td>
<td>Activates several enzymes. Associated with K⁺/Na⁺ pump in active transport, anion-cation balance in the cells, brings about opening and closing of stomata, common in cell sap in plant vacuoles and helps in turgidity of cells.</td>
<td>Stunted growth, yellow and shrivelled leaf margins, mottled appearance of older leaves and premature death.</td>
</tr>
<tr>
<td>Element (Symbol)</td>
<td>Form</td>
<td>Function</td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>------</td>
<td>----------</td>
<td></td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>$Ca^{2+}$</td>
<td>Present as calcium pectate in the middle lamella of cell wall that joins adjoining cells together. Activates enzymes needed for the growth of root and shoot tip, needed for normal cell wall development, required for cell division, cell enlargement and translocation of carbohydrates. Chlorosis of young leaves. Die-back of shoots due to death of apical buds, poor root growth, leaf tips become hooked, blossom end rot of tomato.</td>
<td></td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>$Mg^{2+}$</td>
<td>Forms part of the chlorophyll molecule. Activates enzymes of phosphate metabolism. Important for synthesis of fats and respiration and essential for binding components of ribosomes. Interveinal chlorosis especially of older leaves, necrosis.</td>
<td></td>
</tr>
<tr>
<td>Sulphur (S)</td>
<td>$SO_4^{2-}$</td>
<td>As a constituent of amino acids - cysteine, cystine and methionine and hence some of the proteins. Present in coenzyme A, vitamin, thiamine and biotin. Increases root development, nodule formation in legumes. Chlorosis like in nitrogen deficient plants but first in young leaves, tea yellow and less juice content in citrus.</td>
<td></td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>$Fe^{3+}$</td>
<td>Needed for the synthesis of chloroplast protein and so affects the chlorophyll and carotenoid synthesis. As a constituent of ferrodoxin and cytochromes. Intervenial chlorosis, particularly in young leaves. May be localised to single leaf or branch due to limited mobility.</td>
<td></td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>$Mn^{2+}$</td>
<td>Activates the enzyme catalase, carboxylase, acts as electron donor for chlorophyll $b$, involved in decarboxylation reactions during respiration. Leaf - flecking or greyspots due to chlorosis and necrosis in interveinal zones. Grey speck of oat, marsh spot disease of pea.</td>
<td></td>
</tr>
<tr>
<td>Molybdenum (Mo)</td>
<td>$MoO_4^{2-}$</td>
<td>Required for nitrogen fixation, activates the enzyme nitrate reductase. Fall in the ascorbic acid content of the plant, mottling and necrosis first in older leaves and then in young leaves, may lead to abscission of flowers, whiptail disease and loosing of inflorescence in cauliflower.</td>
<td></td>
</tr>
<tr>
<td>Boron (B)</td>
<td>$BO_3^- \text{ or } B_4O_7^{2-}$</td>
<td>Increases the uptake of water and calcium, essential for meristem activity and growth of pollen tube, involved in translocation of carbohydrates. Death of stem and root apices, thickened leaves curl and become brittle, reduced flower production, causes heart rot of beets, browning of cauliflower and decreased nodulation in legumes.</td>
<td></td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>$Cu^{2+}$</td>
<td>Component of oxidase enzymes and plastocyanin. Involved in electron transport in photosynthesis. Reduced absorption of $CO_2$, dieback of shoots, necrosis of young leaves extending towards base along the margin.</td>
<td></td>
</tr>
<tr>
<td>Nickel (Ni)</td>
<td>$Ni^{2+}$</td>
<td>Component of urease required for metabolism of urea and ureides. Leaf tip necrosis</td>
<td></td>
</tr>
</tbody>
</table>
SOIL CULTURE EXPERIMENTS

- Mineral requirements of plants is determined by culture experiment first developed by botanist Julius von Sachs (1860).
- Culture experiments involve raising of plants on artificial media having nutrients. This technique was first initiated by Home and later developed by Sachs (1860) and Knop (1865).
- The solution containing various mineral elements is prepared. A normal or balanced solution is one having all essential elements in proper proportion.
- The element for which deficiency symptoms are to be studied is made deficient in the solution.
- Seedlings are reared either directly in such solution or in an earthen pot having sterilised sand.
- To study the effect of microelements, organs of plants containing reserve food are removed.

Advantages of Culture Experiments

<table>
<thead>
<tr>
<th>It is useful in determining</th>
</tr>
</thead>
<tbody>
<tr>
<td>Essentiality of mineral nutrients</td>
</tr>
<tr>
<td>Role of essential element in physiology of plants</td>
</tr>
<tr>
<td>Deficiency symptoms</td>
</tr>
<tr>
<td>Toxicity due to excess of an element</td>
</tr>
<tr>
<td>Interaction of different elements</td>
</tr>
<tr>
<td>Role of non-essential but functional elements</td>
</tr>
</tbody>
</table>

Hydroponics

- The soilless production of plants wherein solution culture is used to raise flowers and vegetables is called hydroponics.
- The plants are cultured in small tanks of concrete or metal, provided with nutrient solution.
- The pump circulates air as well as nutrient solution to plants and its roots.
- The cost of setting up a hydroponic system is very high.

Types of Hydroponic System

- **Tank system**
  - The roots are immersed in nutrient solution and air is bubbled through the solution.
  - Fig.: Hydroponic Growth System

- **Nutrient film system**
  - The plants are grown in a trough or tube having a thin film of recirculated nutrient solution.
  - Fig.: Nutrient Film Growth System

- **Aeroponics**
  - Roots are suspended in the air over the nutrient solution which is whipped into a nutrient mist by a motor driven rotor.
  - Fig.: Aeroponic Growth System
**Advantages of Hydroponics**
- Conserve water
- Useful in areas having thin, infertile and dry soil.
- Regulate pH optimum for a particular crop.
- Obtain consistently better yield.
- Control soil borne pathogens and avoid problems of weeding.

**ABSORPTION OF MINERALS**
- Plants absorb their mineral salts from the soil, through their roots.
- The most active areas of the root for mineral absorption are zones of elongation and root hair.
- Minerals are absorbed as ions and are accumulated by plants against their concentration gradient.
- The rate of mineral absorption is usually independent of its concentration in soil.

**Mechanism of Absorption of Mineral Elements**

**Absorption of minerals occurs in two phases**

**Initial phase**
- Rapid uptake of ions into outer or free space of cells, comprising of intercellular spaces.
- Ions absorbed in free space are freely exchangeable.
- Passive absorption without the expenditure of energy.

**Metabolic phase**
- Ions pass into inner space or symplast consisting of cell membranes, cytoplasm and other living structures.
- Absorption of ions into inner space requires metabolic energy.
- Movement of ions into cell is influx and movement of ions outside cell is efflux.
- Uptake of ions takes place by ionic pumps or ion-carrier complex and ions are released on inner side of membrane.

**MINERAL TRANSLOCATION**
- Absorption of mineral ions by epiblema cells.
- With water, mineral salts pass radially inwards into the tracheary elements.
- Salt uptake depends upon transpiration pull. It increases with the rate of transpiration.
- The mineral salts reach other parts of plant through phloem by bi-directional movement of salts.
- Salts move laterally in the cambium and phloem.
- Upward movement of minerals in xylem from stem to leaves.

**NITROGEN METABOLISM**
- Nitrogen is the fourth most prevalent element in living systems and forms an essential constituent of protoplasm.
- It is a component of amino acids, proteins, enzymes and nucleic acids.
- Nitrogen is available in abundance (78% of atmosphere) but plants cannot absorb it directly. Hence, N₂ is the most critical element.
- Nitrogen compounds are obtained from reservoir pool through nitrogen fixation, which is replenished through denitrification of nitrates and release of nitrogen from decaying organic matter. The cycling pool is augmented by ammonification and nitrification.

**Nitrogen Fixation**
- It refers to the conversion of inert atmospheric nitrogen or dinitrogen (N₂) into utilisable compounds of nitrogen like nitrate, ammonia, amino acids, etc.
**Methods of Nitrogen Fixation**

**Natural**

Due to lightening and thundering of clouds, N₂ and O₂ of the air react to form nitric oxide (NO). It is further oxidised to form nitrogen peroxide.

\[
\text{N}_2 + \text{O}_2 \xrightarrow{\text{lightening}} 2\text{NO} \\
2\text{NO} + \text{O}_2 \xrightarrow{\text{oxidation}} 2\text{NO}_2
\]

This NO₂ reacts with H₂O to form nitrous acid (HNO₂) and nitric acid (HNO₃). HNO₃ acid falls along with rain water and acts with alkaline radicals to form water soluble (NO₃⁻) nitrates and NO₂ (nitrites).

\[
2\text{NO} + 3\text{[O]} \xrightarrow{\text{Ozonisation}} \text{N}_2\text{O}_5 \\
\text{H}_2\text{O} + \text{N}_2\text{O}_5 \xrightarrow{} 2\text{HNO}_3
\]

**Abiological**

Forms major source of nitrogen fixation and is second most important natural process. It is of two types carried by two types of organisms.

- **Free living**
  - Cyanobacteria: E.g., Anabaena, Nostoc, Calothrix, Aulosira (in rice fields), Cylindrospermum (in sugarcane and maize fields)

- **Symbiotic**
  - Bacteria: E.g., Azotobacter, Beijerinckia (aerobic), Bacillus, Klebsiella, Clostridium (anaerobic), Desulphovibrio (Chemotrophic) Rhodospirillum and Chromatium (anaerobic photoautotrophic)

**Biological**

E.g., Frankia in root nodules of non-leguminous plants i.e., Casuaria, Myrica, Alnus, Rhizobium in root nodules of leguminous plants i.e., Sesbania rostrata, Azolla and cycad roots

**Industrial**

Nitrogen and hydrogen combines to form ammonia industrially, under high temperature and pressure.

\[
\text{O} \\
\text{NH}_2 + \text{H}_2 \xrightarrow{} 2\text{NH}_3 + \text{CO}_2
\]
Formation of Root Nodules in Leguminous Plants

1. Roots emit chemical signals that attract Rhizobium bacteria. The bacteria then emit signals that stimulate root hair to elongate, and to form an infection thread by an invagination of the plasma membrane.

2. The bacteria penetrate the root cortex within the infection thread. Cells of the root cortex and the pericycle of the stele begin dividing, and vesicles containing the bacteria bud into the cortical cells from the branching infection thread. The vesicle membranes are derived by invagination from the plasma membranes of the root cells.

3. Growth continues in the affected regions of the cortex and pericycle and these two masses of dividing cells fuse, forming the nodule.

4. The nodule continues to grow, and vascular tissue connecting the nodule to the xylem and phloem of the stele develops. This vascular tissue supplies nutrients to the nodule and carries nitrogenous compounds from the nodule into the stele for distribution to the rest of the plant.

Mechanism of Nitrogen Fixation

Requirements for Nitrogen Fixation

- Reducing power e.g., NADPH, FMNH₂
- Source of energy e.g., ATP
- Dinitrogenase enzyme consisting of Fe and Mo. Both take part in attachment of N₂ molecule, so that the bonds between two atoms of nitrogen become weakened.
- Compounds for trapping ammonia formed by reduction of dinitrogen.

Steps in Nitrogen Fixation

- Bond between the two atoms of nitrogen become weakened by their attachment to the metallic components. The weakened nitrogen molecule is acted upon by hydrogen from a reduced coenzyme.

- It produces dimide (N₂H₂), hydrazine (N₂H₄) and ammonia (not liberated).

- The nitrogen fixers protect themselves from toxic concentrations of ammonia by providing organic acids which reacts with ammonia to form amino acids.

- The reduction of nitrogen into ammonia by nitrogenase in bacteroids depend upon availability of ATP and substrate capable of donating hydrogen atoms to nitrogen.

- ATP interacts with non-heme iron protein component of nitrogenase and bring about conformational change to convert it to a powerful reductant.

- This powerful reductant becomes capable of transferring electrons to reduce N₂ into NH₃.

- Four molecules of ATP are hydrolysed for each pair of electrons transferred to nitrogen. Thus, reduction of one molecule of nitrogen into two molecules of ammonia require twelve molecules of ATP.

Flowchart: Steps in Nitrogen Fixation
Ammonification
- It is carried out by decay causing organisms. They act upon nitrogenous excretions and proteins of dead bodies of living organisms e.g., Bacillus ramosus, B. vulgaris, Actinomyces.

\[
\text{Proteins} + \text{H}_2\text{O} \rightarrow \text{R–NH}_2 + \text{H}_2\text{O} \rightarrow \text{ROH + NH}_3
\]

- Ammonia does not remain in gaseous state but is changed to ionic form in soil (NH}_4\text{^+}) which is used by plants directly (if the pH of soil is more than 6 and plant contains abundant organic acids).

Nitrification
- It is the phenomenon of conversion of ammonium to nitrate. It is performed in two steps:
  - Nitrite formation
    Ammonium ions are oxidised to nitrites by bacteria e.g., Nitrosococcus, Nitrosomonas.
    \[
    2\text{NH}_3 + 3\text{O}_2 \rightarrow 2\text{NO}_2^- + 2\text{H}^+ + 2\text{H}_2\text{O} + \text{energy}
    \]
  - Nitrate formation
    Nitrites are changed to nitrates by bacteria e.g., Nitrocystis, Nitrobacter.
    \[
    2\text{NO}_2^- + \text{O}_2 \rightarrow 2\text{NO}_3^- + \text{energy}
    \]
- The nitrifying bacteria are chemoautotrophs since they use the liberated energy in synthesis of organic compounds.

Denitrification
- Under anaerobic conditions, some microbes use nitrate and other oxidised ions as source of oxygen. In such process, nitrates are reduced to gaseous compounds of nitrogen, which escape from soil. Examples of denitrifying bacteria are Pseudomonas denitrificans, Thiobacillus denitrificans, Micrococcus denitrificans.

\[
2\text{NO}_3^- \rightarrow 2\text{NO}_2^- \rightarrow 2\text{NO} \rightarrow \text{N}_2 \rightarrow \text{N}_2\text{O} \rightarrow \text{N}_2
\]
- The process not only depletes nitrogen from soil but also causes its acidification.

Nitrate Assimilation
- The nitrates produced by nitrification are absorbed by higher plants and assimilated by the process called nitrate assimilation.
- The nitrates absorbed by plants get converted into amino acids and amides before incorporating into proteins and other macromolecules.

Steps in nitrate assimilation
- It involves reduction of nitrate into ammonia by two enzymatic reactions:
  - Reduction of nitrate to nitrite
    \[
    \text{NO}_3^- + \text{NAD(P)H} + \text{H}^+ \rightarrow \text{NO}_2^- + \text{H}_2\text{O} + \text{NADP}^+
    \]
  - Reduction of nitrite
    \[
    2\text{NO}_2^- + 7\text{NAD(P)H} + 7\text{H}^+ \rightarrow 2\text{NH}_3 + 4\text{H}_2\text{O} + 7\text{NAD(P)}^+
    \]
    (This step occurs inside chloroplasts in leaf cells and therefore it is presumed that in higher plants nitrite is translocated to leaf cells.)

Synthesis of Amino Acids
- Ammonia liberated from reduction of nitrite combines with organic acids to produce amino acids.
- Amino acids are first organic compounds of nitrogen assimilation.
Methods of Synthesis of Amino Acids

Reductive amination
Ammonia reacts with α-ketoglutaric acid to form glutamic acid or with oxaloacetic acid to form aspartate amino acid.

\[
\alpha\text{-ketoglutaric acid} + NH_4^+ + NAD(P)H \xrightarrow{\text{glutamate dehydrogenase}} \text{Glutamate} + H_2O + \text{NAD(P)}
\]

Catalytic amidation
Ammonia combines with glutamic acid in presence of ATP to produce an amide - glutamine.

\[
\text{Glutamate} + NH_4^+ + \text{ATP} \xrightarrow{\text{glutamine synthetase}} \text{Glutamine} + \text{ADP} + \text{Pi}
\]

Transamination
It is transfer of amino group of one amino acid with the keto group of keto acid. Glutamic acid is the primary amino acid involved in transfer of amino group.

\[
\text{Glutamic acid} + \text{Oxaloacetic acid} \xrightarrow{\text{glutamate aspartate transaminase}} \alpha\text{-ketoglutaric acid} + \text{Aspartic acid}
\]

• The amino acids thus formed, form polypeptide chains by establishing peptide bonds between carboxylic group of one amino acid and amino group of an adjacent amino acid. The polypeptides give rise to proteins.

Amides
• They are amino acid derivatives in which –OH component of carboxylic group (–COOH) is replaced by another amino group (–NH₂).
• The two most important amides are asparagine and glutamine.
• Their formation requires ATP, ammonia and synthetase enzyme.

SPEED PRACTICE

1. Grey specks of oat are caused due to the deficiency of
   (a) Cu   (b) Zn
   (c) Mn   (d) Fe.
2. Which of the following statements is incorrect?
   (a) Boron and potassium are involved in translocation of organic substances in phloem.
   (b) Ca²⁺, Mg²⁺ and K⁺ minimise toxic effects of heavy elements.
   (c) Nitrogen is a beneficial element.
   (d) Phosphorus is the component of energy compounds.

   ANSWERS

   ANS: (i) A; (ii) B; (iii) C; (iv) D; (v) E

   WHOM: (a) (i) - C; (ii) - D; (iii) - A; (iv) - E; (v) - B
   (b) (i) - D; (ii) - C; (iii) - A; (iv) - B; (v) - E
   (c) (i) - E; (ii) - D; (iii) - B; (iv) - A; (v) - C
   (d) (i) - C; (ii) - E; (iii) - D; (iv) - A; (v) - B
5. Identify the incorrect pair.
   (a) Tea yellow - Sulphur
   (b) White bud - Zinc
   (c) Brown heart of turnip - Nickel
   (d) Blossom end rot of tomato - Calcium

6. Identify the free living anaerobic nitrogen fixing bacteria.
   (a) Azotobacter  (b) Beijerinckia
   (c) Nostoc        (d) Klebsiella

7. Plants are raised in a trough with a thin layer of recirculated nutrient solution in the process of
   (a) hydroponic growth system
   (b) nutrient film growth system
   (c) aeroponic growth system
   (d) soil culture.

8. In root nodules, leghaemoglobin
   (a) helps in translocation of mineral
   (b) acts as an oxygen scavenger
   (c) acts as a catalyst in transamination
   (d) transports oxygen to root nodule.

9. The immobile element in plants is
   (a) calcium         (b) nitrogen
   (c) phosphorus      (d) magnesium.

10. Which micronutrient helps in nitrogen fixation?
    (a) Mg$^{2+}$   (b) Cu
    (c) Zn          (d) Mo

11. Ammonia liberated from nitrite reduction combines with oxaloacetic acid to form
    (a) glutamate   (b) malate
    (c) aspartate   (d) α-ketoglutarate.

12. The elements involved in catalytic reactions are
    (a) carbon, hydrogen and magnesium
    (b) nitrogen, sulphur and potassium
    (c) zinc, potassium and manganese
    (d) arsenic, silicon and manganese.

13. Match column I with column II and select the correct option from the codes given below.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Nitrogen</td>
<td>A. Interverinal chlorosis</td>
</tr>
<tr>
<td>(ii) Iron</td>
<td>B. Rossetting of leaves</td>
</tr>
<tr>
<td>(iii) Boron</td>
<td>C. Wrinkling of cereal grains</td>
</tr>
<tr>
<td>(iv) Chlorine</td>
<td>D. Bronze colour in leaves</td>
</tr>
</tbody>
</table>
| (a) (i) - A; (ii) - D; (iii) - C; (iv) - B  
| (b) (i) - C; (ii) - A; (iii) - B; (iv) - D |

(c) (i) - A; (ii) - C; (iii) - D; (iv) - B
(d) (i) - D; (ii) - A; (iii) - B; (iv) - C

14. Read the given statements and select the correct option.

   Statement A : Iron takes part in electron transport system of mitochondria.
   Statement B : Iron has no role in chlorophyll synthesis.

   (a) Both statements A and B are true and statement B is correct explanation of statement A.
   (b) Both statements A and B are true but statement B is not the correct explanation of statement A.
   (c) Statement A is true but B is false.
   (d) Both statements A and B are false.

15. Read the following statements and choose the correct one from options given below.

   (i) Hydroponics is the practice of growing plants in nutrient enriched water, without soil.
   (ii) Hydroponics is useful for cultivation of plants in areas with thin, infertile and dry soils.
   (iii) Hydroponics is not useful in controlling the soil pathogens and problems of weeding.
   (iv) Only seasonal vegetables can be successfully grown through hydroponics, but not flowering plants.

   (a) (i) and (iii) only  (b) (i) and (ii) only
   (c) (i), (iii) and (iv) only  (d) (i), (ii), (iii) and (iv)

16. If a plant’s younger leaves are yellowing but older one remains green, what could be the most probable cause of plant’s blight?

   (a) Improper sunlight
   (b) Lack of nitrogen fixing bacteria in soil
   (c) Deficiency of immobile mineral nutrient
   (d) Deficiency of mobile mineral nutrient

17. Refer the given reaction. What does it depict?

   OCTOBER 2016
   1-h- HAEMOCOEL  2-f- EMPHYSEMA
   3-e-AESTIVATION  4-a-SPERMATELIOSIS
   5-j- PHYCOCYANIN  6-i- TOCOPHEROL
   7-c-TRANSPOSONS  8-g- PYELONEPHRITIS
   9-d- ELECTROPORATION 10-b-ACHONDROPLASIA

   Winners: Victor Ghosh (Andhra Pradesh), Dheeraj Swamy (Karnataka),
   Anupama, Vardhan (Visakhapatnam),
   Mijan Ahamed Khan (West Bengal)

* There was printing error in the letters of unscrambled word ‘YLOPNEPHSITIRE’. 
18. Study the given table of differences between macro and micronutrients and choose the incorrect one.

<table>
<thead>
<tr>
<th>Macronutrients</th>
<th>Micronutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Occur in concentration of 1000 mg/gm of dry matter.</td>
<td>Occur in concentration of 0.1 mg/gm of dry matter.</td>
</tr>
</tbody>
</table>

(a) (ii) and (iii) only  
(b) (iii) only  
(c) (i) and (iv) only  
(d) (ii) only

19. Which of the following functions can be carried out in the deficiency of copper?

(a) Activation of plastocyanin  
(b) Metabolism of urea  
(c) Chlorophyll synthesis  
(d) Electron transfer

(a) Nitrobacter  
(b) Aspergillus flavus  
(c) Pseudomonas  
(d) Nitrosococcus

20. Which microorganism takes part in conversion of both ammonium ions to nitrites and nitrites to nitrates?

(a) Nitrobacter  
(b) Aspergillus flavus  
(c) Pseudomonas  
(d) Nitrosococcus

---

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**MPP-6 CLASS XII**

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Answer</th>
<th>Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>(c)</td>
<td>2.</td>
</tr>
<tr>
<td>6.</td>
<td>(b)</td>
<td>(b)</td>
</tr>
<tr>
<td>11.</td>
<td>(a)</td>
<td>(b)</td>
</tr>
<tr>
<td>16.</td>
<td>(b)</td>
<td>(c)</td>
</tr>
<tr>
<td>21.</td>
<td>(b)</td>
<td>(c)</td>
</tr>
<tr>
<td>26.</td>
<td>(b)</td>
<td>(c)</td>
</tr>
<tr>
<td>31.</td>
<td>(a)</td>
<td>(d)</td>
</tr>
<tr>
<td>36.</td>
<td>(b)</td>
<td>(c)</td>
</tr>
<tr>
<td>4.</td>
<td>(c)</td>
<td>5.</td>
</tr>
<tr>
<td>9.</td>
<td>(a)</td>
<td>(a)</td>
</tr>
<tr>
<td>14.</td>
<td>(b)</td>
<td>15.</td>
</tr>
<tr>
<td>19.</td>
<td>(c)</td>
<td>(c)</td>
</tr>
<tr>
<td>24.</td>
<td>(b)</td>
<td>25.</td>
</tr>
<tr>
<td>29.</td>
<td>(b)</td>
<td>(c)</td>
</tr>
<tr>
<td>34.</td>
<td>(a)</td>
<td>(a)</td>
</tr>
<tr>
<td>39.</td>
<td>(b)</td>
<td>(a)</td>
</tr>
<tr>
<td>17.</td>
<td>(c)</td>
<td>18.</td>
</tr>
<tr>
<td>13.</td>
<td>(b)</td>
<td>14.</td>
</tr>
<tr>
<td>19.</td>
<td>(c)</td>
<td>20.</td>
</tr>
</tbody>
</table>

**ANSWER KEY**

1. (c)  2. (c)  3. (b)  4. (c)  5. (b)  6. (d)  7. (b)  8. (b)  9. (a)  10. (a)  11. (c)  12. (a)  13. (b)  14. (c)  15. (b)  16. (c)  17. (c)  18. (b)  19. (b)  20. (a)  21. (b)  22. (c)  23. (d)  24. (b)  25. (d)  26. (b)  27. (a)  28. (d)  29. (b)  30. (c)  31. (a)  32. (d)  33. (d)  34. (a)  35. (a)  36. (b)  37. (c)  38. (b)  39. (b)  40. (a)
1. Living sclerenchymatous fibres possessing nucleated protoplast are found in
   (a) grapevine  (b) *Tamarix aphylla*  
   (c) *Corchorus*  (d) *Cannabis*.

2. Which of the following statements is incorrect?
   (a) In exarch condition, protoxylem lies outside of metaxylem.
   (b) In endarch condition, protoxylem lies towards the centre.
   (c) In centrarch condition, the protoxylem lies in the middle of metaxylem.
   (d) Exarch condition is found in roots while endarch condition is found in stem.

3. Identify the correctly matched pair.
   (a) Bicollateral vascular bundles - *Cucurbita pepo*
   (b) Amphicribal vascular bundles - *Dracaena*
   (c) Amphivasal vascular bundles - *Prunus*
   (d) Open vascular bundles - Stem of *Zea mays*

4. Match the column I with column II and select the correct option from the codes given below.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Astrosclereid</td>
<td>(i) Dicot leaves</td>
</tr>
<tr>
<td>B. Osteosclereid</td>
<td>(ii) Grit of fruits</td>
</tr>
<tr>
<td>C. Macrosclereid</td>
<td>(iii) Intracellular spaces of leaves and stem in hydrophytes</td>
</tr>
<tr>
<td>D. Brachysclereid</td>
<td>(iv) Seed coat of leguminosae family</td>
</tr>
</tbody>
</table>

   (a) A-(ii), B-(iv), C-(i), D-(iii)  
   (b) A-(iv), B-(iii), C-(ii), D-(i)  
   (c) A-(iii), B-(i), C-(iv), D-(ii)  
   (d) A-(ii), B-(iii), C-(i), D-(iv)

5. Refer to the given diagram and select the correct statements regarding this.

   (i) A is responsible for increase in length and is found at base of internodes, leaves or nodes.
   (ii) B is a separated part of A that contributes to increase in length of plant.
   (iii) C divides only radially and contributes to increase in girth of plant.
   (iv) B and C are present on lateral sides of plant.

   (a) (ii) and (iii) only  
   (b) (i) and (iv) only  
   (c) (ii), (iii) and (iv) only  
   (d) All of these

6. Which of the following is not a function of epidermis?
   (a) Protection of internal tissues  
   (b) Exchange of gases  
   (c) Provide mechanical strength and flexibility  
   (d) Minimise surface transpiration

7. Read the following statements and choose the incorrect statement.
   (a) Annual rings are not distinct in plants of tropical regions.
   (b) The spring wood is wider than autumn wood.
   (c) Spring wood is darker in colour and of higher density than autumn wood.
   (d) The transition from spring to autumn wood is a gradual process.
8. Select the incorrectly matched pair.
(a) Vascular cambium of root - Derived from conjunctive parenchyma
(b) Interfascicular vascular cambium of stem - Derived from medullary ray cells
(c) Cork cambium - Derived from inner layer of cortex
(d) Wound cambium - Derived from cells around injury

9. Read the given table of differences between two secondary tissues X and Y.

<table>
<thead>
<tr>
<th></th>
<th>X</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i)</td>
<td>X is composed of dead cells.</td>
<td>Y is composed of living cells.</td>
</tr>
<tr>
<td>(ii)</td>
<td>It is protective in function.</td>
<td>It takes part in storage of food.</td>
</tr>
<tr>
<td>(iii)</td>
<td>Cell walls are impermeable.</td>
<td>Cell walls are permeable.</td>
</tr>
<tr>
<td>(iv)</td>
<td>The cells are compactly arranged.</td>
<td>The cells enclose small intercellular spaces.</td>
</tr>
</tbody>
</table>

Select the correct option regarding X and Y.
(a) X is phloem fibre and Y is companion cell.
(b) X is sieve tube and Y is vessel.
(c) X is epidermis and Y is cortex.
(d) X is phellem and Y is phelloderm.

10. Anomalous secondary growth occurs in
(a) Cortical bundles of Nyctanthes
(b) Stem of Zea mays
(c) Stem of Helianthus
(d) All of these.

11. Consider the following differences between primary phloem and secondary phloem.

<table>
<thead>
<tr>
<th>Primary phloem</th>
<th>Secondary phloem</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Occurs in all vascular plant organs.</td>
<td>Restricted to stem and roots of perennial dicots and gymnosperms.</td>
</tr>
<tr>
<td>(ii) Formed from lateral meristem.</td>
<td>Formed from procambium.</td>
</tr>
<tr>
<td>(iii) Present towards the periphery.</td>
<td>Formed inner to primary phloem.</td>
</tr>
<tr>
<td>(iv) There is no differentiation.</td>
<td>Differentiated into protophloem and metaphloem.</td>
</tr>
<tr>
<td>(v) Radial system of phloem rays is present.</td>
<td>Radial system is absent.</td>
</tr>
</tbody>
</table>

Choose the incorrect set of differences.
(a) (i), (ii) and (iii) only
(b) (ii), (iv) and (v) only
(c) (ii), (iii) and (iv) only
(d) (i), (iv) and (v) only

12. Which of the given statements is correct regarding anatomical adaptations in leaves?
(a) Epidermis is single layered in leaves of Begonia and Nerium.
(b) Upper surface of leaf bear stomatal crypts in Nerium.
(c) Floating leaves are epistomatic as in Nymphea.
(d) Submerged hydrophytic leaves of Hydrilla bears stomata only on lower surface.

13. Match the column I with column II.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Cutch</td>
<td>(i) Caesalpinia sappan</td>
</tr>
<tr>
<td>B. Haematoxylin</td>
<td>(ii) Pterocarpus santalinus</td>
</tr>
<tr>
<td>C. Braselin</td>
<td>(iii) Acacia catechu</td>
</tr>
<tr>
<td>D. Santalin</td>
<td>(iv) Haematoxylon campechianum</td>
</tr>
</tbody>
</table>

Select the incorrect statement about Casparian strips.
(a) These are bands of thickenings along the radial and tangential walls of endodermal cells.
(b) They prevent plasmolysis of endodermal cells.
(c) These are composed of lignin, suberin and tannins.
(d) It prevents movement of substances between cortex and pericycle.

15. Consider the following statements regarding epidermal appendages and select the correct option stating which one is true and which one is false.
(i) Aerial hairs are unicellular appendages that enclose stationary hair and protect plant parts against sudden temperature changes.
(ii) Glandular trichomes secrete oil and impart characteristic odour to plants.
(iii) Prickles are multicellular emergences devoid of vascular supply.
(iv) The digestive glands of insectivorous plants are also trichome in nature.

Choose the incorrect statement.
(a) Pericycle gets converted into secondary meristem to form phellogen.
(b) Phellogen divides towards the inner side to form few layers thick phelloderm.
(c) Towards the outer side of phellogen are formed dead cells.
(d) The phellogen, phelloderm and periderm together constitute phellem.
17. Consider the differences between two simple permanent tissues and identify them correctly from given option.

<table>
<thead>
<tr>
<th>Tissue A</th>
<th>Tissue B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Composed of living cells.</td>
<td>Composed of dead cells.</td>
</tr>
<tr>
<td>(ii) Walls comprise of angular thickenings.</td>
<td>Wall thickenings may be of lignin or cellulose or both.</td>
</tr>
<tr>
<td>(iii) Provides mechanical strength and elasticity.</td>
<td>Provides mechanical strength only.</td>
</tr>
</tbody>
</table>

(a) A is chlorenchyma and B is collenchyma.
(b) A is parenchyma and B is sclerenchyma.
(c) A is collenchyma and B is sclerenchyma.
(d) A is collenchyma and B is sclereid.

18. Hard bast are
(a) axial phloem parenchyma with longitudinally arranged cells
(b) secondary phloem without fibres
(c) secondary phloem with abundant fibres
(d) ray parenchyma with radially arranged cells.

19. The cork is impervious to water because
(a) it is filled with air
(b) its cells have deposition of lignin and tannins
(c) its cell possess suberised cell walls
(d) all of these.

20. Identify the incorrect commercial use of bark.
(a) In tanning
(b) As insect repellent
(c) As antiseptic
(d) In sound proofing

21. Refer to the statements regarding sieve elements.
(i) Sieve elements show nacreous thickenings on lateral walls.
(ii) They may possess simple or compound sieve plate.
(iii) Sieve tubes are syncytes and the perforations are surrounded by callose.
(iv) They allow selective and restricted diffusion of soluble organic substances.

Select the option with all correct statements.
(a) (i) and (iv) only
(b) (ii) and (iv) only
(c) (i), (iii) and (iv) only
(d) (i), (ii) and (iii) only

22. Festucoid grasses are monocots
(a) with single bundle sheath
(b) having double bundle sheath
(c) having large bundle sheath extensions
(d) showing Kranz anatomy.

23. Which of the following is not a function of cortex in monocot roots?
(a) Conduction of water from root hairs to inner tissues
(b) Produce protective exodermis in older roots
(c) Produce lateral roots
(d) Storage of food

24. Refer to the given characteristic features of a given section of stem and identify it correctly.
(i) The hypodermis is made up of 3-4 layered lacunate collenchyma.
(ii) The pericycle is homogenous comprising of 4-5 layers of sclerenchyma.
(iii) Vascular bundles are bicollateral.
(iv) The outline of primary stem is angular.

Select the correct option.
(a) The given section is of sunflower, a primary dicot stem.
(b) The section belongs to Zea mays, a monocot stem.
(c) The section is a primary dicot stem of Cucurbita.
(d) The section shows secondary growth in stem of Begonia.

25. Select the incorrect statement.
(a) Ring porous wood is found in Cassia fistula.
(b) Ring porous wood shows broader vessels in spring wood and quite narrow vessels in autumn wood.
(c) In diffuse porous wood, both autumn and spring wood comprises of large sized vessels.
(d) Diffuse porous wood is more advanced than ring porous wood since it helps in better translocation at great heights.

26. Refer to the given table of differences between vessels and tracheids and select the incorrect pair of differences.

<table>
<thead>
<tr>
<th>Vessels</th>
<th>Tracheids</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) These are made up of single cell.</td>
<td>These are made up of numerous cells.</td>
</tr>
<tr>
<td>(ii) The ends are rounded or transverse.</td>
<td>The ends are generally oblique and tapering.</td>
</tr>
<tr>
<td>(iii) Walls are thick and lumen is narrow.</td>
<td>Walls are less thickened lumen is wide.</td>
</tr>
<tr>
<td>(iv) Occur in all angiosperms.</td>
<td>Occur in all vascular plants.</td>
</tr>
</tbody>
</table>

(a) (i), (iii) and (iv) only
(b) (ii) and (iii) only
(c) (i) and (ii) only
(d) (iv) only

27. Select the incorrect statements with respect to lenticels.
(a) They are raised corky spots in periderm of stem.
(b) They are formed beneath the stomata of epidermis.
(c) These comprise of unsuberised complementary cells.
(d) They get closed in summer in temperate plants to check excessive evaporation.
28. Select the incorrect statement regarding given figure.

![Diagram]

(a) A gives rise to medullary rays.
(b) B gives rise to epidermis.
(c) C gives rise to vascular tissues.
(d) A, B and C are histogens of shoot apex.

29. The cells of the quiescent centre are characterised by

(a) having dense cytoplasm and prominent nuclei
(b) actively dividing cells giving rise to initials
(c) inactive cells in central part of root apex
(d) a zone of active and inactive cells in region of root apex.

30. The process of dilation involves

(a) formation of secondary xylem on the inner side
(b) formation of vascular rays
(c) gradual movement of vascular cambium to outside
(d) both (a) and (c).

31. Torus refers to

(a) thickening on pit membrane of tracheids in some gymnosperms
(b) pit cavity of tracheids in the form of a flask
(c) elongated tubes or tracheids closed at one end
(d) none of these.

32. The activities of sieve tube are controlled by

(a) albuminous cells
(b) nucleus of companion cells
(c) adjacent sieve tube member
(d) phloem parenchymatous cells.

33. Depending upon the type of xylem found in roots of plants, match the column I and II.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Diarch</td>
<td>(i) Castor</td>
</tr>
<tr>
<td>B. Triarch</td>
<td>(ii) Maize</td>
</tr>
<tr>
<td>C. Tetrarch</td>
<td>(iii) Tomato</td>
</tr>
<tr>
<td>D. Polyarch</td>
<td>(iv) Pea</td>
</tr>
</tbody>
</table>

Select the correct option.

(a) A-(i), B-(ii), C-(iii), D-(iv)
(b) A-(iii), B-(i), C-(ii), D-(iv)
(c) A-(i), B-(ii), C-(iii), D-(iv)
(d) A-(iv), B-(i), C-(iii), D-(iii)

34. From the given section of conducting tissue, identify the labels A-D and select the correct option.

Select the correct option.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vessels</td>
<td>Tracheids</td>
<td>Xylem fibres</td>
<td>Xylem parenchyma</td>
</tr>
<tr>
<td>Sieve plate</td>
<td>Phloem fibres</td>
<td>Sieve tube</td>
<td>Companion cell</td>
</tr>
<tr>
<td>Sieve tube</td>
<td>Phloem fibres</td>
<td>Sieve plate</td>
<td>Phloem parenchyma</td>
</tr>
<tr>
<td>Tracheids</td>
<td>Xylem fibres</td>
<td>Vessels</td>
<td>Xylem parenchyma</td>
</tr>
</tbody>
</table>

35. The epidermal tissue system in plants has many important roles. Choose the incorrect function not displayed by this tissue system.

(a) Storage of water
(b) Healing of wounds
(c) Maintenance of root pressure
(d) Rolling and unrolling of leaves

36. Refer to the given figure of T.S. of old woody dicot stem and consider the statements regarding A, B and C. Choose the option with incorrect ones.

(i) A is protective in function and is called periderm.
(ii) B is soft and lighter in colour.
(iii) C is susceptible to attack of pathogen and insects.
(iv) B is mechanical in function due to deposition of metabolites and tyloses.

(a) (i) and (ii) only
(b) (iii) and (iv) only
(c) (i) and (iv) only
(d) None of these

37. Select the incorrectly matched pair.

(a) Nectaries - *Euphorbia pulcherrima*
(b) Digestive glands - *Drosera*
(c) Resin secreting glands - *Pinus*
(d) Hydathodes - *Calotropis*
38. Choose the correct statement.
(a) Additive divisions add to dilation by anticlinal divisions.
(b) Multiplicative division of vascular cambium forms secondary tissues by periclinal divisions.
(c) Radial system of secondary vascular tissues is produced by ray initials.
(d) Axial system of secondary vascular tissues is formed by vascular rays.

39. Duramen is
(a) softwood devoid of vessels
(b) nonfunctional heartwood
(c) porous wood with abundant vessels
(d) functional sapwood.

40. Consider the table of differences between two tissues X and Y.

<table>
<thead>
<tr>
<th>Tissue X</th>
<th>Tissue Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Comprises mainly of dead cells but only one living cell.</td>
<td>Comprises of mainly living cells but one dead cell.</td>
</tr>
<tr>
<td>(ii) Related to conduction of sap.</td>
<td>Helps in conduction of organic solutes.</td>
</tr>
<tr>
<td>(iii) Conducting elements are of two types.</td>
<td>Conducting elements are of one type.</td>
</tr>
<tr>
<td>(iv) Constitutes the bulk of woody parts.</td>
<td>Constitutes a small part of vascular tissue.</td>
</tr>
</tbody>
</table>

Based on above differences, identify the tissues X and Y.
(a) X is sapwood and Y is heart wood.
(b) X is secondary tissue and Y is primary tissue.
(c) X is xylem and Y is phloem.
(d) X is protoxylem and Y is metaxylem.

41. Refer to the given figure of section of plant part and identify its characteristics. Select the incorrect option.
(a) Hairs are absent in epidermal tissue system.
(b) Endodermis and pericycle are absent.
(c) Vascular bundles are scattered, conjoint, collateral and open.
(d) The section belongs to that of a monocot stem.

42. Read the following stages in formation of secondary vascular tissues and arrange them in sequence, as they occur.
I. Pericycle gives rise to wavy band of vascular cambium.
II. Cambial strips and primary phloem bundles are pushed slightly to outside.
III. The primary phloem gets crushed by growth of secondary vascular tissues.
IV. Secondary xylem is produced on the inner side and secondary phloem is formed on outside.
V. Wide multiseriate medullary rays are formed opposite protoxylem.
(a) I → II → V → IV → III
(b) II → I → V → IV → III
(c) V → IV → II → III → I
(d) III → II → I → V → IV

43. Refer to the given figure and select the incorrect statement regarding them.

(a) A tissues are irregularly arranged angular tissues, with thickenings at angles e.g., Vitis.
(b) B tissues are identified as plate thickenings on tangential walls e.g., stem of sunflower.
(c) C tissues are lacunate thickenings found on the walls bordering intercellular spaces.
(d) C tissues are found in stem of Tagetes.

44. Consider the following statements regarding the given figure and select the incorrect one.
(i) ‘L’ is the collenchymatous hypodermis that provides mechanical strength and flexibility to young dicot stems.
(ii) ‘M’ is the innermost layer of cortex which usually possesses casparian strips.
(iii) ‘N’ is the parenchymatous pericycle that synthesizes food.
(iv) ‘O’ is xylem which is exarch with respect to the positions of protoxylem and metaxylem.

(a) (i) only     (b) (i) and (ii) only
(c) (iv) only    (d) (ii), (iii) and (iv) only

45. Refer to the given flow chart showing differentiation of cells.

Cells showing continuous state of division

Yes → P

No

Consists of only single type of dead cells

Yes

Q

Consists of similar type of cells

No

Chiefly a mechanical tissue

Yes

Possess uniform lignified wall thickenings

Yes

S

Choose the correct statement regarding P, Q, R and S.
(a) P is the terminal portion of root.
(b) Q represents sieve tubes formed of several cells placed end to end.
(c) R may be living parenchymatous cells comprising of thin walled isodiametric cells.
(d) S can be collenchyma tissue providing strength to young stems and petioles.

46. Read the differences between tissues X and Y and choose the correct statement regarding X and Y.

<table>
<thead>
<tr>
<th>Tissue X</th>
<th>Tissue Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Parenchymatous containing chloroplasts.</td>
<td>Parenchyma containing air cavities.</td>
</tr>
<tr>
<td>(ii) Cells are large.</td>
<td>Cells are small.</td>
</tr>
<tr>
<td>(iii) Helps in photosynthesis.</td>
<td>Helps in buoyancy.</td>
</tr>
</tbody>
</table>

(a) Tissue X is xylem parenchyma found in stem of Cucurbita.
(b) Tissue Y is prosenchyma providing strength to tender parts of plant.
(c) Tissue X is phloem parenchyma taking part in both storage and conduction of food.
(d) Tissue Y is aerenchyma found in petiole of Canna.

47. Select the incorrect statements regarding figures A-E.

I. D-shows thickening present in the form of ladder.
II. A-shows annular thickenings laid in the form of rings.
III. C-thickenings are present in early formed tracheids in the form of a network.
IV. B-shows pitted tracheids which may be simple and bordered.
V. E-represents spiral thickenings in tracheids.

(a) IV and V only     (b) I and III only
(c) I, III and IV only  (d) III, IV and V only

48. Refer to the given figure and read the statements regarding labels A-D.

(i) A forms pith.
(ii) B forms endodermis.
(iii) C gives rise to cortex.
(iv) D gives rise to protoderm.

Choose the correct pair of statements.
(a) (i), (ii) and (iv) only  (b) (ii) and (iii) only
(c) (i) and (ii) only    (d) All of these

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49. Read carefully the differences between the two sections X and Y of plant parts showing secondary growth.

<table>
<thead>
<tr>
<th>Section X</th>
<th>Section Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) The vascular cambium is in the form of a circular strip.</td>
<td>Vascular cambium is in the form of a wavy band.</td>
</tr>
<tr>
<td>(ii) Vascular cambium is made up of both primary and secondary meristematic tissues.</td>
<td>Vascular cambium is secondary in origin.</td>
</tr>
<tr>
<td>(iii) Annual rings are present.</td>
<td>Annual rings are absent.</td>
</tr>
<tr>
<td>(iv) Phellogen arises from a superficial layer of cortex.</td>
<td>Phellogen originates from pericycle.</td>
</tr>
</tbody>
</table>

Select the correct option regarding plant sections X and Y.
(a) Section X can be of a dicot leaf.
(b) Section Y is of monocot root.
(c) Section X shows secondary growth in dicot stem.
(d) Section Y shows secondary growth in monocot stem.

50. Refer to the given figure and identify the statements correctly describing it.

Unscramble the words given in Column I and match them with their explanations in Column II.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. LNSIERBIGLBE</td>
<td>(a) Fungal component of lichens.</td>
</tr>
<tr>
<td>2. OTFIESNRERN</td>
<td>(b) Method of recombinant DNA insertion using high velocity microparticles.</td>
</tr>
<tr>
<td>3. TNSATSI</td>
<td>(c) Help in elongation and improvement of shape in apple.</td>
</tr>
<tr>
<td>4. YBNMOTOCI</td>
<td>(d) Cultivation and management of individual specimens of ornamental trees.</td>
</tr>
<tr>
<td>5. MSTAOARNIANTN</td>
<td>(e) Blood cholesterol lowering agents produced by yeast.</td>
</tr>
<tr>
<td>6. CLIOBISI</td>
<td>(f) Activates immune system and help in destroying tumor in immunotherapy.</td>
</tr>
<tr>
<td>7. HIUORPRMLOIDS</td>
<td>(g) Condition in which insufficient oxygen is reaching to the heart muscles.</td>
</tr>
<tr>
<td>8. RBALUCOIRERT</td>
<td>(h) Withdrawal of pseudopodia and secretion of hard covering by Amoeba.</td>
</tr>
<tr>
<td>9. GANAIN</td>
<td>(i) Free living, anaerobic, nitrogen fixing microbe.</td>
</tr>
<tr>
<td>10. NYTNETCSAOI</td>
<td>(j) Transfer of amino group to a keto acid to form amino acid.</td>
</tr>
</tbody>
</table>

Readers can send their responses at editor@mtg.in or post us with complete address by 25th of every month to win exciting prizes. Winners’ names will be published in next issue.
1. Filiform papillae of the tongue contain
   (a) thermoreceptors  (b) chemoreceptors
   (c) tactile receptors  (d) none of these.

2. A typical tooth consists of crown, neck and root regions. Which of the following parts come under the crown region?
   (a) Enamel, Dentin, Periodontal ligament
   (b) Enamel, Dentin, Cement
   (c) Enamel, Dentin, Odontoblasts
   (d) Enamel, Dentin, Gum

3. Waldeyer’s ring consists of
   (a) palatine tonsil  (b) tubal tonsil
   (c) lingual tonsil  (d) all of these.

4. Match column I with column II and select the correct option given below.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Auerbach’s plexus</td>
<td>(i) Vitamin B₁₂ reabsorption</td>
</tr>
<tr>
<td>B. Meissner’s plexus</td>
<td>(ii) Control peristalsis</td>
</tr>
<tr>
<td>C. Peyer’s patches</td>
<td>(iii) Increase absorptive surface</td>
</tr>
<tr>
<td>D. Valves of Kerkring</td>
<td>(iv) Produce lymphocytes</td>
</tr>
<tr>
<td>E. Castle’s intrinsic factor</td>
<td>(v) Control secretion of intestinal juice</td>
</tr>
</tbody>
</table>

   (a) A-(ii), B-(v), C-(iv), D-(iii), E-(i)
   (b) A-(iii), B-(iv), C-(ii), D-(v), E-(i)
   (c) A-(v), B-(iii), C-(i), D-(ii), E-(iv)
   (d) A-(iv), B-(i), C-(v), D-(iii), E-(iii)

5. Read the following sentences and select the correct one.
   I. Salivary amylase is present in herbivores.
   II. Parotid glands are the largest salivary glands located near the ears.
   III. The duct of submandibular gland is called Wharton’s duct.
   IV. Submandibular ducts open near second upper molar.

   (a) I and II only  (b) II and III only
   (c) III and IV only  (d) I and IV only

6. Which of the following statements is correct regarding the given diagram?

   (a) Part B secretes pepsinogen and prorennin.
   (b) Part A is present throughout the epithelium and secretes mucus.
   (c) Labelled part C is large and present abundantly on the side walls of gastric glands.
   (d) Part D lie against the basement membrane.

7. Read the given statements and select the incorrect option.

   (a) Kupffer cells are phagocytic in nature which eat worn out WBCs, RBCs and bacteria.
   (b) Liver lies on the lower side of the abdominal cavity below the diaphragm.
   (c) pH of the blood decreases as CO₂ content increases in blood.
   (d) Stem cells increase in number when the gastric epithelium is damaged.

8. Glisson’s capsule is characteristic feature of mammalian

   (a) small intestine  (b) liver
   (c) stomach  (d) both (a) and (b).
9. The opening of hepatopancreatic ampulla is guarded by
   (a) sphincter of Boyden (b) sphincter of Oddi
   (c) Glisson’s capsule (d) both (b) and (c).
10. Which of the following is not a function of liver?
   (a) Secretion of heparin (b) Synthesis of vitamin A
   (c) Destruction of RBCs (d) Secretion of pepsinogen
11. Select the correct sequence of the flow of bile from the liver.
   (a) Hepatic ducts → Gall bladder → Cystic duct → Bile duct → Hepatopancreatic ampulla → Duodenum
   (b) Hepatic ducts → Cystic duct → Hepatopancreatic ampulla → Bile duct → Gall bladder → Duodenum
   (c) Hepatic ducts → Cystic duct → Bile duct → Gall bladder → Hepatopancreatic ampulla → Duodenum
   (d) Hepatic ducts → Bile duct → Hepatopancreatic ampulla → Cystic duct → Gall bladder → Duodenum
12. Which one of the following is known as accessory pancreatic duct?
   (a) Ampulla of Vater (b) Duct of Wirsung
   (c) Duct of Santorini (d) Duct of Rivinus
13. Mucosa membrane of alimentary canal consists of
   (a) muscularis mucosa (b) lamina propria
   (c) epithelium (d) all of these.
14. Which of the following is not an accessory digestive organ?
   (a) Liver (b) Pancreas
   (c) Tongue (d) Small intestine
15. Select the mismatched pair.

<table>
<thead>
<tr>
<th>Enzyme</th>
<th>Site of action</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Chymotrypsin</td>
<td>Small intestine</td>
</tr>
<tr>
<td>(b) Rennin</td>
<td>Adult’s stomach</td>
</tr>
<tr>
<td>(c) Ptyalin</td>
<td>Mouth</td>
</tr>
<tr>
<td>(d) Enterokinase</td>
<td>Small intestine</td>
</tr>
</tbody>
</table>
16. Read the following statements regarding gastrointestinal hormones and select the correct option.
   (a) Gastrin is the first hormone discovered by scientists.
   (b) Duocrinin hormone stimulates pancreas to secrete digestive enzymes.
   (c) Enterocrin stimulates the crypts of Lieberkuhn to release enzymes into intestinal juice.
   (d) Somatostatin stimulates the secretion of glucagon.
17. Select the correct option to fill up the blanks.
   (i) The exchange of gases between tissue blood capillaries and tissue cells is called ______.
   (ii) ______ is caused by the regurgitation of acid from the stomach into the oesophagus.
   (iii) The volume of air inspired or expired during a normal breathing is ______.
   (iv) Chronic obstructive pulmonary disease refers to ______.

<table>
<thead>
<tr>
<th>Column I</th>
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</tr>
</thead>
<tbody>
<tr>
<td>A. Functional Residual</td>
<td>(i) Pepsin</td>
</tr>
<tr>
<td>Capacity</td>
<td>(ii) Elastase</td>
</tr>
<tr>
<td>B. Endopeptidases</td>
<td>(iii) Nucleotidases</td>
</tr>
<tr>
<td>C. Vital capacity</td>
<td>(iv) Chymotrypsin</td>
</tr>
<tr>
<td>D. Pancreatic juice</td>
<td>(v) Tidal volume</td>
</tr>
<tr>
<td>E. Intestinal juice</td>
<td>(vi) Residual volume</td>
</tr>
<tr>
<td></td>
<td>(vii) Inspiratory reserve volume</td>
</tr>
<tr>
<td></td>
<td>(viii) Trypsinogen</td>
</tr>
<tr>
<td></td>
<td>(ix) Nucleosidases</td>
</tr>
<tr>
<td></td>
<td>(x) Expiratory reserve volume</td>
</tr>
</tbody>
</table>

(a) A-(vi, x), B-(i, iv), C-(v, vii, x), D-(ii, vii), E-(iii, ix)
(b) A-(v, vii, x), B-(iii, iv), C-(vi), D-(i, ii), E-(viii, ix)
(c) A-(v), B-(i, iv), C-(vi, vii, x), D-(ii, iii), E-(viii, ix)
(d) A-(vi, vii, x), B-(i, iv), C-(v), D-(viii, ix), E-(ii, iii)
18. Read the given statements and select the correct option.
   Statement 1: Fatty acids and glycerol cannot reach the blood stream directly.
   Statement 2: Fatty acids and glycerol are insoluble in water.
   (a) Both statements 1 and 2 are correct and statement 2 is the correct explanation of statement 1.
   (b) Both statements 1 and 2 are correct but statement 2 is not the correct explanation of statement 1.
   (c) Statement 1 is correct but statement 2 is incorrect.
   (d) Both statements 1 and 2 are incorrect.
19. Match column I with column II. (There can be more than one match for items in column I).

<table>
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<td>B. Endopeptidases</td>
<td>(iii) Nucleotidases</td>
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<tr>
<td>C. Vital capacity</td>
<td>(iv) Chymotrypsin</td>
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<td>D. Pancreatic juice</td>
<td>(v) Tidal volume</td>
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<td>E. Intestinal juice</td>
<td>(vi) Residual volume</td>
</tr>
<tr>
<td></td>
<td>(vii) Inspiratory reserve volume</td>
</tr>
<tr>
<td></td>
<td>(viii) Trypsinogen</td>
</tr>
<tr>
<td></td>
<td>(ix) Nucleosidases</td>
</tr>
<tr>
<td></td>
<td>(x) Expiratory reserve volume</td>
</tr>
</tbody>
</table>

(a) A-(vi, x), B-(i, iv), C-(v, vii, x), D-(ii, vii), E-(iii, ix)
(b) A-(v, vii, x), B-(iii, iv), C-(vi), D-(i, ii), E-(viii, ix)
(c) A-(v), B-(i, iv), C-(vi, vii, x), D-(ii, iii), E-(viii, ix)
(d) A-(vi, vii, x), B-(i, iv), C-(v), D-(viii, ix), E-(ii, iii)
20. Read the given statements.
   I. Partial pressure of oxygen in inspired air is 104 mm Hg.
   II. CO₂ is less soluble in venous blood than in arterial blood.
   III. Liver is the chief site for deamination.
   IV. Pepsin cannot hydrolyse milk proteins.
   Of the above statements
   (a) I, II and III are correct
   (b) III and IV are incorrect
   (c) I, II and IV are incorrect
   (d) Only I is correct.
21. During CO₂ transport, HCO₃⁻ diffuses from erythrocytes to plasma and in turn upsets the ionic balance momentarily. In order to maintain the ionic balance, Cl⁻ pass into the erythrocytes from plasma. The process is known as
(a) Hamburger’s phenomenon
(b) bicarbonate shift
(c) carbonation
(d) Bohr’s effect.

22. Read the given statements and select the correct option.

Statement 1 : CO₂ passes from the blood to the alveoli.
Statement 2 : pCO₂ is higher in deoxygenated blood than in alveoli.
(a) Both statements 1 and 2 are correct and statement 2 is the correct explanation of statement 1.
(b) Both statements 1 and 2 are correct but statement 2 is not the correct explanation of statement 1.
(c) Statement 1 is correct but statement 2 is incorrect.
(d) Both statements 1 and 2 are incorrect.

23. The person suffering from X needs adequate amount of proteins, fats and carbohydrates. X refers to
(a) scurvy
(b) keratomalacia
(c) marasmus
(d) kwashiorkor.

24. Which of the following is incorrect about the given graph?
(a) Increase in partial pressure of CO₂ shift the curve to right.
(b) At low temperature the curve shifts to left.
(c) At high pH the curve shifts to right.
(d) Decrease in partial pressure of oxygen shifts the curve to right.

25. A limit of gaseous exchange of respiratory membrane between alveoli and pulmonary blood is known as
(a) partial pressure
(b) alveolar air
(c) diffusing capacity
(d) inspired air.

26. Every A of deoxygenated blood delivers approximately B of CO₂ to the alveoli.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>(a) 100 mL</td>
<td>4 mL</td>
</tr>
<tr>
<td>(b) 50 mL</td>
<td>13 mL</td>
</tr>
<tr>
<td>(c) 70 mL</td>
<td>2 mL</td>
</tr>
<tr>
<td>(d) 80 mL</td>
<td>0.5 mL</td>
</tr>
</tbody>
</table>

27. Which of the statements given below is/are incorrect?
I. Pneumonia is caused by Corynebacterium.
II. Fat is more suitable as a stored food than glycogen.
III. Emphysema is an abnormal distention of bronchioles of the lungs.
IV. Galactose is the most rapidly transported disaccharide.
V. Swallowing is controlled by swallowing centre located in hypothalamus region of the brain.
(a) II and III only
(b) I, II and V only
(c) I, III, IV and V only
(d) I, IV and V only

28. Given table shows differences between vital capacity and total lung capacity.

<table>
<thead>
<tr>
<th></th>
<th>Vital capacity</th>
<th>Total lung capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>It is the amount of air which can be inhaled forcefully.</td>
<td>It is the extra volume of air that can be breathed out.</td>
</tr>
<tr>
<td>II.</td>
<td>It is sum total of TV + IRV + ERV.</td>
<td>It is sum total of VC + RV.</td>
</tr>
<tr>
<td>III.</td>
<td>It varies from 2500-3000 mL.</td>
<td>It varies from 3400 to 4800 mL.</td>
</tr>
</tbody>
</table>

Select the correct differences between them.
(a) I and II only
(b) I and III only
(c) II only
(d) I, II and III

29. What is the partial pressure of O₂ when blood is entering and leaving the alveolar capillaries respectively?
(a) 95 mmHg, 40 mmHg
(b) 80 mmHg, 45 mmHg
(c) 75 mmHg, 40 mmHg
(d) 86 mmHg, 35 mmHg

30. Select the correct sequence for the process of expiration.
(a) Alveoli → Bronchi → Trachea → Pharynx → Nasal cavities → Internal nares → External nares
(b) Alveoli → Bronchi → Trachea → Larynx → Pharynx → Internal nares → Nasal cavities → External nares
(c) Bronchi → Alveoli → Trachea → Pharynx → Larynx → Internal nares → Nasal cavities → External nares
(d) Bronchi → Alveoli → Trachea → Internal nares → Larynx → Pharynx → Nasal cavities → External nares
31. Given below are some disorders. Identify the respiratory disorders among them.
   (i) Diphtheria  (ii) Cheilosis  (iii) Silicosis  (iv) Fluorosis  (v) Coryza  (vi) Sprue
   (a) (ii), (iii) and (iv) only  (b) (iv), (v) and (vi) only  (c) (i), (iii) and (v) only  (d) (ii) and (iv) only

32. Refer to the given figure and select the correct option, which correctly identifies the label.
   (a) A-Alveolar ducts, B-Alveoli, C-Venule, D-Arteriole, E-Blood capillaries
   (b) A-Alveoli, B-Alveolar ducts, C-Arteriole, D-Blood capillaries, E-Venule
   (c) A-Arteriole, B-Alveoli, C-Alveolar ducts, D-Venule, E-Blood capillaries
   (d) A-Alveoli, B-Arteriole, C-Venule, D-Blood capillaries, E-Alveolar ducts

33. Which of the following reactions is correct?
   (a) Lactose $\xrightarrow{Lactase}$ Glucose + Fructose
   (b) Fat $\xrightarrow{Bile}$ Fatty acid + Glycerol
   (c) $\text{CO}_2 + \text{H}_2\text{O} \xrightarrow{\text{Carbonic anhydrase}} \text{H}_2\text{CO}_3 \xrightarrow{\text{Carbonic anhydrase}} \text{HCO}_3^- + \text{H}^+$
   (d) None of these

34. The outer covering which encloses the lungs is
   (a) parietal pleura  (b) visceral pleura  (c) mediastinum  (d) peritonium

35. A flap like structure which checks the entry of food into opening of windpipe is
   (a) glottis  (b) epiglottis  (c) Adam’s apple  (d) hyoid bone.

36. When diaphragm of man is completely dome shaped it indicates
   (a) end of expiration and beginning of inspiration  (b) beginning of expiration and end of inspiration
   (c) hyperpnea  (d) dyspnea.

37. A film of thin membrane which lowers the surface tension and keeps the alveoli open is
   (a) laryngeal prominence  (b) lecithin  (c) pleural membrane  (d) schneiderian membrane.

38. Read the given statements and select the correct option.
   Statement 1 : Glucagon is a diabetogenic hormone.
   Statement 2 : Glucagon hormone converts glycogen into glucose in the liver.
   (a) Both statements 1 and 2 are correct and statement 2 is the correct explanation of statement 1.
   (b) Both statements 1 and 2 are correct but statement 2 is not the correct explanation of statement 1.
   (c) Statement 1 is correct but statement 2 is incorrect.
   (d) Both statements 1 and 2 are incorrect.

39. Which enzyme acts as an antibacterial agent of saliva?
   (a) Ptyalin  (b) Lysozyme  (c) $\alpha$-Dextrinase  (d) Sucrase

40. What is the primary function of pneumotaxic centre?
   (a) To limit inspiration  (b) To limit expiration  (c) Send chemical signals  (d) Maintain body temperature

---

**Check your score! If your score is**

<table>
<thead>
<tr>
<th>No. of questions attempted</th>
<th>No. of questions correct</th>
<th>Marks scored in percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**EXCELLENT WORK !** You are well prepared to take the challenge of final exam.

**GOOD WORK !** You can score good in the final exam.

**SATISFACTORY !** You need to score more next time.

**NOT SATISFACTORY !** Revise thoroughly and strengthen your concepts.
A disease is a particular abnormal, pathological condition that affects part or all of an organism. It is often construed as a medical condition associated with specific symptoms and signs.

In humans, “disease” is often used more broadly to refer to any condition that causes pain, dysfunction, distress, social problems, or death to the person afflicted, or similar problems for those in contact with the person.

A symptom is a sensation or change in health experienced by a patient e.g., fatigue, pain, nausea, etc.

Pathogen (pathos-disease, gen-causing) refers to an organism that causes certain diseases in animals and plants, e.g., bacteria, virus, fungi, etc.

Vectors are the carriers that do not cause disease themselves but transmit the disease causing pathogens from infected person to a healthy person, e.g., female Anopheles mosquito is the vector of malarial pathogen, Plasmodium.

Pathogens cause diseases in two ways:

- **Tissue damage**
  - The bacteria responsible for tuberculosis, damage cells and cause lesions in the lungs.
  - The bacteria that cause meningitis attack the protective membranes, called meninges, covering the brain.

- **Toxin secretion**
  - Many microbes produce powerful poisons, called toxins which cause diseases.

Types of toxins:

- **Exotoxins**
  - These are released as soon as they are produced.
  - The diseases brought about by exotoxins include tetanus, diphtheria and botulism (food poisoning).

- **Endotoxins**
  - These are retained in the bacterial cells and released when bacteria die and disintegrate.
  - The diseases caused by endotoxins include typhoid fever, cholera, bubonic plague and dysentery.
**Types of Diseases**

**Congenital Diseases**
Diseases which a person has already contracted at birth.

**Acquired Diseases**
Diseases which are contracted after birth due to various factors like infection, degeneration, diet, etc.

**Hereditary/Genetic Diseases**
These are caused either due to single gene mutation e.g., albinism, haemophilia, colour blindness etc. or chromosomal aberrations e.g., Down’s syndrome, Turner’s syndrome, etc.

**Diseases due to environmental factors**
These are caused due to influence during the embryonic development e.g., cleft palate, hair lip, etc.

**Communicable/Infectious diseases**
These diseases are caused by pathogens and can spread from infected person to a healthy one.

**Non-communicable/Non-infectious diseases**
These diseases remain confined to the persons who develop them and do not spread to others.

**Contagious diseases**
Pathogen is transferred to a healthy person through contact e.g., ringworm.

**Non-contagious diseases**
Pathogen spreads through a vector or vehicle, blood, serum, foot, etc.

**Deficiency diseases**
These are produced due to deficiency of nutrients, minerals, vitamins and hormones e.g., kwashiorkor, beriberi, goitre, etc.

**Mental disorders**
These include emotional instability, behavioural dysregulation, cognitive dysfunction or impairment e.g., depression, anxiety disorder, schizophrenia, etc.

**Allergies**
These are caused when body becomes hypersensitive to certain foreign substances e.g., rhinitis.

**Organic diseases**
These are caused due to physical or physiological changes of some tissue or organ of the body e.g., heart diseases, epilepsy, etc.

**Cancers**
These are caused by an uncontrolled growth of certain tissues e.g., breast cancer, lung cancer, etc.

**Addictions**
These are due to drug abuse, alcohol or tobacco, e.g., liver cirrhosis, etc.

**Flow chart: Classification of Diseases**

**Transmission of Diseases**

Diseases can be transmitted in following ways:

**Modes of Transmission of Diseases**

**Direct Transmission**
The pathogens are carried directly to the human body without intermediate agents.

Various ways are

- **Direct physical contact**
  E.g., Chicken pox

- **Droplet contact**
  By sneezing, coughing, spitting and talking e.g., diphtheria, influenza, measles.

- **Contact with soil**
  E.g., Bacteria responsible for tetanus.

- **Arthropod vectors**
  E.g., Typhoid, cholera by housefly.

- **Vehicle borne methods**
  E.g., AIDS, Hepatitis-B by blood.

- **Air borne methods**
  E.g., Epidemic typhus

- **Through placenta**
  E.g., German measles and syphilis

- **Animal bites**
  E.g., Rabies

- **Fomite-borne methods**
  E.g., Influenza

- **Human carriers**
  E.g., Diphtheria, typhoid

**Indirect Transmission**
The pathogens are carried through some intermediate agents.

Various ways are

**Flow chart: Transmission of Diseases**
Communicable Diseases

- Communicable diseases are classified into nine types according to the nature of pathogen i.e., the disease causing agent.

Viral Diseases

Viral hepatitis

- Viral hepatitis is commonly called jaundice.
- In early stage, the liver is enlarged and congested. In later stage, the liver becomes smaller, yellowish or greenish.
- The symptoms in early phase include – fever, anorexia, nausea, vomiting, epigastric discomfort, pains in muscles and joints.
- The urine is dark in colour. Leukopenia (reduction in the number of WBCs) is followed by lymphocytosis (increase in the number of lymphocytes). Splenic enlargement is sometimes present.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Pathogen</th>
<th>Mode of transmission/Incubation period</th>
<th>Symptoms</th>
<th>Prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Dengue fever</td>
<td>Flavivirus</td>
<td>By bite of Aedes aegypti mosquito/3-8 days</td>
<td>Fever, headache, muscles and joint pains, rashes, nausea, vomiting, excessive thirst, bleeding from nose, mouth, gums</td>
<td>Eliminating mosquito breeding places and applying mosquito repellents.</td>
</tr>
<tr>
<td>2. Common cold</td>
<td>Rhinovirus</td>
<td>Droplet contact/3-7 days</td>
<td>Nasal congestion, running nose, sneezing, sore throat, cough, fever, headache</td>
<td>Washing hands frequently and using face masks.</td>
</tr>
<tr>
<td>3. Mumps</td>
<td>Paramyxovirus</td>
<td>Droplet contact/7-18 days</td>
<td>Fever, painful swelling of parotid glands</td>
<td>Avoiding contact with the sick; MMR vaccine is available.</td>
</tr>
<tr>
<td>4. Measles</td>
<td>Rubeola virus</td>
<td>Droplet contact/8-15 days</td>
<td>Fever, rash, itching, inflammation of respiratory passage</td>
<td>Same as that of mumps.</td>
</tr>
<tr>
<td>5. Chicken pox</td>
<td>Varicella zoster virus</td>
<td>Direct contact and droplet contact/14-21 days</td>
<td>Fever, rash which changes into vesicles, pustules and then brown scab which falls off</td>
<td>Scabs should be collected and burnt, soiled articles should be washed and boiled. Vaccine is available.</td>
</tr>
<tr>
<td>6. Smallpox</td>
<td>Variola virus</td>
<td>Direct contact and droplet contact/12 days</td>
<td>High fever, chill, headache, vomiting, rash that turn into scabs that fall off</td>
<td>Same as that of chicken pox.</td>
</tr>
<tr>
<td>7. Poliomyelitis</td>
<td>Polio virus</td>
<td>Contaminated food and water/7-14 days</td>
<td>Stiffness of neck, paralysis of skeletal muscles, fever, headache, pain</td>
<td>Avoiding contaminated food and water. Salk vaccine and OPV vaccine available.</td>
</tr>
<tr>
<td>8. Swine flu</td>
<td>Swine influenza (H1N1) viruses</td>
<td>Droplet contact</td>
<td>Fever, cough, bodyaches, headache, chills</td>
<td>Avoiding close contact with the sick. Vaccine is available.</td>
</tr>
<tr>
<td>9. SARS (Severe Acute Respiratory Syndrome)</td>
<td>Coronavirus</td>
<td>Droplet contact/2-7 days</td>
<td>Fever, chills, muscleache, cough, dizziness, running nose, vomiting, diarrhoea</td>
<td>Avoiding contact with the sick.</td>
</tr>
</tbody>
</table>
Bacterial Diseases

Typhoid
• Typhoid is a common bacterial disease caused by a rod-like bacterium, *Salmonella typhi*, which is commonly found in the intestine of man.

Mode of transmission
• Typhoid spreads through food and water contaminated with faeces of the patient. House flies may carry the pathogens from the faeces to the food, milk and water.
• Incubation period varies from 1-3 weeks (average 2 weeks).

Symptoms
• This disease is characterised by the inflammation of ileum and colon, enlargement of liver and spleen, abdominal pain, pea-soup diarrhoea which may become haemorrhagic, constant fever, extreme weakness, vomiting, rash of rose coloured spots called rose spots on the upper abdomen and sore throat.
• Typhoid is diagnosed by Widal test.

Prevention and Treatment
- Isolation and hygienic disposal of faeces
- Proper sewage treatment
- Purification of water supplies
- Reduction in contamination of food by personal hygiene and control of flies
- Giving TAB vaccine which provide immunity for about 3 years
- Antibiotics like ampicillin and chloramphenicol

Anthrax
• Anthrax is an acute infectious disease caused by air-borne, spore-forming, rod-like, non-motile bacterium, *Bacillus anthracis*.
• Anthrax spores can be produced in a dry form which can be stored as particles that can be used in biological warfare.

Mode of transmission
• Infected animals shed a large number of bacilli (bacteria) in the discharges from the mouth, nose and rectum which sporulate in the soil. These spores act as source of infection.
• It requires thousands of spores to cause human infection. Anthrax does not spread from human to human.

Symptoms
• Initial symptoms resemble those of common cold. Later there is difficulty in breathing, cough, fever, fast pulse and cardiovascular collapse.
• If left untreated, anthrax in all forms can lead to septicemia and death.

Prevention and treatment
• The only known effective prevention against anthrax is the anthrax vaccine, which was developed from an attenuated strain of *B. anthracis*.
• A suitable antibiotic like ciprofloxacin is quite effective, particularly if used in the initial stages of disease. But in cattle, ciprofloxacin may be effective only in chronic area.

Table: Other bacterial diseases

<table>
<thead>
<tr>
<th>Disease</th>
<th>Pathogen</th>
<th>Mode of transmission/ Incubation period</th>
<th>Symptoms</th>
<th>Control measures/ Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cholera</td>
<td><em>Vibrio cholerae</em></td>
<td>Contaminated food and drinks / 2 - 3 days</td>
<td>Vomiting, dehydration, muscular cramps</td>
<td>Proper sanitation/ORS, tetracycline</td>
</tr>
<tr>
<td>Diarrhoeal diseases</td>
<td><em>E.coli, Shigella, Campylobacter, Salmonella, Clostridium</em></td>
<td>Contaminated food and drinks/variable period</td>
<td>Frequent stools with blood, dehydration, low blood pressure</td>
<td>Proper sanitation/ORS</td>
</tr>
<tr>
<td>Disease</td>
<td>Cause</td>
<td>Mode of transmission</td>
<td>Symptoms</td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
<td>--------------------------------------------</td>
<td>--------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Pneumonia</td>
<td><em>Streptococcus pneumoniae</em>, <em>Haemophilus influenzae</em></td>
<td>Direct contact / 1 - 3 days</td>
<td>Cough, fever, pain in the lungs</td>
<td></td>
</tr>
<tr>
<td>Diphtheria</td>
<td><em>Corynebacterium diphtheriae</em></td>
<td>Droplet infection/2-5 days</td>
<td>Fever, sore throat</td>
<td></td>
</tr>
<tr>
<td>Whooping cough or pertussis</td>
<td><em>Bordetella pertussis</em></td>
<td>Direct contact / 10 - 16 days</td>
<td>Cough, breathlessness and vomiting</td>
<td></td>
</tr>
<tr>
<td>Tuberculosis</td>
<td><em>Mycobacterium tuberculosis</em></td>
<td>Droplet infection and contaminated food and drinks / 3 - 6 weeks</td>
<td>Constant cough, pain in chest, loss of weight and appetite</td>
<td></td>
</tr>
<tr>
<td>Tetanus (Lock jaw)</td>
<td><em>Clostridium tetani</em></td>
<td>Spores enter the wounds / 3 - 25 days</td>
<td>Painful muscular spasms, fever, lock jaw</td>
<td></td>
</tr>
<tr>
<td>Plague (Black death)</td>
<td><em>Pasteurella/Yersinia pestis</em></td>
<td>Bite of infected rat flea <em>Xenopsylla cheopis</em> / 2 - 6 days</td>
<td>Painful buboes, fever, haemorrhages</td>
<td></td>
</tr>
<tr>
<td>Leprosy (Hansen’s disease)</td>
<td><em>Mycobacterium leprae</em></td>
<td>Prolonged direct contact / 2 - 5 years</td>
<td>Infection of skin, wasting of body parts, deformities of fingers, toes, hypopigmentation</td>
<td></td>
</tr>
</tbody>
</table>

**Protozoan Diseases**

- Protozoans are diverse group of eukaryotic, unicellular organisms.
- Human diseases caused by protozoa are relatively few, but are individually of devastating consequences.

**Malaria**

- Malaria is caused by a digenetic (have two hosts to complete its life cycle) protozoan parasite known as *Plasmodium*.
- The primary host is female Anopheles mosquito and secondary host is man.
- Sir Ronald Ross established that malarial parasite is transmitted by the bite of a female *Anopheles* mosquito for which he got Nobel Prize in 1902.

**Mode of transmission**

- The malarial parasite, *Plasmodium* enters the human body as sporozoites (infectious form) through the bite of infected female *Anopheles* mosquito.
- There are four species of *Plasmodium* which causes four main types of malaria in human.

**Types of Malaria**

- **Benign tertian malaria**
  - Caused by *Plasmodium vivax*.
  - Fever recurs after every 48 hours.
  - Incubation period is about 14 days.

- **Quartan malaria**
  - Caused by *P. malariae*.
  - Fever appears after every 72 hours.
  - Incubation period is 28-30 days.

- **Cerebral malaria**
  - Caused by *P. falciparum*.
  - Fever is irregular.
  - Incubation period is 12 days.

- **Mild tertian malaria**
  - Caused by *P. ovale*.
  - Fever recurs in every 48 hours.
  - Incubation period is 14 days.

**Symptoms**

- Malaria is characterised by fever at intervals, sudden acute chillness (cold or rigor stage) accompanied by shivering followed by rise in temperature.
- Peak fever (hot or febrile stage) is 41.1°C or 106°F which persists for 3-6 hours. After 2-4 hours of fever, there is profuse sweating (sweating or defervescence stage) which lowers the body temperature to near normal.
- Malaria is also accompanied by nausea, headache, laziness and muscular pains. It also results in anaemia and splenomegaly.
Fig.: Life cycle of *Plasmodium*

**Prevention and Treatment**
- Spraying DDT, BHC and other insecticides
- Fitting doors and windows with wire nets
- Using mosquito nets and repellants
- Use of drugs like chloroquine, quinine, primaquine etc.

**Table: Other protozoan diseases**

<table>
<thead>
<tr>
<th>Disease</th>
<th>Pathogen</th>
<th>Mode of transmission/Incubation period</th>
<th>Symptoms</th>
<th>Control measures /Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amoebiasis</td>
<td><em>Entamoeba histolytica</em></td>
<td>Faecal - oral route, sexual contact, vectors e.g., flies / 2-4 weeks</td>
<td>Abdominal pain, diarrhoea, blood in faeces.</td>
<td>Sanitary disposal of faecal matter / Emetine, stremetine, metronidazole and tinidazole.</td>
</tr>
<tr>
<td>Giardiasis</td>
<td><em>Giardia intestinalis</em></td>
<td>Contaminated food and water / 1-3 weeks</td>
<td>Epigastric pain, headache, diarrhoea.</td>
<td>Clean food and water/Metronidazole, tinidazole.</td>
</tr>
<tr>
<td>African sleeping sickness or Trypanosomiasis</td>
<td><em>Trypanosoma sp.</em></td>
<td>Biting of tse tse fly <em>Glossina</em> sp./Weeks or months</td>
<td>Swelling of lymphatic glands, recurrent fever, anaemia, patient falls asleep</td>
<td>Pentamidine, atoxyl, tryparsamide, germanin.</td>
</tr>
<tr>
<td>Kala-azar or Dum-dum fever</td>
<td><em>Leishmania donovani</em></td>
<td>Bite of sandfly <em>Phlebotomus argentipes</em> / 3-6 months</td>
<td>High fever, spleen enlargement, anaemia, darkening of skin.</td>
<td>Sodium antimony tartrate, glyconate, urea stebamine, neostibosan.</td>
</tr>
</tbody>
</table>

**Helminthic Diseases**
- Helminths are animals that belong to the Phylum *Platyhelminthes* (flatworms) and *Nematoda* (roundworms).
- Many parasitic forms of this group, popularly known as *parasitic worms*, are endoparasites of gut and blood in human body and cause various diseases called as *helminthiasis*.
### Table: Helminthic diseases

<table>
<thead>
<tr>
<th>Disease</th>
<th>Pathogen</th>
<th>Mode of transmission</th>
<th>Symptoms</th>
<th>Prevention / Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taeniasis</td>
<td><em>Taenia solium</em>, <em>Taenia saginata</em></td>
<td>Raw or under-cooked pork or beef.</td>
<td>Abdominal pain, nausea, anaemia, indigestion, epilepsy.</td>
<td>Pork or beef to be cooked properly before eating / Camoquin and atabrin</td>
</tr>
<tr>
<td>Ascariasis</td>
<td><em>Ascaris lumbricoides</em></td>
<td>Contaminated food or water containing <em>Ascaris</em> eggs.</td>
<td>Diarrhoea, vomiting, impaired digestion, inflammation of alveolar tissues, leucocytosis.</td>
<td>Preventing exposure to unhygienic conditions / Chenopodium oil, tetrachloroethylene.</td>
</tr>
<tr>
<td>Filariasis</td>
<td><em>Wuchereria bancrofti</em>, <em>W. malayi</em></td>
<td>Bite of <em>Culex</em> mosquito.</td>
<td>Swelling of feet, legs, thighs, scrotal sacs, breast.</td>
<td>Take precautions against mosquito bites / Albendazole, hetrazan, diethyl carbamazine (DEC).</td>
</tr>
<tr>
<td>Ancylostomiasis</td>
<td><em>Ancylostoma duodenale</em></td>
<td>Juveniles penetrate through skin of hands and feet.</td>
<td>Gastrointestinal disturbances, anaemia, nervous disorders.</td>
<td>Proper sanitation and hygiene / Tetrachloroethylene and carbon tetrachloride.</td>
</tr>
</tbody>
</table>

### Fungal Diseases
- The fungal diseases of man are either **mycoses** (caused by infection of fungi) or **toxicoses** (caused by toxic fungal metabolites).

### Ringworm or Tinea
- Fungi belonging to genera *Trichophyton*, *Epidermophyton* and *Microsporum* are responsible for ringworm or tinea in man.

#### Mode of transmission
- The infection is generally acquired from soil or by using towels, clothes or even the comb of infected persons.

#### Symptoms
- The lesions of ringworm may form partial or complete rings.
- There are dry scaly lesions on skin, nails and scalp that cause intense itching. Heat and moisture promote growth of these fungi especially in skin folds (*e.g.*, groin, between toes).

#### Prevention and treatment
- Maintaining sanitation and hygiene are the best methods of preventing these diseases.
- These can be cured by **griseofulvin** (orally) and **miconazole** (topically).

### NON-COMMUNICABLE DISEASES
- These diseases are not transmitted from infected persons to healthy persons.

### IMMUNITY
- Immunity is the ability of the body to protect against all types of foreign bodies like bacteria, virus, toxic substances, etc., which enter the body. It is also called disease resistance. The lack of immunity is known as **susceptibility**.
- The study of body’s defence mechanism against pathogens is called **immunology**.
- Edward Jenner (1749 - 1823) is known as **Father of Immunology**.
Components of Acquired Immunity

It has two components:

1. **Antibody mediated immune system (AMIS) or humoral immunity**
   - It consists of antibodies that circulate in the body fluids like blood plasma and lymph.
   - B-lymphocytes or B-cells produce antibodies and that regulate antibody mediated or humoral immunity.
   - T-lymphocytes do not secrete antibodies but help B lymphocytes to produce them.

2. **Cellular immunity or cell-mediated immune system or T-cell immunity (CMIS)**
   - T lymphocytes or T-cells are produced in the bone marrow and mature in thymus.
Antigen enters body

T-cells produce many more T-cells that are sensitised to the antigen.

Some T-cells attach to the cell that has the antigen and destroy it (cytolysis).

Other T-cells "remember" the antigen.

These T-cells also stimulate the inflammatory response.

Memory cells cause the production of new T-cells when the same antigen again enters the body.

Function as effector

Flow chart: Functioning of Cell-mediated Immunity

- **Antigen presenting cells** (APCs) are specialised cells which include macrophages, B-lymphocytes and dendritic cells (e.g., Langerhans cells of epidermis of skin).
- **Antibodies** are immunoglobulins (Igs) which are produced in response to antigenic stimulation.
- **Antigens** are substances which when introduced into the body, stimulate the production of antibodies.
- **Immunoglobulins** are glycoproteins made up of four polypeptide chains (linked by disulphide bonds)—two heavy (H) (440 amino acids) and two light (L) (220 amino acids).

**Types of immunoglobulins**

- **IgG** (Eg. Abundant antibody.
  - Predominant antibody in the secondary response.
  - Only antibody to cross the placenta.
  - Ospnizes i.e., enhance phagocytosis.
  - Fixes complements.

- **IgM (Macroglobulin)**
  - Largest antibody.
  - Produced early in the primary response.
  - Most efficient in agglutination, complement fixation.

- **IgA (Secondary immunoglobulin)**
  - Second most abundant antibody.
  - Found in body secretions including saliva and tears.
  - Available in colostrum (first milk secreted by a mother).
  - Localised protection in external secretions.

- **IgE**
  - Least abundant.
  - Bound to mast cells and basophils throughout the body.
  - Mediate immediate hypersensitivity
  - Involved in allergic reactions.

**Immune Response**

- The specific reactivity induced in a host by an antigenic stimulus is known as the immune response.

**Immune System in the Body**

- The human immune system comprises of lymphoid organs, tissues and soluble molecules such as antibodies.
- Lymphoid organs are those organs where the maturation and proliferation of lymphocytes takes place. The structurally and functionally diverse lymphoid organs and tissues are interconnected by the blood vessels and lymphatic vessels through which lymphocytes circulate.
**VACCINATION AND IMMUNISATION**

- Vaccine (L. *vacca* = cow) is a preparation/suspension or extract of dead/attenuated (weakened) germs of a disease which on inoculation (injection) into a healthy person provides temporary/permanent active/passive immunity by inducing antibodies formation.
- The process of introduction of vaccine into an individual to provide protection against a disease is called *vaccination*.
- *Immunisation* is the process by which the body produces antibodies against the vaccine preventable diseases through administration of specific vaccines.

**ORGAN TRANSPLANT**

- Transplantation involves the removal of damaged/injured tissues or organs from the body of a person and their substitution by similar tissues/organs from a donor.
- Tissue matching and blood group matching are essential before undertaking any graft/transplant. Sometimes, the immune system may reject the transplanted organ by recognising its protein as foreign. Therefore, patient has to take immuno-suppressants (drugs) to prevent organ rejection throughout the life.
- The success of tissue and organ transplants depends on the donor’s and recipient’s human leucocyte antigens (HLA) encoded by the HLA genes. The genes for the HLA proteins are clustered in the major histocompatibility complex (MHC), located on the short arm of chromosome 6.

**DISORDERS OF IMMUNE SYSTEM**

**Hypersensitivity (Allergy)**

- Hypersensitivity or allergy is the excessive immune response to common antigens, called allergens.
- Allergy is due to the release of chemicals like histamine and serotonin from the mast cells.
Common examples of allergens are mites in dust, pollens, animal dander, etc.

Symptoms of allergic reactions include sneezing, watery eyes, running nose and difficulty in breathing.

The use of drugs such as antihistamines, adrenaline and steroids quickly reduce the symptoms of allergy.

Common examples of allergy are hay fever and asthma.

Autoimmunity

Autoimmunity refers to abnormal immune responses in which the immune system fails to properly distinguish between self and non-self and attacks self body part.

When the cells act as antigens in the same body, they are called autoantigens.

Some of the examples of autoimmune disorders and their autoantigens are given in the following table.

<table>
<thead>
<tr>
<th>Disorders</th>
<th>Autoantigens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glomerulonephritis</td>
<td>Kidney cell antigens that resemble Streptococcus bacteria antigens.</td>
</tr>
<tr>
<td>Graves’ disease</td>
<td>Thyroid gland antigens near thyroid stimulating hormone receptor, causing over activity.</td>
</tr>
<tr>
<td>Myasthenia gravis</td>
<td>Receptors for nerve messages on skeletal muscle (acetylcholine receptor).</td>
</tr>
<tr>
<td>Pernicious anaemia</td>
<td>Binding site for vitamin B&lt;sub&gt;12&lt;/sub&gt; on cells lining stomach.</td>
</tr>
<tr>
<td>Rheumatic fever</td>
<td>Heart cell antigens that resemble Streptococcus bacteria antigens.</td>
</tr>
<tr>
<td>Systemic lupus erythematosus (SLE)</td>
<td>Heart, joints, nervous system, blood vessels.</td>
</tr>
</tbody>
</table>

Immunodeficiency Diseases

Immunodeficiencies occur when one or more of the components of the immune system are inactive due to gene mutations, infections, malnutrition or accident.

A person suffering from an immunodeficiency disease is liable to suffer from diseases which normally would not occur (opportunistic diseases).

SCID and AIDS are two common immunodeficiency diseases.

**SCID or Severe Combined Immuno Deficiency**

It is a defect in the specialised white blood cells (B and T-cells) that represents a group of rare, sometimes fatal, congenital disorders characterised by little or no immune response.

**AIDS or Acquired Immuno Deficiency Syndrome**

AIDS is a disorder of cell-mediated immune system of the body. There is a reduction in the number of helper T cells which stimulate antibody production by B-cells.

This results in the loss of natural defence against viral infection.

The infection by human immuno-deficiency virus (HIV) causes AIDS.

The incubation period of AIDS ranges between 6 months to 10 years.

**Transmission of AIDS Virus**

(i) Infection: Virus enters the body of person and reaches macrophages (cells of immune system).

(ii) Reverse transcription: The viral RNA is converted to viral DNA with the help of reverse transcriptase enzyme.

(iii) Integration: Viral DNA is incorporated into the host cell’s DNA and gets replicated.

(iv) Multiplication: The viral DNA replicates along with infected host cell. Thus, the infected macrophages acts as HIV factory.

(v) Assembly of virus: The viral proteins formed are assembled to form new viral particles which are released from the infected cell. They mature and target T-cells of body (destroy them).

(vi) Since the number of helper T lymphocytes decreases in the body, the person starts suffering from infections of bacteria, viruses, fungi and even parasites like *Toxoplasma*.
The patient gets immune deficient and he/she is unable to protect himself/herself against these infections.

- **Symptoms** of HIV infection include fever, lethargy, pharyngitis, nausea, headache, rashes, etc.
- For prevention, one should avoid sharing needles, syringes and should have safe sex.
- Although there is no cure for AIDS, use of certain drugs can prolong the life of AIDS patient.

**Cancer**

- Cancer or malignant neoplasm is a disease of abnormal and uncontrolled proliferation of cells without any differentiation.
- Due to uncontrolled divisions, an abnormal growth called **tumour** occurs.
- **Tumour** or neoplasm is any abnormal swelling, lump or mass in the body. Tumour is of two types: Benign and Malignant.

---

**Types of Cancer**

- **Carcinomas**
  - Mainly derived from epithelial cells.
  - *E.g.*, cervical (cervix is part of uterus) cancer, breast cancer, skin cancer, lung cancer, stomach cancer, etc.

- **Leukaemias**
  - Commonly called as **blood cancers**.
  - Result from excessive formation of WBCs in the bone marrow and lymphatic nodes.

- **Sarcomas**
  - These cancers are located in connective and muscular tissues derived from mesoderm.
  - Include the cancers of bones, cartilages, tendons, adipose tissue, lymphoid tissue and muscles.

- **Melanoma**
  - Cancer of the pigment producing cells especially in the skin (melanocytes).

- **Germ cell tumour**
  - Tumours derived from totipotent cells, found in adults, most often in the testes and ovaries.

- **Blastic tumour**
  - Tumour resembles an immature or embryonic tissue. Many of these tumours are most common in children.

- **Myeloma**
  - Cancer of plasma cells (B-lymphocytes) which are immune system cells in bone marrow that produce antibodies.

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**Causes of cancer**

- Chemical and physical agents that can cause cancer are called **carcinogens**.

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**Oncogenic transformation**

They are the carcinogens which bring about changes in genetic material. They are of two types, *radiations* (X-rays, cosmic rays, UV rays etc.) and *chemicals*.

**Tumour promoters**

They promote proliferation of cells which have undergone oncogenic transformation, *e.g.*, some growth factors, hormones etc.

**Tumour viruses**

Some viruses are known to be involved in oncogenic transformations.

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**Possible symptoms of cancer**

- (i) A lump or hard area in the breast.
- (ii) Unexplained low-grade fever.
- (iii) Unexplained loss of weight.
- (iv) Non-injury bleeding from the surface of the skin, mouth or any other opening of the body.
- (v) Bleeding in vagina at times other than the menstruation.

**Treatment**

- The common approaches for treatment of cancer are surgery, radiation therapy, chemotherapy and immunotherapy.

**ALCOHOL ADDICTION**

- Alcohol refers to ethyl alcohol or ethanol (C₂H₅OH) manufactured by fermentation of sugars.
• Drinking of excessive alcohol that impairs one’s physical, physiological and psychological functions, refers to alcohol abuse. The dependence or addiction of alcohol is called alcoholism and the addict is termed as alcoholic. WHO declared in 1964 that alcoholism is disease.

**Problems Caused by Alcohol**

**Social problems**
- These include absence from work, unemployment, marital (marriage) tensions, child abuse, financial difficulties and problems with law, including violence and traffic offences.

**Psychological problems**
- Heavy drinking causes depression. Suicide attempt is much common in alcoholics than in the rest of society.
- Sexual relationship is usually deteriorated because of impotence or rejection by the partner.

**Physical problems**
- These are variable and can affect virtually any organ in the body.

**DRUG ADDICTION**

• **Drug addiction** or drug abuse is taking drugs for purpose other than clinical use, in amount, concentration or frequency that impairs physical, physiological and psychological functions of the body. The drugs, which are commonly abused are opioids, coca alkaloids and cannabinoids.

**Habituating Drugs**

**Psychotropic drugs**
Mood altering drugs that affect behaviour and mental activity. Includes tranquilisers, sedatives, hypnotics, opioids and stimulants.

**Psychodelic drugs**
Drugs change one’s behaviour, thoughts, feelings and perceptions without any actual sensory stimulus. Includes LSD, mescaline, psilocybine, cannabinoids etc.

• **Opiate narcotics/Opioids** are the drugs derived from dried latex of unripe fruits of poppy plant (*Papaver somniferum*). They are also called pain killers and have narcotic, analgesic, astringent (that causes contraction of body parts) and sedative effect, *e.g.*, opium (afeem), heroin, smack etc.

• **Cocaine** is natural coca alkaloid obtained from leaves of coca (or cocca) plant (*Erythroxylum coca*). Cocaine has vasconstrictor properties and acts as a good local anaesthetic. It is a powerful CNS stimulant. Its overdose causes hallucinations.

• **Hemp** or cannabis compounds (hallucinogenic chemicals) are obtained from leaves, resin and flowering tips (inflorescence) of hemp plant that naturally have sedative effects, *e.g.*, bhang, charas, ganja, marijuana, etc.

• **Tobacco** has volatile poisonous alkaloid called nicotine which causes addiction. High concentration of nicotine paralyses nerve cells and may also lead to heart diseases.

**Addiction and Dependence**

• **Addiction** is a psychological attachment to certain effects such as euphoria and a temporary feeling of well-being that is associated with drugs and alcohol.

• **Dependence** is an adaptive state that develops from repeated drug administration. It can result in withdrawal syndrome (anxiety, nausea, shivering), if the drug is abruptly discontinued.

• Effects/symptoms of drug abuse include reckless behaviour, vandalism, violence, socially inactive, lack of concentration etc.

**Prevention and Control**

• Psychologists, psychiatrists, deaddiction and rehabilitation specialists are available to help individuals who fall in the trap of drug, tobacco or alcohol abuse.

• Teachers and parents should always be careful to look for and identify danger signs that can indicate tendency to go in for addiction.

• Avoid undue pressure on child.
1. Which of the following sets of diseases are autoimmune diseases?
(a) Myasthenia gravis and anaphylaxis
(b) Anaphylaxis and pernicious anaemia
(c) SCID and Addison’s disease
(d) SLE and myasthenia gravis

2. Match the bacterial disease given under Column-I with the causative bacteria given under Column-II. Choose the correct option matching for the two columns.

<table>
<thead>
<tr>
<th>Column-I (Bacterial disease)</th>
<th>Column-II (Causing bacteria)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Pneumonia</td>
<td>p. <em>Vibrio cholerae</em></td>
</tr>
<tr>
<td>B. Citrus canker</td>
<td>q. <em>Mycobacterium leprae</em></td>
</tr>
<tr>
<td>C. Cholera</td>
<td>r. <em>Xanthomonas citri</em></td>
</tr>
<tr>
<td>D. Leprosy</td>
<td>s. <em>Diplococcus pneumoniae</em></td>
</tr>
</tbody>
</table>

(a) A - s, B - p, C - r, D - q
(b) A - s, B - q, C - p, D - r
(c) A - s, B - r, C - q, D - p
(d) A - s, B - r, C - p, D - q

3. Schuffner’s dots are granules found in
(a) *Entamoeba histolytica*
(b) leucocytes
(c) mosquito
(d) RBCs of humans.

4. Thiamine deficiency in alcohol addicts causes Wernicke’s syndrome which is characterised by
(a) double vision
(b) loss of muscular co-ordination
(c) decreased mental function
(d) all of these.

5. Which one of the following is the correct statement regarding the particular psychotropic drug specified?
(a) Morphine leads to delusions and disturbed emotions.
(b) Barbiturates cause relaxation and temporary euphoria.
(c) Hashish causes alteration of thoughts, perceptions and hallucinations.
(d) Opium stimulates nervous system and causes hallucinations.

6. Fear of water, choked throat and depression alternating with moods of excitement are symptoms of
(a) bacterial disease shigellosis
(b) viral disease hepatitis A
(c) viral disease rabies
(d) drug addiction of barbiturates.

7. Select the correct statement regarding immunodeficiency diseases.
(a) The immune system of body destroys its own proteins.
(b) The body is protected from external pathogens.
(c) The defence mechanisms of body become weak.
(d) Addison’s disease and Hashimoto’s thyroiditis are examples of immunodeficiency diseases.

8. Select the mismatched pair.
(a) Yellow fever - Viral disease
(b) Diphtheria - Bacterial disease
(c) Hansen’s disease - Rickettsia disease
(d) Syphilis - Spirochaetal disease.

9. Select the incorrect statements regarding malaria.
(i) Patient suffering from benign tertian malaria experiences fever at an interval of 48 hours.
(ii) *Plasmodium falciparum* cause quartan malaria in primates.
(iii) Sexual stage of *Plasmodium* develop in intestine of mosquito.
(iv) Sporozoites of *Plasmodium* reproduce asexually in human liver cells.
(a) (i) and (ii)
(b) (ii) and (iii)
(c) (iii) and (iv)
(d) (i) and (iv)

10. Identify the incorrect pair.
(a) Melanomas - Cancer of melanocytes
(b) Lipomas - Cancer of lymphoid tissues
(c) Myomas - Cancer of muscles
(d) Leukemias - Cancer of blood cells

11. Which of the following statement is correct regarding atherosclerosis?
(a) In this disease, a lumpy thickness develops on the inner walls of the arteries.
(b) It is a type of coronary heart disease.
(c) The vessels become dilated and more blood reaches heart thus causing hypertension.
(d) In this disease, sclerosis of the coronary arteries occur which causes excess pain in the chest.

### MPP-6 CLASS XI

<table>
<thead>
<tr>
<th>Question</th>
<th>Option</th>
<th>Answer</th>
<th>Key</th>
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<tbody>
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<td>(b)</td>
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<tr>
<td>36.</td>
<td>(a)</td>
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</tbody>
</table>
12. Chagas disease is caused by
(a) Trypanosoma gambiense
(b) Trypanosoma rhodesiense
(c) Trypanosoma cruzi
(d) both (a) and (c)

13. Column I lists the components of body defense system and column II lists the corresponding descriptions. Match the two columns and choose the correct option from those given.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Active natural immunity</td>
<td>p. Complement proteins and interferons</td>
</tr>
<tr>
<td>B. First line of defense</td>
<td>q. Direct contact with the pathogens that have entered inside</td>
</tr>
<tr>
<td>C. Passive natural immunity</td>
<td>r. Surface barriers</td>
</tr>
<tr>
<td>D. Second line of defense</td>
<td>s. Antibodies transferred through the placenta</td>
</tr>
</tbody>
</table>

(a) A - r, B - q, C - s, D - p
(b) A - q, B - r, C - p, D - s
(c) A - q, B - r, C - s, D - p
(d) A - s, B - q, C - p, D - r

14. Which of the following is/are introduced in the drains and ponds to check the spread of mosquito borne diseases?
(i) Gambusia
(ii) Utricularia
(iii) Snail
(iv) Dragon fly
(a) (i) only
(b) (i), (ii) and (iii)
(c) (ii) and (iii)
(d) (i), (ii) and (iv)

15. Identify P, Q, R and S in the following table.

<table>
<thead>
<tr>
<th>Plant</th>
<th>Source</th>
<th>Drug</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Papaver somniferum</td>
<td>Leaves</td>
<td>Morphine</td>
</tr>
<tr>
<td>2. Q</td>
<td>Leaves</td>
<td>Bhang</td>
</tr>
<tr>
<td>3. Erythroxylum coca</td>
<td>Leaves and young twigs</td>
<td>R</td>
</tr>
<tr>
<td>4. S</td>
<td>Fruiting bodies</td>
<td>LSD</td>
</tr>
</tbody>
</table>

(a) Dried leaves (b) Unripe capsules (c) Dried leaves (d) Unripe capsules

16. Which of the following human immunoglobulins can be transferred through placenta?
(a) IgA and IgD
(b) IgE only
(c) IgD and IgM
(d) IgG only

17. Read the given statements and select the correct option.

Statement 1: B-cells form humoral or antibody mediated immune system.
Statement 2: B-cells defend against viruses and bacteria that enter the blood and lymph.
(a) Both statements 1 and 2 are correct and 2 is the correct explanation of statement 1.
(b) Both statements 1 and 2 are correct but statement 2 is not the correct explanation of statement 1.
(c) Statement 1 is correct but 2 is incorrect.
(d) Both statements 1 and 2 are incorrect.

18. A person has contracted fungal infection on skin and nails but not on the hair. He is most likely to be infected by
(a) Trichophyton rubrum only
(b) Epidermophyton floccosum
(c) Microsporum canis
(d) any species of Trichophyton.

19. Which of the following statements is incorrect?
(a) Perforins are chemicals produced by Natural killer cells to create pores in the plasma membrane of the target cells.
(b) Acquired immunity consists of specialised cells and antibodies that circulate in the body fluid.
(c) Humoral immunity provides immunity against cancer.
(d) T-cells defend against pathogens including protists and fungi that enter the cells.

20. Which of the following is incorrectly matched?
(a) Autograft - Grafting of one’s own tissue to another part of the body.
(b) Isograft - Transplantation from a twin brother or sister.
(c) Allograft - Transplantation between individuals of same species with same genetic make up.
(d) Xenograft - Transplantation between animals of different species.

ANSWER KEY
1. (d) 2. (d) 3. (d) 4. (d) 5. (c)
6. (c) 7. (c) 8. (c) 9. (b) 10. (b)
11. (a) 12. (c) 13. (c) 14. (d) 15. (b)
16. (d) 17. (b) 18. (b) 19. (c) 20. (c)
Phytohormones refer to a chemical substances other than nutrient molecules produced naturally in plants. They may be translocated to another region and are capable of regulating one or more physiological reactions, when present in low concentrations.

**Auxin**

- Nature: Weakly acidic growth hormone having an unsaturated ring structure. Auxins refer to natural (IAA, PAA, IAN) and synthetic (Indole 3-butyric acid, NAA, 2, 4-D, 2, 4, 5-T) compounds having similar structure and properties.
- Discovery: Darwin (1880) was first to find sensation of unilateral illumination in the coleoptile tip of canary grass. Later Kogl and Smith (1931) isolated three chemicals from human urine which they named as auxin a, auxin b and hetero auxin. IAA is the universal natural auxin.
- Location: It is found in shoot apices, leaf primordia and developing seeds and is synthesised from amino acid tryptophan, a precursor of IAA or auxins.
- Bioassay: Avena curvature test and root growth inhibition test are done for examining auxin effect.
- Physiological functions:
  - Promotes cell enlargement and division and initiates root formation on stem cuttings.
  - Cambial activity and xylem differentiation is also regulated by auxins.
  - Shows apical dominance i.e., inhibits the growth of lateral buds.
  - Prevents or delays abortion as well as induces synthesis of ethylene.
  - Promotes tropic plant responses like phototropism and geotropism.
  - Shows feminising effect on some plants.
- Commercial uses:
  - In tissue and organ culture to form callus and initiate rooting.
  - To produce parthenocarpic fruits.
  - Auxin like 2, 4-D and 2, 4, 5-T acts as weedicides by being selectively harmful to broad leaved dicot weeds.
  - Induces flowering in litchi and pineapple.
  - NAA increases the number of dwarf shoots and fruits on them.
- Application of cytokinin increases the shelf life of flowers and vegetables, keeping them fresh for longer periods.

**Ethylene**

- Nature: It is the only gaseous phytohormone which stimulates transverse or isodiametric growth but retards the longitudinal one.
- Discovery: R. Gane (1934) found that substance causing ripening was ethylene. But it was recognised as a plant hormone by Cockburn et al. (1935).
- Location: It is found in almost all parts of plants in minimal amount but maximum production occurs during ripening of fruits and in tissues undergoing senescence. It is synthesised from amino acid methionine in plants.
- Bioassay: The 'triple response' of etiolated pea plant and gas chromatographic assay are used as bioassays.
- Physiological functions:
  - Promotes apical dominance and prolongs dormancy of lateral buds but breaks the dormancy of buds, shoots and storage organs.
  - Induces abscission and senescence of various parts i.e., leaves, flowers and fruits etc.
  - Induces epinasty, a phenomenon which decreases the sensitivity to gravity.
  - Helps in root initiation, growth of lateral roots and root hairs.
  - Stimulates flowering in pineapple and other related plants and helps in synchronising fruit set.
  - Induces ripening of fleshy climacteric fruits and dehiscence of dry fruits.
- Commercial uses:
  - Ethylene lamps are used for ripening of fleshy fruits e.g. banana, mango, apple, tomato.
  - Ethylene is used to induce feminising effect e.g., number of female flowers and thus fruits in cucumber.
  - Ethylene also permits thinning of excess flowers and young fruits so as to allow better growth of remaining fruits.

**Gibberellin**

- Nature: Weakly acidic growth hormone having gibbane ring structure. Discovery: Hori and Kurosawa discovered the active substance from filtrate of fungus, Gibberella fujikuroi (causing bakane disease in rice plants) and named it gibberellin. Ga5 was first gibberellin to be isolated in its pure form and remains the most extensively studied.
- Location: The major sites of gibberellin production in plants are embryos, roots and young leaves near the shoot tip. Mevalonic acid (derived from acetyl (Co-A) acts as precursor for synthesis of gibberellins. It is transported through simple diffusion as well as via conducting channels.
- Bioassay: Barley endosperm test and germination of dwarf pea seeds are used as bioassays.
- Physiological functions:
  - Stimulates stem elongation and leaf expansion.
  - Overcome natural dormancy of buds, tubers, seeds etc.
  - Induces elongation of reduced stem or bolting in rosette plants e.g., henbane, cabbage.
  - Promotes seed germination by inducing production of hydrolytic enzymes for solubilising reserve food.
  - Promotes flowering in long day plants during non-inductive period.
  - Controls fruit growth and development as well as induces parthenocarpy.
  - Promotes formation of male flowers on female plants e.g., Cannabis. They can also replace female flowers with male ones on monoeocious plants of cucurbits.
- Commercial uses:
  - Exogenous application of Ga4 and Ga6 mixture to increase the number and size of fruits e.g., apple, grapes, tomato.
  - Production of seedless pomaceous fruits by parthenocarpy.
  - Ga6 delays senescence of fruits and delays its ripening thus, extending its shelf life and storage period.
  - Induces off-season flowering in many long day plants as well as those required vernalisation.
  - Application of gibberellins increases length of stem and yield of sugarcane.
  - Promotes early maturity resulting in seed production in juvenile conifers.

**Abscisic Acid**

- Nature: It is a mildly acidic growth hormone which acts as a general growth inhibitor. It is also called as stress hormone since its production is stimulated under conditions of drought, water logging and adverse environmental conditions.
- Discovery: The hormone was first isolated by Addicott et al. (1963) from cotton bolls. Location: It is found in many parts of the plant but is more abundant in chloroplast of green cells. It is synthesised from mevalonic acid or xanthophyll.
- Bioassay: Rice seedling growth inhibition test and inhibition of α-amylase synthesis in barley endosperm are used as bioassay.
- Physiological functions:
  - Induces dormancy of buds, seeds and underground stems, hence also called as dormin.
  - Promotes abscission of flowers and fruits.
  - Induces senescence of leaves by promoting degradation of chlorophyll and proteins.
  - Stops cambium activity (in vascular cambium) towards the approach of winter.
  - Inhibits seed germination by inhibiting gibberellin mediated amylase formation.
  - It is antagonist to gibberellin and counteracts the effect of growth promoting hormones-auxins and cytokinins.
- Commercial uses:
  - Used as antitranspirant (as application of even closure of stomata), thus, preventing transpiration as well as reducing photosynthesis.
  - Induces flowering in some short day plants, even under unfavourable photoperiods.
  - External application on stem cuttings initiate rooting.
  - Induces parthenocarpic development in rose.
  - Used in prolonging dormancy of buds, storage organs and seeds.

**Cytokinin**

- Nature: These are basic hormones, being derivatives of either aminopurine or phenylurea that promote cytokinesis.
- Discovery: The first cytokinin was discovered from autoclaved herring sperm DNA which stimulated cell division in tobacco pith cells. It is called kinekin and does not occur naturally in plants.
- The first natural cytokinin was obtained from unripe maize grains, zeatin (6-hydroxy 3-methyl trans 2-butenyl aminopurine). It is found in coconut milk.
- Location: It is mainly found in roots, however it is also synthesised in endosperm regions of seeds, growing embryos, young fruits and developing shoot buds.
- Bioassay: Tobacco pith culture, retardation of leaf senescence and excised radish cotyledon expansion are used as bioassays for cytokinins.
- Physiological functions:
  - Promotes cell division.
  - Essential for morphogenesis and differentiation of tissues and organs.
  - Delays senescence by mobilisation of nutrients.
  - Overcome apical dominance caused by auxins and promote lateral bud development.
  - Induces accumulation of salts inside cells and help in phloem transport.
  - Promotes femaleness in flowers.
- Commercial uses:
  - Forms essential component of tissue culture as required for morphogenesis.
  - Application of cytokinin increases the shelf life of flowers and vegetables, keeping them fresh for longer periods.
  - Helps in developing resistance to pathogens and extremes of temperature, in plants.
- Shows senescence of intact plant parts.
1. Which of the following statements is/are incorrect?
   (a) I and II only
   (b) I and II only
   (c) I and IV only
   (d) I, III and IV only

2. Select the correctly matched pair.
   (a) Plasmid - Molecular scissors
   (b) DNAse - Treatment of cystic fibrosis
   (c) Vaccine - Introduced by Murray
   (d) Vitamin C - Golden rice

3. Read the following statements.
   Statement 1: Restriction endonucleases are also called ‘biological scissors’.
   Statement 2: Free sticky ends on ssDNA are joined together by DNA ligases.
   (a) Both statements 1 and 2 are correct and 2 is the correct explanation of 1.
   (b) Both statements 1 and 2 are correct but statement 2 is not the correct explanation of 1.
   (c) Statement 1 is correct but 2 is incorrect.
   (d) Both statements 1 and 2 are incorrect.

4. Read the following statements and select the correct one.
   (a) pBR322 was the first artificial cloning vector.
   (b) Agrobacterium tumefaciens is effectively used as vector for transferring genes to animal cells.
   (c) Interferon-b is produced by fibroblasts and macrophages in response to viral infections.
   (d) Bioweapons are very expensive weapons and have pungent smell.

5. Transgenic microorganism Bacillus amyloliquefaciens have been prepared to produce
   (a) insulin
   (b) amino acid
   (c) hGH
   (d) glucose.

6. Which one of the following is not a correct match?
   (a) DNA ligase - Sealing enzyme
   (b) Transgenic tobacco - Bacillus thuringiensis
   (c) Stirred-tank bioreactor - Nitrogen delivery system
   (d) Biological tool - Vehicle DNA

7. The transferred gene of Brassica napus lead to
   (a) female sterility
   (b) male sterility
   (c) male fertility
   (d) hybridisation.

8. What is the useful character of transgenic plant Flavr Savr ‘tomato’?
   (a) Herbicide tolerant
   (b) Insect resistant
   (c) Increased shelf life
   (d) Rich in vitamin A

9. Select the mismatched pair.
   (a) Transgenic rabbit - ANDI
   (b) Transgenic cow - Rosie
   (c) Transgenic sheep - Tracy
   (d) Transgenic dog - Dogie

10. Who discovered polymerase chain reaction?
    (a) Kary Mullis
    (b) Barbara McClintock
    (c) Collins
    (d) Both (a) and (b)

11. Which of the following methods is/are used in vectorless gene transfer?
    (a) Microinjection
    (b) Transformation
    (c) Insertional inactivation
    (d) Both (a) and (c)
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12. Select the incorrect option regarding PCR.
(a) DNA polymerase used in PCR can withstand temperature of > 90°C.
(b) Taq polymerase is used for DNA synthesis.
(c) It helps in detecting genetic diseases in fetus before birth.
(d) Primers are annealed to ssDNA at temperature of 70° – 80°C.

13. Given figure represents the synthesis of insulin. Select the correct statement regarding it.

(a) Labelled part P consists of four chains A, B, C and D.
(b) Labelled part P matures to form R.
(c) Labelled part S contains 30 amino acids and is not present in mature insulin.
(d) None of these

14. Electroporation involves
(a) promotion of seed germination by induced imbibition of water with electric current
(b) making transient pores in cell membrane to facilitate entry of foreign DNA
(c) purification of saline water with the help of an artificial membrane
(d) passage of sucrose through sieve pores by electrosorption.

15. The production of transgenic animals includes
(a) insertion of desired gene into the vector
(b) introduction of recombinant vector in host cells
(c) separation of desired gene
(d) all of these.

16. Disorder which can be treated by gene therapy is
(a) cancer  (b) sickle cell anaemia  (c) AIDS  (d) syphilis.

17. A technique of separation of molecules on the basis of their size in the presence of an electrical field is called
(a) elution  (b) electroporation  (c) electrophoresis  (d) transformation.

18. Which among the given diseases are caused by bioweapon agents?

(i) Small pox  (ii) Empysema
(iii) Plague  (iv) Asthma
(v) Q-fever  (vi) Viral encephalitis
(a) (i), (ii), (v) and (vi) only
(b) (ii), (iii) and (iv) only
(c) (i), (iv) and (vi) only
(d) (i), (ii), (iv) and (v) only

19. pBR322 is an artificial cloning vector. What does BR stands for?
(a) Baltimore and Ry13  (b) Bacillus and Roundup
(c) Boliver and Rodriguez  (d) Berg and Ry13

20. In vector mediated gene transfer, to increase efficiency of DNA transfer, bacterial cells are treated with
(a) cellulase  (b) polyethylene glycol
(c) calcium  (d) CaCl₂.

21. What is the therapeutic use of the recombinant protein hirudin?
(a) It stimulates wound healing.
(b) It is used as an anticoagulant.
(c) It is used to prevent acute kidney transplantation rejection.
(d) It helps in prevention of hepatitis B.

22. Study the given figure and select the correct statement(s) regarding it.

(i) In step A, the DNA template is heated at 50° to 55°C.
(ii) Step B requires Mg²⁺.
(iii) In step C, repeated amplification is achieved by the use of a thermostable DNA polymerase.
(a) I and II only  (b) II and III only
(c) III only  (d) None of these
23. Which transgenic plant contains β-carotene is?
   (a) Tobacco  (b) Flavr savr  
   (c) Brassica napus  (d) Golden rice

24. Read the statements given below.
   1. Unwinding and activation of siRNA and RISC respectively.
   2. Processing of dsRNAs into 21-23 nucleotide RNAs.
   3. Activated RISC cut the transcripts in an area where siRNA binds to the mRNA.
   4. siRNA integrates with ribonucleases to form RISC.

Select the option which shows correct sequence of steps of RNA interference.
   (a) 3 → 2 → 1 → 4 → 5
   (b) 2 → 4 → 1 → 3 → 5
   (c) 3 → 4 → 5 → 1 → 2
   (d) 2 → 5 → 1 → 3 → 4

25. GEAC stands for
   (a) Genome Engineering Action Committee
   (b) Genetic and Environment Approval Committee
   (c) Ground Environment Action Committee
   (d) Genetic Engineering Approval Committee.

26. Select the correct option to fill up the blanks.
   (i) _____ enzyme helps in the DNA synthesis on DNA template.
   (ii) Chemical knife is the nick-name of _____.
   (iii) Human protein _____ is used to treat emphysema.
   (iv) The first restriction endonuclease was ________.
   (a) (i)-restriction exonuclease, (ii)-DNA polymerase, 
     (iii)-humulin, (iv)-**Bam** HI.
   (b) (i)-DNA polymerase, (ii)-restriction endonuclease, (iii)-
     α-1-antitrypsin, (iv)-**Hind** II
   (c) (i)-Restriction endonuclease, (ii)-alkaline phosphatase, 
     (iii)-α-1-antitrypsin, (iv)-**Eco** RI
   (d) (i)-Alkaline phosphatase, (ii)-restriction exonuclease, 
     (iii)-humulin, (iv)-**Hind** III

27. Cloning vector used for cloning DNA fragments of upto 300 - 350 kb is
   (a) BAC  (b) YAC
   (c) cosmId  (d) phagemid.

28. Which of the following restriction enzymes produce blunt ends?
   (a) **Bam** HI and **Eco** RI  (b) **Hind** II and **Sal** I
   (c) **Hind** III and **Sca** I  (d) **Sma** I and **Alu** I

29. Which of the following sequences is recognised by **Hind** III?
     (c) 3’–G–A–C–C–C–G–G–A–5’  (d) None of these

30. The given table shows differences between types of restriction endonucleases.

<table>
<thead>
<tr>
<th>Type</th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>Enzyme structure is simple.</td>
<td>Enzyme structure consists of 2 different subunits.</td>
<td>Enzyme structure consists of 3 different subunits.</td>
</tr>
<tr>
<td>II.</td>
<td>Require ATP, Mg²⁺ and S-adenosyl-methionine for restriction.</td>
<td>Require Mg²⁺ for restriction.</td>
<td>Require ATP, Mg²⁺ and S-adenosyl-methionine for restriction.</td>
</tr>
<tr>
<td>III.</td>
<td>Not used in rDNA technology.</td>
<td>Used in rDNA technology.</td>
<td>Not used in rDNA technology.</td>
</tr>
</tbody>
</table>

Visit “**MTG IN YOUR CITY**” on www.mtg.in to locate nearest book seller OR write to info@mtg.in OR call 0124-6601200 for further assistance.
Which option shows correct differences?
(a) I only  (b) II only  (c) II and III only  (d) I, II and III

31. Identify the scientist who isolated restriction endonuclease enzyme for first time in bacteria.
(a) W. Arber  (b) Stanley Cohen  (c) H. Smith  (d) D. Nathan

32. Formation of competent host by vector mediated gene involves
(a) bombardment of cells with high velocity microprojectiles coated with DNA  
(b) injection of foreign DNA into nucleus of host cell using microneedles  
(c) formation of pores in plasma membrane of host cell using lysozyme  
(d) incubation of cells containing rDNA on ice, then at 42°C and back on ice.

33. Transgenic animal used for organ transplantation in humans is
(a) dog  (b) sheep  (c) mice  (d) pig.

34. Match the columns and select the correct option.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Monoclonal antibodies</td>
<td>(i) Temin</td>
</tr>
<tr>
<td>B. Selectable markers</td>
<td>(ii) Ampicillin resistance</td>
</tr>
<tr>
<td>C. Reverse transcriptase</td>
<td>(iii) Baltimore</td>
</tr>
<tr>
<td>D. Molecular probes</td>
<td>(iv) Tetracyclin resistance</td>
</tr>
<tr>
<td>E. ELISA</td>
<td>(v) Georges Kohler</td>
</tr>
<tr>
<td></td>
<td>(vi) Single stranded DNA</td>
</tr>
<tr>
<td></td>
<td>(vii) Cesar Milstein</td>
</tr>
<tr>
<td></td>
<td>(viii) Peroxidase</td>
</tr>
<tr>
<td></td>
<td>(ix) Radio isotopes</td>
</tr>
<tr>
<td></td>
<td>(x) Alkaline phosphatase</td>
</tr>
</tbody>
</table>

35. What does ‘d’ stands for in restriction endonuclease Hind II?
(a) Strain Rd  (b) ds DNA  (c) D-galactose  (d) None of these

36. Which of the following is not correct for chromosomal DNA?
(a) It is coated with histone protein.  
(b) It replicates independent of main genome.  
(c) It acts as genetic factor.  
(d) It contains both exons and introns.

37. pBR322 is a
(a) molecular glue  
(b) passenger DNA  
(c) workhouse for gene cloning  
(d) mobile genetic element.

38. Select the correct sequence of major steps involved in gene cloning.
I. Introduction of recombinant DNA into the host.  
II. Isolation of desired DNA fragment containing the gene to be cloned.  
III. Incubation of DNA fragments and digested vector in presence of DNA ligase.  
IV. Cut the vector with restriction endonuclease.
(a) I → II → III → IV  
(b) II → IV → III → I  
(c) II → I → IV → III  
(d) III → I → IV → II

39. Organism X infects all broad-leaved agricultural crops. For genetic engineering, its tumor forming genes are deleted. Here, X is
(a) Bacillus thuringiensis  
(b) Agrobacterium tumefaciens  
(c) Meloidogyne incognita  
(d) Bacillus amyloliquefaciens.

40. Vectors present in both eukaryotic and prokaryotic cells are-
(a) shuttle vectors  
(b) cosmids  
(c) transposons  
(d) phagemids.
CHAPTER-1 : REPRODUCTION IN ORGANISMS

Multiple Choice Questions

1. Which of the following has the shortest life span?
   (a) May fly          (b) Butterfly
   (c) Fruit fly       (d) Both (a) and (c)

2. Select the correct statement.
   (a) During maturity stage, organism develops the capacity
to reproduce.
   (b) A mango tree has a much shorter life span as
       compared to a peepal tree.
   (c) Mode of reproduction does not depend upon the
       habitat of organisms.
   (d) Asexual reproduction occurs only in unicellular
       organisms.

3. Clones are a group of
   (a) morphologically similar individuals
   (b) genetically similar individuals
   (c) both (a) and (b)
   (d) none of these.

4. Asexual reproduction is absent in
   (a) monerans          (b) protists
   (c) vertebrates      (d) both (a) and (b).

5. Who discovered regeneration in \textit{Hydra}?
   (a) Panchanan Maheshwari
   (b) Camerarius
   (c) Abraham Trembley
   (d) Leeuwenhoek

6. Select the incorrect statement.
   (a) Sexual reproduction is usually biparental.
   (b) Zygotic meiosis occurs in \textit{Ulothrix}.
   (c) Gametogenesis is the formation of diploid gametes.
   (d) In internal fertilisation, only the male gametes are
       released from the body.

7. In potato, a meiocyte has 48 chromosomes. What will be
   the number of chromosomes in its somatic cell?
   (a) 96          (b) 24
   (c) 16          (d) 48

8. Select the mismatched pair.
   (a) Dioecious plant - Papaya
   (b) Hermaphrodite - Sweet potato
   (c) Monococious plant - Coconut
   (d) Polycarpic plant - Carrot

9. Which of the following is not an example of rhizome?
   (a) Banana          (b) \textit{Chrysanthemum}
   (c) \textit{Adiantum}  (d) \textit{Aspidium}

10. Which of the following plant flowers once in 12 years?
    (a) \textit{Ophioglossum}
    (b) \textit{Strobilanthes}
    (c) \textit{Bambusa}
    (d) Both (b) and (c)
11. Match Column I with Column II.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Parthenogenesis</td>
<td>Monocystis</td>
</tr>
<tr>
<td>B. Hologamy</td>
<td>Gladiolus</td>
</tr>
<tr>
<td>C. Isogamy</td>
<td>Charles Bonnet</td>
</tr>
<tr>
<td>D. Anisogamy</td>
<td>Chlamydomonas braunii</td>
</tr>
<tr>
<td>E. Micropropagation</td>
<td>Yeast</td>
</tr>
</tbody>
</table>

12. Match Column I with Column II. (There can be more than one match for items in Column I).

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Embryogenesis</td>
<td>Rhizopus</td>
</tr>
<tr>
<td>B. Water hyacinth</td>
<td>Syllis</td>
</tr>
<tr>
<td>C. Chlamydospores</td>
<td>Cell division</td>
</tr>
<tr>
<td>D. Exogenous budding</td>
<td>Vegetative propagation</td>
</tr>
<tr>
<td>E. Plasmotomy</td>
<td>Agaricus, Grows in standing water, Cell differentiation, Opalina, Salpa, Pelomyxa</td>
</tr>
</tbody>
</table>

13. Complete the given passage with appropriate words or phrases.

All organisms have to reach a certain stage of growth and maturity in their life before they can reproduce sexually. This period of growth is called (i) or (ii). The end of (i)(ii) marks the beginning of (iii). After attainment of maturity, all sexual reproducing organisms have remarkable fundamental similarity. Sexual reproduction is also called (iv). The events of sexual reproduction are elaborate and complex, yet follow a regular sequence.

Several organisms belonging to monera, fungi, algae etc., have (v) body. The structures formed by the fusion of gametes is always (vi). In (vi) organisms, specialised cells called (vii) undergo (viii). At the end of (viii), (ix) set of chromosomes gets incorporated into (x).

14. Assertion: During gamete transfer, the number of female gametes produced is several thousand times more than the number of male gametes produced.

Reason: A large number of female gametes get ruptured before getting fertilised by the male gamete.

15. Assertion: Parthenogenesis is a simpler and easier means of reproduction.

Reason: Parthenogenesis permits the establishment of triploid and aneuploid chromosomal combinations.

16. Assertion: In oviparous animals, the chances of survival of young ones are less.

Reason: A hard protective covering is absent around the eggs.

17. Assertion: Asexual reproduction leads to overcrowding.

Reason: Asexual reproduction involves rapid multiplication.

18. Assertion: Zygote is the vital link between one generation and the next.

Reason: Every sexually reproducing organism begins life as a single cell, the zygote.

19. Refer to the given figure and answer the following questions.

(a) Identify the given figure. Which organism reproduces by this method?
(b) Identify the labelled parts A, B and C.
(c) Briefly describe labelled part C.

20. Observe the given figure carefully and answer the following questions.

(a) Identify the labelled parts A, B, C and D.
(b) Define labelled part A. How does A get dispersed?
(c) Give examples of organisms which reproduce by this method.
Multiple Choice Questions

1. Which of the following is not an essential floral organ?
   (a) Androecium (b) Gynoecium (c) Calyx (d) Anther

2. The study of external morphology of mature pollen grains is called
   (a) embryology (b) gerontology (c) palynology (d) pomology.

3. Which of the following is not a function of tapetum?
   (a) It nourishes developing pollen grains.
   (b) It secretes enzyme callase.
   (c) It produces lipid rich Ubisch granules.
   (d) It provides a characteristic sculpturing over the surface of pollen grains.

4. Mature ovules are classified on the basis of funiculus. If micropyle comes to lie close to the funiculus the ovule is termed as
   (a) orthotropous (b) anatropous (c) hemitropous (d) campylotropous.

5. Pollen viability is the period for which pollen grains retain the ability to germinate. What is the pollen viability of rice?
   (a) 2 days (b) 1 month (c) 30 minutes (d) 2 weeks

6. Who among the following recognised the role of insects in pollination?
   (a) Theophrastus (b) Kolreuter (c) Amici (d) Knox

7. The micropylar cells are collectively known as
   (a) egg apparatus (b) antipodal cells (c) help cells (d) megaspore mother cell.

8. Read the following statements and select the correct one.
   (a) The development of male gametophyte begins outside the microsporangium.
   (b) The development of microsporangium is eusporangiate.
   (c) The male gametophyte is 7-celled.
   (d) Chasmogamous flowers undergo only self pollination.

9. In entomophilous flower, odour of *Rafflesia* attracts carrion flies. Which type of mechanism of pollination is demonstrated by its flower?
   (a) Fly trap mechanism (b) Lever mechanism (c) Gun powder mechanism (d) Fail safe mechanism

10. Coconut milk is considered as highly nutritious, since it is rich in
    (a) minerals (b) vitamins (c) proteins (d) all of these.

Match The Columns

11. Match Column I with Column II.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Tetrasporangiate</td>
<td>(i) β-1, 3 glucan</td>
</tr>
<tr>
<td>B. Callose</td>
<td>(ii) Wall of pollen grain</td>
</tr>
<tr>
<td>C. Sporoderm</td>
<td>(iii) Bilobed anther</td>
</tr>
<tr>
<td>D. Connective</td>
<td>(iv) Plant breeding</td>
</tr>
<tr>
<td>E. Pollen banks</td>
<td>(v) Vascular strand</td>
</tr>
</tbody>
</table>

12. Match Column I with Column II. (There can be more than one match for items in Column I).

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Ruminate endosperm</td>
<td>(i) <em>Zostera</em></td>
</tr>
<tr>
<td>B. Hypohydrophily</td>
<td>(ii) Line of dehiscence</td>
</tr>
<tr>
<td>C. Anther</td>
<td>(iii) <em>Passiflora</em></td>
</tr>
<tr>
<td>D. Ovule</td>
<td>(iv) <em>Ceratophyllum</em></td>
</tr>
<tr>
<td>E. Ornithophilous plants</td>
<td>(v) <em>Areca</em></td>
</tr>
<tr>
<td></td>
<td>(vi) Pollen sacs</td>
</tr>
<tr>
<td></td>
<td>(vii) Funiculus</td>
</tr>
<tr>
<td></td>
<td>(viii) <em>Erythrina</em></td>
</tr>
<tr>
<td></td>
<td>(ix) Raphe</td>
</tr>
<tr>
<td></td>
<td>(x) <em>Lobelia</em></td>
</tr>
</tbody>
</table>

Passage Based Question

13. Complete the given passage with appropriate words or phrases.
    (i) is the male reproductive organ of a flower whereas, (ii) represents the female reproductive part of the flower. Transfer of pollen grains to the (iii) of a (ii) is termed as pollination. It is of two types. The transfer of pollen grains from another to the (iii) of same or genetically similar flower is called (iv), while to a genetically different flower is called (v). Plants use either (vi) or (vii) agents to achieve pollination. (viii) determines the suitability of pollen for carrying out the process of sexual reproduction. In (ix), the male gametes are brought to the egg enclosed within female gametophyte by a pollen tube in seed plants. Inability of certain viable gametes to fuse with each other and produce fertile offspring is (x).

Assertion & Reason

In each of the following questions, a statement of Assertion (A) is given and a corresponding statement of Reason (R) is given just below it. Of the statements, mark the correct answer as :
(a) if both A and R are true and R is the correct explanation of A
(b) if both A and R are true but R is not the correct explanation of A
(c) if A is true but R is false
(d) if both A and R are false.

14. **Assertion :** Anemophily requires light and non-sticky pollen grains.
**Reason :** Anemophily is performed by biotic agencies.

15. **Assertion :** Exalbuminous seeds do not exhibit residual endosperm.
**Reason :** Residual endosperm gets completely consumed during embryo development.

16. **Assertion :** Entomophily is specific and directional.
**Reason :** Entomophilous flowers produce fewer pollen grains.

17. **Assertion :** In megasporogenesis, generally a large number of megaspore mother cells are functional in a megasporangium.
**Reason :** Megasporogenesis occurs inside the embryo sac.

18. **Assertion :** Testa is single layered, thick outer covering of seed.
**Reason :** The cells of testa are rich in sclereids.

### Figure Based Questions

19. Refer to the given figure and answer the following questions.

(a) Identify the labelled parts A, B, C, D and E.
(b) What does this figure depict?
(c) Mention important functions of the labelled part A.

20. Study the given figure and answer the following questions.

(a) Identify the labelled parts A, B, C and D.
(b) Define and identify the location of labelled part A.
(c) Differentiate between parts B and D.

### CHAPTER-3 : HUMAN REPRODUCTION

#### Multiple Choice Questions

1. A fibrous cord extending from the caudal end of the testis to the scrotal wall is called
   (a) inguinal canal  (b) gubernaculum  (c) spermatic cord  (d) mesorchium.

2. Which of the following is a source of energy for the sperm?
   (a) Clotting proteins  (b) Prostaglandins  (c) Fructose  (d) Amylase.

3. Read the following statements and select the correct one.
   (a) Graffian follicle consists of lutein cells, fibrin and blood clot.
   (b) Endometrium is involved in the uterine movements.
   (c) The ampulla is the widest and longest part of the Fallopian tube.
   (d) Implantation takes place in the oviduct.

4. The area between labia minora is called X, which is homologous to membranous urethra of male. Identify X.
   (a) Areola  (b) Vestibule
   (c) Clitoris  (d) Mons pubis

5. Which of the following are main constituents of milk?
   (a) Fat, Casein, Lactose  (b) Iron, Vitamins, Sodium  (c) Casein, Iron, Prolactin  (d) Prolactin, Iron, Sodium

6. Rebuilding of endometrium takes place in
   (a) luteal phase  (b) menstrual phase  (c) follicular phase  (d) ovulatory phase.

7. Which of the following is not derived from mesoderm?
   (a) Muscles of iris  (b) Dentine of teeth  (c) Kidneys  (d) Heart

8. Identify and select the incorrect statement regarding acrosomal reaction during fertilisation.
   (a) Acrosomal reaction does not occur in absence of Ca^{2+}.
   (b) Hyaluronidase acts on ground substance of follicle cells.
   (c) Cortical enzymes are released from granules fusing with the membrane of secondary oocyte which harden the zona pellucida, preventing entry of more sperms.
   (d) Optimum pH, Mg^{2+} ions and temperature is essential for acrosomal reaction to occur.

9. Women having higher levels of corticotropin releasing hormone in early pregnancy are more likely
   (a) to deliver after their due date  (b) to deliver prematurely
   (c) to have more chances of abortion  (d) to have more labour pain.
10. Select the mismatched pair.
(a) Menorrhagia - Absence of menstruation
(b) Capacitation - Sperm activation
(c) Ectoderm - Enamel of teeth
(d) Myometrium - Uterine movements

11. Match Column I with Column II.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Oophoritis</td>
<td>(i) Child birth</td>
</tr>
<tr>
<td>B. Parturition</td>
<td>(ii) Pre-menstrual pain</td>
</tr>
<tr>
<td>C. Endometriosis</td>
<td>(iii) Inflammation of ovary</td>
</tr>
<tr>
<td>D. Type B spermatogonia</td>
<td>(iv) Ciliated cells present</td>
</tr>
<tr>
<td>E. Vasa efferentia</td>
<td>(v) Precursor of sperms</td>
</tr>
</tbody>
</table>

12. Match Column I with Column II. (There can be more than one match for items in Column I).

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Testes</td>
<td>(i) Cortex</td>
</tr>
<tr>
<td>B. Sertoli cells</td>
<td>(ii) Epiblast</td>
</tr>
<tr>
<td>C. Ovarian stroma</td>
<td>(iii) Production of sperms</td>
</tr>
<tr>
<td>D. Embryonic disc</td>
<td>(iv) Sperm nutrition</td>
</tr>
<tr>
<td>E. Lactation</td>
<td>(v) Medulla</td>
</tr>
<tr>
<td></td>
<td>(vi) Inhibin</td>
</tr>
<tr>
<td></td>
<td>(vii) Secretion of sex hormone</td>
</tr>
<tr>
<td></td>
<td>(viii) Prolactin</td>
</tr>
<tr>
<td></td>
<td>(ix) Hypoblast</td>
</tr>
<tr>
<td></td>
<td>(x) Oxytocin</td>
</tr>
</tbody>
</table>

13. Complete the given passage with appropriate words or phrases.
The fusion of a sperm with an ovum is called fertilisation.
In human beings, fertilisation takes place in the (i). Male
discharges semen into the female’s vagina during coitus. A
single ejaculation of semen contains (ii). During fertilisation
a sperm comes in contact with (iii) of the ovum. Binding
of the sperm to the secondary oocyte induces (iv) which
prevents (v) and ensures (vi). The secretions of the (vii)
help the sperm enter into the cytoplasm of the ovum. This
induces the completion of (viii) of secondary oocyte. The
(ix) is unequal and results in the formation of a second
polar body and an ootid. The haploid nucleus of the sperm
and ovum fuse together to form (x).

14. **Assertion**: The middle piece of the human sperm is called 'power house of the sperm'.
**Reason**: A ring centriole is present in the middle piece which provide energy for the movement of the sperm.

15. **Assertion**: During oogenesis, oogonia change to primary oocytes.
**Reason**: A primary oocyte divides to form a secondary oocyte and a polar body.

16. **Assertion**: Cleavage involves faster DNA synthesis as compared to mitosis.
**Reason**: In cleavage, nuclear-cytoplasmic ratio increases.

17. **Assertion**: The chorionic fluid serves as a shock absorber.
**Reason**: Chorion surrounding the embryo creates the fluid filled chorionic cavity.

18. **Assertion**: In a mature oocyte, the endoplasmic reticulum membranes are perforated by pores.
**Reason**: The endoplasmic membrane of mature oocyte have usually ribosomes embedded in them.

19. Given diagram shows the T.S. of human testis.

Answer the questions based on the figure.
(a) Identify the labelled parts A, B, C, D and E.
(b) Write a short note on the labelled part B.
(c) What is the function of labelled part C?

20. Study the given diagram and answer the following questions.
(a) Identify A, B, C and D in the given diagram of human placenta.

(b) Write the type of placenta:
   (i) On the basis of intimacy between foetal and maternal parts.
   (ii) On the basis of distribution of villi on chorion.

(c) Name the hormone which is secreted by placenta only. Mention its function also.

**CHAPTER-4 : REPRODUCTIVE HEALTH**

**Multiple Choice Questions**

1. Which of the following is not a temporary method of birth control?
   (a) Vasectomy  
   (b) Use of oral pills  
   (c) Intrauterine devices  
   (d) Lactational amenorrhea

2. Coitus interruptus means
   (a) high chances of fertilisation  
   (b) withdrawal of penis from the vagina  
   (c) preventing implantation of embryo in the uterus  
   (d) inhibition of ovulation.

3. Read the following statements and select the correct answer.
   (a) Immigration is the movement of the individuals out of a place or country.  
   (b) Mortality rate increases population density.  
   (c) Oral contraceptive pills increase the risk of intravascular clotting.  
   (d) Chancroid is a type of STD caused by the pathogen *Treponema pallidum*.

4. Select the mismatched pair of STDs and antibiotics used in treatment.

<table>
<thead>
<tr>
<th>STD</th>
<th>Antibiotic</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Genital Herpes</td>
<td>Erythromycin</td>
</tr>
<tr>
<td>(b) Gonorrhoea</td>
<td>Ciprofloxacin</td>
</tr>
<tr>
<td>(c) Chlamydiasis</td>
<td>Rifampacin</td>
</tr>
<tr>
<td>(d) Candidiasis</td>
<td>Clotrimazole</td>
</tr>
</tbody>
</table>

5. Which of the following method is not used for detection of foetal disorders during early pregnancy?
   (a) Chorionic villi sampling  
   (b) Amniocentesis  
   (c) Artificial insemination  
   (d) Ultrasound imaging

6. Which of the following disease is not diagnosed by ELISA test?
   (a) Genital warts  
   (b) AIDS  
   (c) Hepatitis-B  
   (d) Syphilis

7. The common mode of transmission of Hepatitis-B is/are
   (a) blood transfusion  
   (b) intravenous drug abuse  
   (c) tattooing  
   (d) all of these.

8. Which of the following statements is correct regarding tubectomy?
   (a) It inhibits the production of ova.  
   (b) It prevents the movement of ova.  
   (c) It causes menopause.  
   (d) It results in irregular menstrual bleeding.

9. Amniocentesis is a technique used to
   (a) determine errors in amino acid metabolism in embryo  
   (b) pin point specific cardiac ailments in embryo  
   (c) determine hereditary genetic abnormality in embryo  
   (d) all of these.

10. Which of the following is not a consequence of over population?
    (a) Unemployment  
    (b) Poverty  
    (c) Pollution  
    (d) Surplus food supply

11. Match Column I with Column II.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Non-medicated IUDs</td>
<td>(i) Vault cap</td>
</tr>
<tr>
<td>B. ADAM</td>
<td>(ii) Lippes loop</td>
</tr>
<tr>
<td>C. Barrier method</td>
<td>(iii) Male menopause</td>
</tr>
<tr>
<td>D. Chemical method</td>
<td>(iv) <em>In vivo</em> fertilisation</td>
</tr>
<tr>
<td>E. GIFT</td>
<td>(v) Sponge</td>
</tr>
</tbody>
</table>

12. Match Column I with Column II. (There can be more than one match for items in Column I).

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Hormone releasing IUDs</td>
<td>(i) Saheli</td>
</tr>
<tr>
<td>B. Oral contraceptive</td>
<td>(ii) Coitus interruptus</td>
</tr>
<tr>
<td>C. Natural method</td>
<td>(iii) Pill 72</td>
</tr>
<tr>
<td>D. Emergency contraceptive</td>
<td>(iv) Progestasert</td>
</tr>
<tr>
<td>E. ICSI</td>
<td>(v) Lactogestin amenorrhea</td>
</tr>
<tr>
<td></td>
<td>(vi) Mala D</td>
</tr>
<tr>
<td></td>
<td>(vii) LNG-20</td>
</tr>
<tr>
<td></td>
<td>(viii) TESE</td>
</tr>
<tr>
<td></td>
<td>(ix) I-pill</td>
</tr>
<tr>
<td></td>
<td>(x) MESA</td>
</tr>
</tbody>
</table>

13. Complete the given passage with appropriate words or phrases.
   The rapid increase in population over a relatively short period is called (i). The most important step to overcome this is by using various (ii). They are broadly grouped into
two main types: (iii) and (iv) methods. (v) is generally performed to get rid of unwanted pregnancy and is legalised in our country. Infections which are transmitted through sexual intercourse with infected persons are collectively called (vi). Various methods are now available to help such couples. (viii) followed by (ix) is one of such methods. This method is popularly known as (x).

**Assertion & Reason**

In each of the following questions, a statement of Assertion (A) is given and a corresponding statement of Reason (R) is given just below it. Of the statements, mark the correct answer as:
(a) if both A and R are true and R is the correct explanation of A
(b) if both A and R are true but R is not the correct explanation of A
(c) if A is true but R is false
(d) if both A and R are false.

14. **Assertion**: GIFT technique requires normal Fallopian tubes.
   **Reason**: In GIFT, both the sperm and unfertilised oocytes are transferred into the Fallopian tubes.

15. **Assertion**: Condoms are barrier method of birth control.
   **Reason**: Condoms inhibit the secretion of LH and FSH, hence spermatogenesis stops.

16. **Assertion**: Coitus interruptus may lead to conception.
   **Reason**: Secretion of bulbourethral glands which is released before ejaculation carries some spermatozoa.

17. **Assertion**: In ICSI technique, multiple spermatozoa are injected into the ovum.
   **Reason**: With multiple spermatozoa, rate of successful transplantation increases.

   **Reason**: MTP is comparatively safe upto 12 weeks of pregnancy.

**Figure Based Questions**

19. Consider the given diagram and answer the following questions.

(a) Identify A and B methods of birth control.
(b) Describe A and B briefly.
(c) Mention one drawback of these methods.

20. Refer to the given diagram and answer the following questions.

(a) Identify the given figure and mention the type of contraceptive method to which it belongs.
(b) How does this device help in contraception?
(c) What are the drawbacks of this device?
CHAPTER-2: SEXUAL REPRODUCTION IN FLOWERING PLANTS

1. (c) 2. (c) 3. (d) 4. (b) 5. (c) 6. (b) 7. (a) 8. (b) 9. (a) 10. (d)
11. A-(iii), B-(i), C-(ii), D-(v), E-(iv) 12. A-(iii, v); B-(i, iv); C-(ii, vi); D-(vii, ix); E-(viii, x)

(i) stamen (ii) pistil (iii) stigma (iv) self pollination (v) cross pollination (vi) abiotic (vii) biotic (viii) Pollen-pistil interaction (ix) siphonogamy (x) sexual incompatibility

13. (c) 15. (a) 16. (b) 17. (d) 18. (b)
19. (a) A-Pollen tube; B-Male gametes; C-Tube nucleus; D-Cytoplasmic sheath; E-Callose plugs.
(b) This figure shows the post-pollination development of male gametophyte, on the stigma of compatible pollen grain. From the stigma surface, it absorbs water and nutrients and the vegetative cell enlarges and comes out through one of the germ pores of pollen grains, to form a pollen tube.
(c) The important functions of pollen tube (A) are:
   – It absorbs nutrients from the cells of the style for its growth.
   – It carries male gametes to the female gametophyte (egg + secondary nucleus).
   – It secretes enzyme pectinase and other hydrolytic enzymes to create a passage in solid style.

20. (a) The figure shows a monocot embryo of a grass. The labelled parts are as follows:
   A-Scutellum; B-Coleoptile; C-Epiblast; D-Coleorhiza
   (b) Labelled part A scutellum is the only cotyledon of monocotyledonous embryo. It is situated towards lateral side of the embryonal axis.
   (c) The differences between coleoptile (B) and coleorhiza (D) are as follows:

<table>
<thead>
<tr>
<th>Coleoptile</th>
<th>Coleorhiza</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) It has a terminal pore for emergence of first leaf.</td>
<td>It is a solid structure.</td>
</tr>
<tr>
<td>(ii) It protects the plumele during emergence from soil.</td>
<td>It does not protect the radicle during its passage into the soil.</td>
</tr>
<tr>
<td>(iii) It becomes green and helps in photosynthesis.</td>
<td>It is a non green structure.</td>
</tr>
</tbody>
</table>

CHAPTER-3: HUMAN REPRODUCTION

1. (b) 2. (c) 3. (c) 4. (b) 5. (a) 6. (c) 7. (a) 8. (c) 9. (b) 10. (a)
11. A-(iii), B-(i), C-(ii), D-(v), E-(iv) 12. A-(iii, vii); B-(i, vi), C-(i, v), D-(ii, ix); E-(viii, x)
13. (i) Fallopian tube (ii) 300 million sperms (iii) zona pellucida (iv) depolarisation (v) polyspermy (vi) monospermy (vii) acrosome (viii) meiotic division (ix) second meiotic division (x) diploid zygote
14. (c) 15. (b) 16. (b) 17. (d) 18. (c)
19. (a) The labelled parts are as follows:
   A-Seminiferous tubules; B-Leydig’s cells; C-Sertoli cells; D-Spermatogonium; E-Spermatozoa

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(b) Labelled part B denotes Leydig’s cells or interstitial cells. They are present between the seminiferous tubules in the connective tissue of testes. They are present in small groups of round shaped cells. They secrete male sex hormones or androgens e.g., testosterone.

(c) Labelled part C depicts sertoli cells or sustentacular cells. Sertoli cells are also known as nurse cells as they provide nutrition to the developing sperms. These cells also secrete androgen binding protein that concentrates testosterone in seminiferous tubules and inhibit protein which suppresses FSH synthesis.

20. (a) The labelled parts are:

A-Umbilical arteries
B-Umbilical vein
C-Chorion
D-Desidua basalis

(b) (i) Haemochorial placenta, (ii) Metadiscoidal placenta.

(c) The human chorionic gonadotropin (hCG) hormone is secreted by placenta only. It stimulates and maintains the corpus luteum to secrete progesterone till the pregnancy ends.

CHAPTER-4: REPRODUCTIVE HEALTH

1. (a) 2. (b) 3. (c) 4. (a) 5. (c)
6. (a) 7. (d) 8. (b) 9. (c) 10. (d)
11. A-(ii), B-(iii), C-(i), D-(v), E-(iv)
12. A-(iv, vii); B-(i, vi); C-(ii, v); D-(iii, ix); E-(viii, x)
13. (i) population explosion (ii) contraceptive methods (iii) temporary (iv) permanent (v) Abortion (vi) sexually transmitted diseases (vii) infertility (viii) IVF-fertilisation (ix) embryo transfer (x) test tube baby programme

14. (a) 15. (c) 16. (a) 17. (d) 18. (b)

19. (a) The methods of birth control depicted are:

A-Vasectomy, B-Tubectomy

(b) Sterilisation procedure in the male is termed as vasectomy (A) In this method, a small part of vas deferens is removed or tied up through a small cut on the scrotum. The surgical method of contraception in female is termed as tubectomy (B) In this method, a small part of the Fallopian tube is removed or tied up through a small cut in the abdomen or through vagina.

(c) The one and only drawback of these methods is that both methods show very poor reversibility. Hence are considered as permanent methods only.

20. (a) The given diagram is of CuT. It is a copper releasing intrauterine device which is a barrier method of contraception.

(b) Copper ions released by CuT increases phagocytosis of sperms within the uterus and suppress sperm motility and the fertilising capacity of sperms.

(c) Some of the drawbacks of CuT are:

- They can cause excess menstrual bleeding and pain.
- May cause inflammation in vagina.
- At times, the woman might face automatic expulsion of the device during or after insertion.
- Sometimes the device perforates the uterus wall and leads to internal injuries.
ECOSYSTEM

Ecosystem is the unit of living organisms interacting with their non-living environment in an orderly self-sufficient manner. The term ecosystem was introduced by "A.G. Tansley".

Ecosystem Components

- Natural Ecosystem: Ecosystem develops under natural conditions without any major human interference.
  - Terrestrial ecosystem: E.g.: Forests, grasslands, deserts, garden
  - Aquatic ecosystem: E.g.: Freshwater ponds, lakes, streams

- Man-made Ecosystem: These are maintained artificially by man where, by addition of energy and planned manipulations, natural balance is disturbed regularly. For example, croplands like maize, wheat, rice-fields etc., where man tries to control the biotic community as well as the physico-chemical environment, are artificial or anthropogenic ecosystems.

NEET ESSENTIAL

The syllabus for NEET is very vast which impedes students from acquiring indepth knowledge and covering the entire syllabus at the same time. An essential topic for NEET is therefore presented here to enable students grasp the topic, analyse the type of questions and SCORE HIGH.
Producers (Autotrophs)
Fixation of light energy, use of simple inorganic substances and build up of complex substances predominate in this component. The component is constituted mainly by green plants, including photosynthetic bacteria. Members of the autotrophic component are known as producers. Major producers are algae, bryophytes and vascular plants. Phytoplanktons are major producers of aquatic ecosystem.

Consumers (Heterotrophs)
Utilisation, rearrangement and decomposition of complex materials predominate in this component. The organisms involved are known as consumers, as they consume the matter built up by the producers (autotrophs). Consumers are differentiated into herbivores and carnivores.

Decomposers (Reducers)
They are saprotrophs which feed on dead bodies of organisms and organic wastes of living organisms. The decomposer organisms secrete digestive enzymes to digest the organic matter externally. The digested form of organic matter is partly absorbed by microorganisms for their own assimilation. The remaining adds raw materials and minerals back into the substratum, the phenomenon is called mineralisation. Decomposers are also called reducers because they are able to remove or degrade the dead bodies of organisms. Because of their small size they are known as microconsumers.

Biotic Components
Living members of an ecosystem

Abiotic Components
Non-living substances and factors

Temperature
Temperature range varies in different parts of the earth. Organisms generally live within narrow range of temperature (5° – 35°C). Few organisms can be found in hot springs (60° – 90°C), or permafrost (~30° to −50°C). High or low temperature causes inactivity and death of organisms.

Light
It provides solar energy to the ecosystem for heating and photosynthesis. Maximum solar or light energy is available at equator. It decreases towards poles. In a tree, more energy is available to upper leaves than the lower ones. Their rate of photosynthesis is accordingly higher.

Wind
It controls weather, transpiration, pollination and dissemination of propagules. High speed winds inhibit tree growth and flight animals. Unidirectional wind does not allow growth of branches on the windward side.

Soil
It determines vegetation growth and pattern, underground flora and fauna through its constitution, origin, temperature range, water retentivity, aeration, minerals, etc. Soil present on the slopes as well as the one which is uncovered are liable to be eroded by water and wind respectively.

Water
Land plants meet their water requirements from soil. Land animals obtain the same from pools, lakes, rivers, springs, etc. Plants and animals show modifications according to availability of water in the area and requirement of conserving the obtained water. Xerophytes develop modifications to increase water absorption, reduce transpiration and at times store absorbed water. Certain animals of dry areas do not drink water at all, e.g., kangaroo rat. They use water from food and its metabolism to run their body machinery. Animals of dry areas often reduce water loss by producing solid faeces and excreting solid urine.

Productivity of an Ecosystem
The productivity of an ecosystem refers to the rate of production i.e., the amount of organic matter accumulated per unit area in any unit time. Productivity is of following types:

Primary productivity
The amount of energy accumulated in green plants as biomass or organic matter per unit area over a time period through the process of photosynthesis is known as primary productivity. It is of two sub-types: GPP and NPP.

Gross Primary Productivity (GPP)
It is the amount of organic matter synthesised by producers per unit time and per unit area.
It is equal to rate of increase in body weight of producers plus loss suffered through respiration and damages.
It depends upon photosynthetic efficiency of producers, availability of solar energy as well as inorganic nutrients.
**Net Primary Productivity (NPP)**

- It is the amount of organic matter stored by producers per unit time and per unit area.
- It is equal to organic matter synthesised by photosynthesis minus utilisation in respiration and other losses.
- It depends upon gross primary productivity as well as amount of consumption of photosynthates.
- NPP is equal to GPP – R, where R is energy used in respiration.

**Secondary Productivity:** The rate of resynthesis of organic matter by the consumers is known as secondary productivity.
- It depends upon the loss while transferring energy containing organic matter from the previous trophic level plus the consumption due to respiration and predation.
- It is small and decreases with rise of trophic level.
- It is due to synthesis of organic matter from organic matter.

**DECOMPOSITION**

It is physical and chemical breakdown of complex organic remains with the help of organisms called decomposers. In terrestrial ecosystem, upper layer of soil is the main site of decomposition. Organic remains (dead plant parts, animal remains and excretions) are also called **detritus**. It is of two types: above-ground detritus (leaf litter, dried plant parts, remains of animals, their droppings and excretions) and below-ground detritus (mainly dead roots, also underground dead animals).

Decomposition completely disposes off the whole detritus. It helps in recycling of biogeochemicals and creating space for newer generations of organisms.

**Processes Involved in Decomposition**

- **Fragmentation of detritus**
  
  Detrivores (e.g., termites, carrion beetles, earthworms) feed on larger pieces. The smaller fragments are left. Pulverisation occurs in the digestive tract of detrivores as a part of detritus comes out undigested. The part digested by detrivores is immobilised. Due to fragmentation, left-over detritus comes to have large surface area. Earthworms are called farmer’s friends because they help in fragmentation of detritus and loosening of soil.

- **Catabolism**
  
  The decomposers (e.g., bacteria, fungi) excrete digestive enzymes over the detritus. It changes insoluble complex organic substances into simple and soluble organic compounds and inorganic substances. A part of the broken down food is taken up by decomposers and immobilised.

- **Leaching**
  
  Soluble substances formed during decomposition are subjected to leaching or passage to deeper layers of soil or ground water by percolating water.

Decomposition gives rise to two products; (i) Humus, and (ii) Inorganic nutrients by the process of humification and mineralisation respectively.

**Humus** is:
- (i) Dark coloured amorphous organic matter rich in lignin and cellulose.
- (ii) Resistant to microbial action.
- (iii) Reservoir of nutrients and helpful in maintenance of soil moisture and aeration.
- (iv) Colloidal in nature.
- (v) Decomposed slowly and thus, releases nutrients slowly.

**Mineralisation:**
- (i) Involves both non-minerals and minerals from organic matter.
- (ii) Is a slow process because of trapping in humus and immobilisation in decomposers.
- (iii) Prevents their washing out or leaching.

**Factors Affecting Decomposition**

- **Temperature:** A soil temperature of 25°C and more hastens decomposition. Low temperature of less than 10°C reduces rate of decomposition.
- **Moisture:** It is essential for decomposition. Decomposition rate is very low in tropical deserts despite presence of favourable temperature. Excessive moisture impedes decomposition probably due to anaerobiosis.
- **pH:** Neutral and slightly alkaline soils are rich in detrivores, earthworms and decomposer microbes. Acidity decreases the number of detrivores and earthworms. Decomposer microbes occur in slightly acidic soils but with the rise in acidity, their number begins to fall. As a result decomposition of detritus is quite slow in acidic soils.
- **Aerobiosis:** Aerobic conditions are essential for activity of decomposer organisms because decomposition is oxygen requiring process. Anaerobiosis reduces decomposition and causes piling up of detritus.
FOOD CHAIN

The transfer of food energy from the producers, through a series of organisms (herbivores to carnivores to decomposers) with repeated eating and being eaten, is known as a food chain. Producers utilise the radiant energy of sun which is transformed to chemical form, ATP during photosynthesis.

**FOOD WEB**

It is a network of food chains which become interconnected at various trophic levels so as to form a number of feeding connections amongst the different organisms of a biotic community. For example, in grazing food chain of a grassland, in the absence of rabbit, grass may also be eaten by mouse. The mouse in turn may be eaten directly by hawk or by snake first which is then eaten by hawk. Thus, in nature there are found alternatives which all together constitute some sort of interlocking pattern-the food web.
The food webs are very important in maintaining the stability of an ecosystem in nature. For example, decrease in the population of rabbit would naturally cause an increase in the population of alternative herbivore, the mouse. This may decrease the population of the consumer (carnivore) that prefers to eat rabbit. Thus, alternatives serve for maintenance of stability of the ecosystem. More over, a balanced ecosystem is essential for the survival of all living organisms of the system. For instance, had primary consumers (herbivores) not been in nature, the producers would have perished due to overcrowding and competition. Similarly, the survival of primary consumers is linked with the secondary consumers (carnivores) and so on. Thus, each species of any ecosystem is indeed kept under some sort of a natural check so that the system may remain balanced.

(i) Length of the food chain. Diversity in the organisms based upon their food habits would determine the length of food chain. More diverse the organisms in food habits, more longer would be food chain.

(ii) Alternatives at different points of consumers in the chain. More the alternatives, more would be the interlocking pattern. In deep oceans, seas, etc. where we find a variety of organisms, the food webs are much complex.

ENERGY FLOW
Ecosystems require a constant input of energy as every component of an ecosystem is regularly dissipating energy. Flow of energy is governed by two laws of thermodynamics.

Two Laws of Thermodynamics

First law
Energy can be transferred as well as transformed but is neither created nor destroyed.

Second law
Every activity involving energy transformation is accompanied by dissipation of energy.

Incident solar radiation on vegetation (100%)

Photosynthetically active radiation (PAR) (50%)
Captured in photosynthesis (gross primary productivity) (1-5%)
Net primary productivity (0.8-4%)
Absorbed by gases/water vapour, reflected by clouds and scattered by dust particles (50%)
Loss in respiration (0.2-1%)

Energy does not remain trapped permanently in any organism. It is either passed on to the higher trophic level or becomes available to detrivores and decomposers after the organism dies. Normally, herbivores feed on producers. Part of the food energy is wasted in digestion and assimilation. Some of the assimilated food is broken down to release energy for performing body activities. A very small portion becomes part of the body of herbivore. Herbivores are eaten by primary carnivores, the latter by secondary carnivores and so on. At every step a lot of energy is wasted.
Energy Flow Model

- Energy flow in an ecosystem is always unidirectional or one way, i.e., solar radiations → producers → herbivores → carnivores. It cannot pass in the reverse direction.

- There is decrease in the content and flow of energy with the rise in trophic level. A part of energy captured by producers (gross primary productivity) is used for maintenance (through liberation in respiration) and as food to herbivores. The remaining net productivity is either used by humans or passes into detritus chain.

- A lot of wastage of food occurs during ingestion by herbivores. Energy is used for digestion of food. A part is lost as faecal matter to decomposers.

- Part of assimilated food is also broken down to release energy in the process of respiration. A part of this energy is lost as heat.

Lindeman proposed 10% law, according to which only 10% of the energy available at one trophic level passes to the next trophic level. Thus, 1000 kcal of biomass energy makes available only 1 kcal of biomass energy at the level of carnivore II and 0.1 kcal of biomass energy at the level of carnivore III. Therefore, for supporting a higher trophic level organism a large amount of biomass is required at the producer level.

TROPHIC LEVELS

Trophic level is a step of food chain characterised by method of obtaining its food. The number of trophic levels is equal to the number of steps in the food chain.

<table>
<thead>
<tr>
<th>First trophic level</th>
<th>Producers</th>
<th>Organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>They are autotrophic or photosynthetic organisms found in an ecosystem which synthesise organic nutrients from inorganic raw materials with the help of solar radiations not only for themselves but also for heterotrophic organisms or consumers.</td>
<td>Phytoplankton, grass, trees</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Second trophic level</th>
<th>Primary consumers</th>
<th>Organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>They are herbivores, which depend on plants for nourishment and are consumers of first order.</td>
<td>Zooplankton, cow, grasshopper</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Third trophic level</th>
<th>Secondary consumers</th>
<th>Organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>They are consumers of the second order and are dependent on herbivores.</td>
<td>Birds, fishes, wolf</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fourth trophic level</th>
<th>Tertiary consumers (Top carnivores)</th>
<th>Organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Top carnivores are last order consumers which are not preyed upon by other animals.</td>
<td>Man, Lion</td>
</tr>
</tbody>
</table>

ECOLOGICAL PYRAMIDS (ELTONIAN PYRAMIDS)

An ecological pyramid is a graphic representation of an ecological parameter, like biomass, energy or number of individuals present in various trophic levels of a food chain with producers forming the base and top carnivores the tip. Each trophic level represents a functional level. Therefore, it includes all the members of all the species operating at that level.

Three Types of Ecological Pyramids

- **Pyramid of numbers**
  Shows number of individual organisms at each level.

- **Pyramid of biomass**
  Shows the total dry weight and other suitable measure of total amount of living matter.

- **Pyramid of energy**
  Shows rate of energy flow and productivity at successive trophic land.
In a pyramid, the various steps of a food chain are represented sequence-wise with producers at the base, herbivores above them, followed by primary carnivores and so on with tip carnivores constituting the tip of the pyramid.

### Shape of Ecological Pyramid
- **Inverted**
  - Narrow base, gradually becoming broader towards the tip.
- **Spindle-shaped**
  - Narrow both at base and tip, with broader part in the middle.
- **Upright**
  - With larger base and gradually tapering towards tip.

### Pyramid of Numbers
They show the relationship between producers, herbivores and carnivores at successive trophic levels in terms of their number.

<table>
<thead>
<tr>
<th>Grassland ecosystem</th>
<th>Pond ecosystem</th>
</tr>
</thead>
<tbody>
<tr>
<td>In a grassland, the producers which are mainly grasses, are always maximum in number. This number then shows a decrease towards apex, as the primary consumers (herbivores) like rabbits, mice, etc. are lesser in number than the grasses; the secondary consumers, snakes and lizards are lesser in number than the rabbits and mice. Finally, the top (tertiary) consumers, hawks or other birds, are least in number. Thus, the pyramid becomes upright.</td>
<td>In a pond ecosystem, the pyramid is upright. Here the producers, which are mainly the phytoplanktons as algae, bacteria, etc. are maximum in number; the herbivores, which are smaller fish; rotifers, etc. are lesser in number than the producers; and the secondary consumers (carnivores), such as small fish eating each other, water beetles, etc. are lesser in number than the herbivores. Finally, the top (tertiary) consumers, the bigger fish are least in number.</td>
</tr>
</tbody>
</table>

### Parasitic food chain
In a parasitic food chain the pyramids are always inverted. This is due to the fact that a single plant may support the growth of many herbivores and each herbivore in turn may provide nutrition to several parasites, which support many hyperparasites. Thus, from the producer towards consumers, there is a reverse position, i.e., the number of organisms gradually shows an increase, making the pyramid inverted in shape.

### Forest ecosystem
In a forest ecosystem, the pyramid of numbers is somewhat different in shape. The producers, which are mainly large-sized trees, are lesser in number, and form the base of the pyramid. The herbivores, which are the fruit-eating birds, elephants, deers, etc. are more in number than the producers. Then there is a gradual decrease in the number of successive carnivores, thus making the pyramid again upright.
Pyramid of Biomass
Maximum biomass occurs in producers. There is a progressive reduction of biomass found in herbivores, primary carnivores, secondary carnivores, etc. It is found that about 10-20% of the biomass is transferred from lower trophic level to higher trophic level. The rest is consumed in providing energy for giving heat, overcoming entropy and performing various body activities.

Pyramid of Energy
The energy pyramids give the best picture of overall nature of the ecosystem. Here, number and weight of organisms at any level depends not on the amount of fixed energy present at any one time in the level just below but rather on the rate at which food is being produced. In contrast with the pyramids of numbers and biomass, which are pictures of the standing situations (organisms present at any moment), the pyramid of energy is a picture of the rates of passage of food mass through the food chain. In shape it is always upright, as in most of the cases there is always a gradual decrease in the energy content at successive trophic levels from the producers to various consumers.

BIOTIC OR ECOLOGICAL SUCCESSION
Biotic or ecological succession is the natural development of a series of biotic communities at the same site, one after the other till a climax community develops which does not change further because it is in perfect harmony with the environment of the area. The change is orderly and sequential. There is a parallel change in the physical environment. Rather, succession occurs because each biotic community changes the environment of the area that suits another biotic community more than itself.

<table>
<thead>
<tr>
<th>Table: Differences between pioneer community and climax community</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pioneer Community</strong></td>
</tr>
<tr>
<td>(i) It is the first biotic community which develops in bare area.</td>
</tr>
<tr>
<td>(ii) It is established over a previously bare area.</td>
</tr>
<tr>
<td>(iii) It consists of a fewer small sized organisms.</td>
</tr>
<tr>
<td>(iv) The area is hostile for pioneer community.</td>
</tr>
<tr>
<td>(v) It develops soil.</td>
</tr>
<tr>
<td>(vi) It consists of hardy organisms and the life span of organisms is short.</td>
</tr>
<tr>
<td>(vii) Growth is fast and soon replaced by the next seral community.</td>
</tr>
</tbody>
</table>

![Pyramid of Biomass](image)

![Pyramid of Energy](image)

![Table: Differences between pioneer community and climax community](image)

![Fig.: Pyramid of energy in a fish pond.](image)
Changes during biotic succession

- Small short lived plants (r-selection) to large long-lived plants (k-selection).
- Unstable biotic community to stable biotic community.
- Little diversity to high degree of diversity.
- Greater niche specialisation.
- Increase in biomass.
- Increase in soil differentiation.
- Increase in humus content of soil.
- Aquatic or dry conditions to mesic conditions.
- Simple food chains to complex food webs.
- Reduction in productivity/standing crop (P/B).
- Reduction in environment perturbations.
- Increase in respiratory consumption and decrease in productivity till ultimately the two become equal, P = R or P/R = 1.

The various biotic communities that develop during biotic succession are termed as seral or transitional communities. It is replaced by an other subsequent successional community.

Types of Succession

**Primary succession**

(i) It occurs in an area which has been bare from the beginning.
(ii) Soil is present at the time of beginning of primary succession.
(iii) There is no humus in the beginning.
(iv) Reproductive structures of any previous community are absent.
(v) Pioneer community comes from outside.

(vi) In the beginning the environment is very hostile.
(vii) Seral communities are many.
(viii) Primary succession takes a long time for completion (1000 years or more).

**Secondary succession**

It occurs in an area which has been denuded recently.

Soil is present in the area where secondary succession begins.

Humus is present from the very beginning.

Reproductive structures of the previous occupants are present in the area.

Pioneer community develops partly from previous occupants and partly from migrants.

The environment is favourable from the beginning.

Few seral communities are found.

Secondary succession takes less time for completion (50-200 years).

**Xerosere:** This is a type of biotic succession that occurs on bare rock which is water deficient.

<table>
<thead>
<tr>
<th>Rock</th>
<th>Lichens/Mosses</th>
<th>Grasses and Herbs</th>
<th>Shrubs and Mosses</th>
<th>Woodland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare rock stores very little water and has few available nutrients. The only species that can survive are lichens, a mutualistic relation between an alga and a fungus which starts the process of succession.</td>
<td>The first pioneers are lichens, which can absorb the scarce water from the bare rock. Mosses can then grow on top of the lichens. These species are very small, slow-growing, wind-dispersed and tolerant of extreme conditions. Mosses start to weather the rock by secreting acids, and so begin to form a very thin soil.</td>
<td>The next colonisers are grasses and ferns, followed by small herbaceous plants such as dandelion and nettles. These species have a larger leaf area so these can grow fast and out-compete the pioneers. Their larger roots weather the rock and add more detritus, inorganic and organic matter to the soil, which now holds more water.</td>
<td>Larger plants (shrubs) such as bramble, gorse, hawthorn, broom and rhododendron can now grow in the thicker soil. These species have larger, animal-dispersed seeds and they grow faster and taller, out-competing the smaller herbs.</td>
<td>Trees grow slowly, but eventually shade and out-compete the shrubs, which are replaced by shade-tolerant forest-floor species. A complex layered community is now established with many trophic levels and interactions. This is the climax community.</td>
</tr>
</tbody>
</table>
Hydrosere: This is a type of biotic succession that develop in a pond or lake.

It is the pioneer stage of hydrosere. Spores of this stage reach the water body through wind or animals. Phytoplanktons are minute autotrophic organisms which are first to appear. They multiply rapidly. Soon a balance is created by the appearance of zooplankton which feed on phytoplankton. Death and decomposition of plankton produce organic matter. The latter mixes up with clay and silt at the bottom to form soft mud favourable for growth of seral stage.

Eventually the sediment rises out of the water to form a waterlogged soil. Reed grasses and sedges colonise to form a reed marsh. Their roots bind the mud together to form semi-solid soil, and the increased rate of transpiration starts to dry the soil. E.g., Carex, Typha.

As the soil dries it can be colonised by more terrestrial species. First herbs replace the marsh vegetation then shrubs replace the herbs and eventually trees replace the shrubs. E.g., Alnus, Populus.

NUTRIENT CYCLES

Nutrient cycles are exchanges, storage and transfers of biogenetic nutrients through various components of ecosystem so that the nutrients can be used again and again. The term biogeochemical cycling is used for exchanges/circulation of biogenetic nutrients between living and non-living components of biosphere. There are two stores of nutrients: reservoir pool and cycling pool.

Reservoir Pool is the reservoir of biogenetic nutrients from which the latter are slowly transferred to cycling pool. The function of reservoir is to meet deficiency of nutrient which occurs due to differences in rate of influx and efflux.

Cycling pool is the pool of biogenetic nutrients which is being emptied and filled repeatedly by exchange between biotic and abiotic components of biosphere.

Gaseous Cycles of Matter

The materials involved in circulation between biotic and abiotic components of biosphere are gases or vapours and the reservoir pool is atmosphere or hydrosphere, e.g., carbon, hydrogen, oxygen, nitrogen, water.

Sedimentary Cycles of Matter

Materials involved in circulation between biotic and abiotic components of biosphere are non-gaseous and the reservoir pool is lithosphere, e.g., phosphorus, calcium, magnesium. Sulphur has both sedimentary and gaseous phases. Gaseous cycles are rapid and more perfect as compared to sedimentary cycles.

The Carbon Cycle

Carbon is a component of all organic compounds of protoplasm like carbohydrates, lipids, proteins, nucleic acid, enzymes, hormones, etc. It constitutes 49% of dry weight and is, therefore, next only to water in abundance.
Antropogenic impact on carbon cycle
• Burning fossil fuels like coal and wood add large amounts of CO₂ to the atmosphere.
• We clear trees and other plants (vegetation) that absorb CO₂ faster than they can regenerate themselves (i.e., replaced).
• The above two activities increase the earth’s average temperature by adding excess CO₂ to atmosphere. The increased concentrations of atmospheric CO₂ and other gases (greenhouse gases) could enhance the planet’s natural greenhouse effect which help to warm the lower atmosphere (troposphere) and the earth’s surface. The resulting global warming could disrupt global food production and wildlife habitats, alter temperature and precipitation pattern and raise the average sea level in different parts of the world.

The Phosphorus Cycle
Phosphorus is component of nucleic acids, biomembranes as phospholipids, cellular transfer system as ATP, body structure as shells, bone and teeth. It takes part in metabolic reactions involved in release of energy from food and utilisation of this energy in various functions of the body.

Antropogenic impact on phosphorus cycle
We intervene in the earth’s phosphorus cycle in following three ways:
• We mine large quantities of phosphate rocks to make commercial inorganic fertilisers and detergents.
• We reduce the available phosphate in soils by cutting down forests.
• We disrupt aquatic systems with phosphates from runoff of animal wastes and fertilisers and discharge from sewage treatment systems.
1. The term ‘ecosystem’ was introduced by
   (a) Charles Elton  
   (b) A.G. Tansley  
   (c) E. Haeckel  
   (d) E.P. Odum.

2. Which of the following pair is mismatched?
   (a) Oceans – Global sink  
   (b) Producers – Transducers  
   (c) Phosphorous – Gaseous cycle  
   (d) Guild – Grazing animal

3. A transitional community which develops in an area during biotic succession is called
   (a) pioneer community  
   (b) seral community  
   (c) climax community  
   (d) both (a) and (c).

4. Match the following and choose the correct option.
   Column I  
   Column II
   A. Amazon rain forest  
   (i) Charles Elton  
   B. Ecological pyramids  
   (ii) Polychagous  
   C. 10% law  
   (iii) Lungs of planet earth  
   D. Food web  
   (iv) Lindeman
   (a) A-(ii), B-(i), C-(iv), D-(iii)  
   (b) A-(i), B-(ii), C-(iii), D-(iv)  
   (c) A-(iii), B-(i), C-(iv), D-(ii)  
   (d) A-(iii), B-(iv), C-(i), D-(ii)

5. Consider the following statements (i-iv) and select the option stating which ones are true (T) and which ones are false (F).
   (i) Detritus is the dried fallen plant matter.  
   (ii) Primary productivity is the rate of synthesis of organic matter by producers.  
   (iii) Rooted plants which occur in shallow waters are called macrophytes.  
   (iv) Submerged hydrophytes have higher photosynthetic rate than the floating hydrophytes.
   (i) (ii) (iii) (iv)
   (a) F T T F  
   (b) T T T F  
   (c) F F F T  
   (d) T F T F

6. Which of the following is pioneer species of xerosere?
   (a) Graphics and Rhizocarpion  
   (b) Hypnum and Bryum  
   (c) Potamogeton and Rubus  
   (d) Lemma and Azolla

7. In an ecosystem, the flow of energy is always
   (a) bidirectional  
   (b) in the reverse direction  
   (c) unidirectional  
   (d) constant.

8. Which of the following factors is/are responsible for secondary succession?
   (a) Forest fire  
   (b) Landslide  
   (c) Drought for successive years  
   (d) All of these

9. Zooplanktons of a pond ecosystem acts as
   (a) decomposers  
   (b) primary consumers  
   (c) secondary consumers  
   (d) producers.

10. The major conduit of energy flow in aquatic ecosystem is
    (a) grazing food chain  
    (b) detritus food chain  
    (c) parasitic food chain  
    (d) both (a) and (c).

11. In an upright pyramid of energy, the base bar comprises of
    (a) top consumers  
    (b) secondary consumers  
    (c) producers  
    (d) tertiary consumers.

12. Read the given statements.
    Statement 1 : Pyramid of biomass is more real than the pyramid of numbers.
    Statement 2 : Pyramid of number does not take into consideration the size of the individual.
    (a) Both statements 1 and 2 are correct and statement 2 is the correct explanation of statement 1.  
    (b) Both statements 1 and 2 are correct but statement 2 is not the correct explanation of 1.  
    (c) Statement 1 is correct but 2 is incorrect.  
    (d) Both statements 1 and 2 are incorrect.

13. The correct sequence of food chain is
    (a) grass → grasshopper → frog → snake → falcon  
    (b) grass → rabbit → wolf → fox  
    (c) grass → insect → snake → predator → insect  
    (d) grass → mouse → deer → fox.

14. A logical sequence of carbon cycle is
    (a) producer - consumer - decomposer  
    (b) decomposer - producer - decomposer  
    (c) consumer - producer - consumer  
    (d) producer - decomposer - consumer.

15. Which of the following is correct order for productivity?
    (a) Coral reefs > Estuaries > Sugarcane fields  
    (b) Estuaries > Sugarcane fields > Coral reefs  
    (c) Coral reefs > Sugarcane fields > Estuaries  
    (d) Sugarcane fields > Estuaries > Coral reefs

Exam Section

1. The primary producers of the deep-sea hydrothermal vent ecosystem are
   (a) green algae  
   (b) chemosynthetic bacteria  
   (c) blue-green algae  
   (d) coral reefs.  
   (NEET Phase-II 2016)
2. Which one of the following is a characteristic feature of cropland ecosystem?
   (a) Absence of weeds 
   (b) Ecological succession 
   (c) Absence of soil organisms 
   (d) Least genetic diversity  \( \text{(NEET Phase-I 2016)} \)

3. Most animals that live in deep oceanic waters are
   (a) tertiary consumers 
   (b) detritivores 
   (c) primary consumers 
   (d) secondary consumers.  \( \text{(AIIMS 2016)} \)

4. Select the correct statement.
   (a) Phosphorus cycle is an example of gaseous nutrient cycle. 
   (b) The pyramid of biomass in sea is generally inverted. 
   (c) By the process of humification, soluble inorganic nutrients go down into the soil horizon. 
   (d) A given organism may not occupy more than one trophic level simultaneously. 
   (e) Pyramid of energy is always inverted, can never be upright.  \( \text{(Kerala PMT 2015)} \)

5. If 30J of energy is trapped at producer level, then how much energy will be available to peacock as food in the following chain?
   Plant → Mice → Snake → Peacock
   (a) 0.3J  \( \text{(b) 0.03J} \)
   (c) 0.0003J  \( \text{(d) 0.003J} \)  \( \text{(Karnataka CET 2015)} \)

6. Match column I with column II.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. Producer</td>
<td>(i) Herbivores</td>
</tr>
<tr>
<td>Q. Primary consumer</td>
<td>(ii) Green plants</td>
</tr>
<tr>
<td>R. Secondary consumer</td>
<td>(iii) Saprotrophs</td>
</tr>
<tr>
<td>S. Decomposer</td>
<td>(iv) Carnivores</td>
</tr>
<tr>
<td>(a) P-(i), Q-(ii), R-(iii), S-(iv)</td>
<td></td>
</tr>
<tr>
<td>(b) P-(ii), Q-(i), R-(iv), S-(iii)</td>
<td></td>
</tr>
<tr>
<td>(c) P-(ii), Q-(iv), R-(iii), S-(i)</td>
<td></td>
</tr>
</tbody>
</table>
   | (d) P-(iii), Q-(ii), R-(i), S-(iv)  \( \text{(WB JEE 2015)} \)

7. Identify the incorrect statement from the following.
   (a) Atmospheric inputs of phosphorus through rainfall are much smaller than carbon inputs.
   (b) The reservoir pool for phosphorus cycle is earth’s crust whereas the reservoir pool for carbon cycle.
   (c) Gaseous exchanges of phosphorus between organism and environment are negligible.
   (d) During carbon cycle and phosphorus cycle, there is very little respiratory release of carbon and phosphorus respectively.  \( \text{(Karnataka CET 2014)} \)

8. Given below is a simplified model of phosphorus cycling in a terrestrial ecosystem with four blanks (A-D). Identify the blanks.

9. Which one of the following processes during decomposition is correctly described?
   (a) Catabolism — Last step in the decomposition under fully anaerobic condition
   (b) Leaching — Water soluble inorganic nutrients rise to the top layers of soil
   (c) Fragmentation — Carried out by organisms such as earthworm
   (d) Humification — Leads to the accumulation of a dark coloured substance humus which undergoes microbial action at a very fast rate.  \( \text{(NEET 2013)} \)

10. When man eats fish which feeds on zooplanktons which have eaten small plants, the producer in this chain is
   (a) small plants  \( \text{(b) fish} \)
   (c) man  \( \text{(d) zooplankton.} \)  \( \text{(NEET - Karnataka 2013)} \)

11. Identify the likely organisms (1), (2), (3) and (4) in the food web shown below.

<table>
<thead>
<tr>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deer</td>
<td>Rabbit</td>
<td>Frog</td>
<td>Rat</td>
</tr>
<tr>
<td>Dog</td>
<td>Squirrel</td>
<td>Bat</td>
<td>Crow</td>
</tr>
<tr>
<td>Rat</td>
<td>Dog</td>
<td>Tortoise</td>
<td>Pigeon</td>
</tr>
</tbody>
</table>
   | Squirrel | Cat  | Rat    | (AIPMT Mains 2012)

12. Standing crops refers to
   (a) all the photosynthetic living forms in an area
   (b) all the living forms in an area
   (c) the amount of living matter in a component population of an ecosystem at any time
   (d) all the crop plants in an area.  \( \text{(J & K CET 2011)} \)
13. Of the total incident solar radiation the proportion of PAR is
(a) about 70%
(b) about 60%
(c) less than 50%
(d) more than 80%.

(AIPMT Prelims 2011)

14. Which of the following representations shows the pyramid
of numbers in a forest ecosystem?

A  D
B  C

(a) D
(b) A
(c) B
(d) C

(AIPMT Mains 2010)

15. Some of the nutrient cycles are labelled as below. Sulphur
cycle (A), phosphorus cycle (B), carbon cycle (C) and nitrogen
cycle (D). Of these, the sedimentary cycle is represented by
(a) (A) only
(b) (B) only
(c) (C) only
(d) (A) and (B) only
(e) (C) and (D) only.

(Kerala PMT 2010)

Statement & Reason

The following questions consist of two statements each: assertion
(A) and reason (R). To answer these questions, mark the correct
alternative as directed below:
(a) If both A and R are true and R is the correct explanation of A.
(b) If both A and R are true but R is not the correct explanation of A.
(c) If A is true but R is false.
(d) If both A and R are false.

1. Assertion (A) : Secondary succession occurs in a freshly
harvested field.
   Reason (R): Secondary succession takes 100-200 years in case of grassland.

2. Assertion (A) : In seral community, the food chains and
   food webs are complex.
   Reason (R): Diversity is of higher degree in seral community.

3. Assertion (A) : Lichen is pioneer inhabitants of lithosphere.
   Reason (R) : Lichen secretes acids which can corrode rocks.

4. Assertion (A) : The amount of inorganic nutrients found
   in an ecosystem is called standing state.
   Reason (R): Standing state vary from ecosystem to ecosystem.

5. Assertion (A) : Net primary productivity is less than the
gross primary productivity.
   Reason (R): Net primary productivity is equal to the
   gross primary minus the respiration losses.

Short Answer Type Questions

1. Fill in the blanks:
   (a) The species which are adapted to colonise newly
   disturbed habitats are called _____.
   (b) The series of development stages of biotic succession
   in water is called _____.
   (c) _____ and _____ are two types of xerosere.
   (d) A group of species belonging to a trophic level which
   exploits a common resource base in a similar fashion is
   _____.

2. Write a short note on pyramid of biomass.

3. Define food chain. What are the types of food chain?

4. Define the following:
   (a) Humification
   (b) Mineralisation
   (c) Leaching

ANSWER KEY

New MCQs

1. (b) 2. (c) 3. (b) 4. (c) 5. (b)
6. (a) 7. (c) 8. (d) 9. (b) 10. (a)
11. (c) 12. (a) 13. (a) 14. (a) 15. (a)

Exam Section

1. (b) 2. (d) 3. (b) 4. (b) 5. (b)
6. (b) 7. (d) 8. (c) 9. (c) 10. (a)
11. (a) 12. (c) 13. (c) 14. (d) 15. (d)

Assertion & Reason

1. Assertion & Reason

(a) fugitive species, (b) hydrosere, (c) Lithosere, psammosere,
(d) guild

2. Pyramid of biomass is a graphic representation of biomass
   present sequence wise per unit area of different trophic
   levels with producers at the base and top carnivores kept
   at the tip. It is upright for terrestrial habitats and inverted
   and spindle shaped for aquatic habitats.

3. A food chain is a sequence of organisms each dependent on
   the next as a source of food. There are three types of food
   chains.
   (i) Parasitic food chain
   (ii) Detritus food chain
   (iii) Grazing food chain

4. (a) Humification is a process of decomposition of organic
   matter in which a partially decomposed amorphous
   matter called humus is formed.
   (b) Mineralisation is the release of inorganic nutrients
   from the decomposing organic matter.
   (c) Leaching is the process where soluble substances which
   are formed during decomposition pass to deeper layers
   of soil or ground water by percolating water.
SECTION - A
1. What are the two main techniques of modern biotechnology?
2. How are lysing enzymes different from cleaving enzymes?
3. There are three types of restriction endonucleases. Which among the three is/are used in recombinant DNA technology?
4. Name the transgenic plant from which hirudin is extracted.
5. Name two transgenic microorganisms that have been used for large scale production of amino acids.

SECTION - B
6. What are the useful applications of Bt cotton?
7. Why some of the genes are called ‘selectable markers’? Name two genes which are useful for ‘selectable markers’.
8. Describe the biological tools used in recombinant DNA technology.
9. Why are bacteriophage vectors more preferred over plasmid vectors?

OR
What is gene therapy? Briefly describe its types also.
10. How is ‘Rosie’ considered different from a normal cow? Explain.

SECTION - C
11. What do you mean by ADA deficiency? How genetic engineering helped patients suffering from this disease?
12. Differentiate between plasmid DNA and chromosomal DNA.
13. Define polymerase chain reaction (PCR). Explain the working mechanism of PCR.
14. Define the following:
   (a) Biopiracy  (b) Biopatent  (c) Biowar
   OR
   Differentiate between upstream processing and downstream processing.
15. (a) What is the full form of ELISA?
(b) Name the principle on which ELISA technique is based.
(c) How does it help in early detection of a disease?
16. (a) What is a bioreactor? Write an advantage and a disadvantage of it.
(b) Name the types of commonly used bioreactors.
17. Name and explain the technique by which male gamete carrying Y chromosome is preferentially selected and inseminated into female.
18. Describe the technique used for separation and isolation of DNA fragments.
19. What is the full form of GEAC? Describe the main objectives of GEAC set up by the Indian government.
21. Why is transgenic mice most preferred for research work on gene transfer?
22. Write the recognition sites of the given restriction enzymes.
   (i) Bam Hi  (ii) Eco RI  (iii) Eco RII
   (iv) Hae III  (v) Hind II  (vi) Sal I
SECTION - D

23. In a group discussion held between the students of class 12th, group A explained the advantages of transgenic organisms to human beings in the field of medicine, industry, etc. Group B discussed the various controversies related to transgenic organisms.

(a) Which of the two groups according to you is justified? Explain with reasons.
(b) What kind of ethical issues are concerned with the production of transgenic animals?

SECTION - E

24. Read the following base sequence of a certain DNA strand and answer the questions that follow:


\[ 3' - T-T-C-T-T- A-A-G-T- T - 5' \]

(a) What is ‘palindromic sequence’ in a DNA?
(b) Write the palindromic nucleotide sequence shown in the given DNA strand and mention the enzyme that will recognise such sequence.
(c) State the significance of enzyme that identifies palindromic nucleotide sequences.

OR

Describe the structure of human insulin. How insulin is synthesised? Diagrammatically explain the production of human insulin by rDNA technology.

25. (a) Draw schematic diagrams of segments of a vector and a foreign DNA with the sequence of nucleotides recognised by EcoRI. Also show rDNA formed by joining sticky ends of vector DNA and foreign DNA.
(b) Describe restriction modification system.

OR

(a) What are genetically modified crops? Write two advantages of technique of producing GM crops.
(b) What are the disadvantages of genetically modified plants?

26. (a) Write short note on the following:
   (i) Transgenic tomato  (ii) ANDI
   (iii) Transgenic sheep
(b) To which virus is transgenic chicken resistant?

OR

(a) Explain the important methods of gene transfer into the host cell without using a vector.
(b) Diagrammatically show steps involved in RNA interference.

SOLUTIONS

1. Two main techniques of modern biotechnology are:
   (i) Genetic engineering  (ii) Chemical engineering.

2. Lysing enzymes are used to open up the cells to get DNA for genetic experiments whereas, cleaving enzymes are used to break DNA molecules.

3. Three types of restriction endonucleases are type I, type II and type III. Only type II restriction enzymes are used in rDNA technology.

4. *Brassica napus*

5. Two transgenic microorganisms used for large scale amino acid production are:
   (i) *Bacillus amyloliquefaciens*
   (ii) *Lactobacillus casei*.

6. The useful applications of Bt cotton are:
   (i) pest resistance
   (ii) herbicide tolerance
   (iii) high yield
   (iv) resistant to bollworm infestation.

7. Some genes help in selecting transformants (i.e., host cells carrying vector) and eliminates non-transformants, such genes are called selectable markers. Two genes ampr and tefp in pBR322 are useful as selectable markers.

8. Three types of biological tools are used in recombinant DNA technology:
   (i) Enzymes: Lysing enzymes (e.g., lysozyme, cellulase and chitinase) and cleaving enzymes (e.g., exonuclease, endonuclease and restriction endonuclease).
   (ii) Cloning vectors: These are DNA molecules that can carry foreign DNA segment and replicate inside a host cell (e.g., plasmids, cosmids, YACs, etc.)
   (iii) Competent host: A prokaryotic or eukaryotic cell capable of getting transformed with recombinant DNA.

9. Bacteriophage vectors are more preferred over plasmid vectors because:
   (i) Bacteriophage vectors can be used for large DNA fragments.
   (ii) These can be easily detected at the time of cloning experiments.

OR

Gene therapy is the technique of genetic engineering to replace a faulty gene by a normal, healthy functional gene. Gene therapy is of two types:
   (i) Germline gene therapy: In this type, germ cells, i.e., sperms or eggs (even zygotes) are modified by the introduction of functional genes.
   (ii) Somatic cell gene therapy: In this type, the genes is introduced only in somatic cells.

10. Rosie is the first transgenic cow which produces human protein enriched milk. The milk contains human alphalactalbumin. This milk is nutritionally more balanced for human babies than natural cow milk.
11. Adenosine deaminase (ADA) is an enzyme which helps in the normal functioning of T-lymphocytes to provide immune response against invading pathogen. ADA deficiency causes severe combined immune deficiency (SCID). Gene therapy is the technique of genetic engineering which helps in curing ADA deficient patient. Lymphocytes, a kind of white blood cells, are extracted from the bone marrow of the patient and are grown in a culture outside the body. A functional ADA cDNA (using a retroviral vector) is then introduced into these lymphocytes, which are reinjected to the patient’s bone marrow. If isolated gene from bone marrow cells producing ADA are introduced into cells at early embryonic stages, then it can be a permanent cure of ADA deficiency.

12. Differences between plasmid and chromosomal DNA are:

<table>
<thead>
<tr>
<th>Plasmid DNA</th>
<th>Chromosomal DNA</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) It is circular and always double stranded.</td>
<td>It is linear or circular and may be single or double stranded.</td>
</tr>
<tr>
<td>(ii) It is naked without histone protein.</td>
<td>It is coated with histone protein.</td>
</tr>
<tr>
<td>(iii) It does not carry any vital gene necessary for cell.</td>
<td>It carries vital genes necessary for cell.</td>
</tr>
<tr>
<td>(iv) It can replicate independent of main genome.</td>
<td>It replicates with genome.</td>
</tr>
<tr>
<td>(v) It does not act as genetic factor.</td>
<td>It acts as genetic factor.</td>
</tr>
<tr>
<td>(vi) Introns are absent.</td>
<td>Both exons and introns are present.</td>
</tr>
</tbody>
</table>

13. Polymerase chain reaction is *in vitro* DNA replication. It is selective amplification of specific DNA segment. The working mechanism of PCR is as follows:

(i) Denaturation: The target DNA (DNA segment to be amplified) is heated to high temperature about (94°C). Heating results in the separation of two strands of DNA.

(ii) Annealing: Two oligonucleotide primers hybridise to each of the single stranded template DNA at temperature of about 40°-60°C.

(iii) Extension: The enzyme Taq DNA polymerase synthesises the DNA segment between the primers using deoxy-nucleotide triphosphates (dNTPs) and Mg²⁺, if occurs at about 72°C.

14. (a) Biopiracy: The use of bioresources by multinational companies and other organisations without proper authorisation from the countries and people concerned, and without compensatory payment to them is called as biopiracy.

(b) Biopatent: Biopatent is the right granted by a government to an inventor of a biological material, securing him for a specific time the exclusive rights of manufacturing, exploiting, using and selling an invention.

(c) Biowar: Biowar (or biological war) is the use of highly infectious pathogens (*e.g.*, bacteria, fungi, viruses, etc.), their spores and toxins as agents of biological weapons against humans, crops and animals of enemy country. A bioweapon is a device that carries and delivers a highly pathological biological agent, its spores or toxin to the target.

OR

Upstream processing: In bioreactors, raw materials are converted into specific products by microbes under optimum conditions like pH, aeration, temperature, etc. Downstream processing: It includes separation and purification of finished product formed in bioreactor. The product is subjected to quality control and kept in processing before releasing in the market.

15. (a) ELISA - Enzyme Linked Immunosorbent Assay.

(b) ELISA is based on the principle of antigen-antibody interaction.

(c) ELISA can detect very small amount of protein (antigen or antibody) with the help of an enzyme *e.g.*, peroxidase or alkaline phosphatase. Infection by pathogen can be detected by the presence of antigen or by detecting the antibodies synthesised against pathogen.

16. (a) A bioreactor is a vessel in which raw materials are biologically converted into specific products by microbes, plant and animal cells and their enzymes. It provides optimal growth conditions (temperature, pH, substrate, salt, vitamins, oxygen) to the microbes for the synthesis of desired product. Advantage of bioreactor is that it is well suited for large-scale production of microorganisms under aseptic conditions for a number of days. A major drawback of bioreactor is that it is relatively expensive to run it.

(b) The most commonly used bioreactors are of stirring type. There are two types of bioreactors.

(i) Simple stirred - tank bioreactor

(ii) Sparged stirred - tank bioreactor

17. Recently techniques have been developed which allow preferential fertilisation by male (carrying Y chromosome) or female (carrying X chromosome) determining sperm. Such techniques allow separation of sperms carrying Y chromosomes, from the ejaculate of a man to be used for insemination of ovulating women. This technique involves ‘sephadex gel column’ in which sperms with Y, being lighter are trapped in gel and those with X being heavier reach the bottom of the column, and can be used for insemination.
18. Separation and isolation of DNA fragments can be done by a technique called agarose gel electrophoresis. It is a technique of separation of molecules such as DNA, RNA or protein, under the influence of an electrical field, so that they migrate in the direction of electrode bearing the opposite charge, viz., positively charged molecules move towards cathode (−ve electrode) and negatively charged molecules travel towards anode (+ve electrode) through a medium/matrix. The most commonly used matrix is agarose. DNA fragments separate according to the size through the pores of agarose gel. Hence, the smaller the fragment size, the farther it moves. The separated DNA fragments can be seen only after staining the DNA with a chemical dye known as ethidium bromide (EtBr) followed by exposure to UV radiation. The fragments are visible as bright orange coloured bands.

19. GEAC is Genetic Engineering Approval Committee. It makes decisions regarding the validity of GM research and the safety of introducing GM organisms for public services. The objectives of setting up GEAC by our government is as follows:
(i) To permit the use of GM organisms and their products for commercial applications.
(ii) To adopt procedures for restriction, production, import, export and application of GM organisms.
(iii) To approve for conduct of large scale field trials and release of transgenic crops in the environment.
(iv) To curb and take punitive action against agencies if they disturb ecological balance.

20. Ti plasmid is tumour inducing plasmid isolated from soil bacterium Agrobacterium tumefaciens and is effectively used as vector for gene transfer in plant cells. For using Ti plasmid as vector, its tumour causing properties are eliminated, while keeping its ability to transfer DNA into plant cells. But it no longer produces tumours. The part of Ti plasmid transferred into plant cell DNA is called the T-DNA. This T-DNA with desired DNA, is inserted into the chromosomes of the host plant where it produces copies of itself by migrating from one chromosomal position to another at random. Such plant cells are then cultured, induced to multiply and differentiate to form plantlets. The plantlets transferred into soil grow into mature plants, carrying the foreign gene that is expressed throughout the new plant.

21. Transgenic mice are most preferred for research work on gene transfer because of the following features:
(i) Short oestrous cycle and gestation period.
(ii) Relatively short generation time.
(iii) Production of several offspring per pregnancy.
(iv) Convenient in vitro fertilisation.
(v) Successful culture of embryos in vitro.

22. (i) **Bam HI**

   \[
   5' - G\_G\_A\_T\_C\_C\_C\_3' \\
   3' - C\_C\_T\_A\_G\_G\_5'
   \]

(ii) **Eco RI**

   \[
   5' - G\_A\_T\_C\_C\_C\_3' \\
   3' - C\_C\_T\_A\_G\_G\_5'
   \]

(iii) **Eco RII**

   \[
   5' - G\_G\_G\_C\_C\_C\_3' \\
   3' - C\_C\_T\_A\_G\_G\_5'
   \]

(iv) **Hae III**

   \[
   5' - G\_G\_G\_C\_C\_C\_3' \\
   3' - C\_C\_T\_A\_G\_G\_5'
   \]

(v) **Hind II**

   \[
   5' - G\_G\_G\_C\_C\_C\_3' \\
   3' - C\_C\_T\_A\_G\_G\_5'
   \]

(vi) **Sal I**

   \[
   5' - G\_G\_G\_C\_C\_C\_3' \\
   3' - C\_C\_T\_A\_G\_G\_5'
   \]

23. (a) Production of transgenic organisms has its own advantages and disadvantages. Transgenic plants are resistant to various diseases, tolerant to adverse environmental conditions, produce pharmaceutically important compounds, etc. Similarly transgenic animals are useful to humans in various regards e.g., transgenic sheep having anti-haemophilic factor IX gene in their genome have been produced. Clotting factor IX obtained from such transgenic sheep can be administered to the haemophilic patients. However, the introduction of transgenic organisms has also created certain controversies. Transgenes in commercial crops can endanger native species. For example, the gene for Bt toxin expressed in pollen might endanger pollinators like honeybees. These crops may cause problems to human health by supplying allergens and transfer of antibiotic resistance markers. They also cause damage to the natural environment. Transgenic crops are always costly so that they are adverse to the interest of the farmers. Thus, both the groups A and B are justified in their explanations.

(b) The ethical issues connected to the production of transgenic animals include:
(i) Introduction of a transgene from one species into another species violates the ‘integrity of species’.
(ii) Transfer of human genes into animals (and vice-versa) dilutes the concept of ‘humanness’.
(iii) When animals are used for production of pharmaceutical proteins, they are virtually reduced to the status of a ‘factory’.
(iv) Use of animals in biotechnology causes great suffering to them.
(v) It is disrespectful to living beings and only exploits them for the benefit of human beings.

24. (a) The palindrome sequence in DNA is a sequence of base pairs that reads same when read forward or backward on
the two strands and when orientation of reading is kept the same. For example, the following sequence reads the same on the two strands in 5′ → 3′ direction, and in 3′ → 5′ direction.

5′-GAATTC-3′
3′-CTTAAG-5′

(b) The palindrome sequence shown in the given DNA strand is 5′-GAATTC-3′
3′-CTTAAG-5′

This is the recognition sequence for restriction enzyme EcoR I.

(c) Restriction endonuclease such as EcoR I, Hind III, BamHI I acts as molecular scissors or chemical scalpels. They serve as the tools for cutting DNA molecules at specific palindromic sites, which is the basic requirement for gene cloning or recombinant DNA technology. Restriction enzymes cut the strand of DNA a little away from the centre of the palindrome sites but between the same two bases of the opposite strands. This leaves single stranded unpaired bases at cut ends. These ends with unpaired bases are called sticky ends or cohesive ends. The latter are named so because they form hydrogen bonds with their complementary cut counter parts. The sticky ends facilitate the action of the enzyme DNA ligase.

Human insulin is made up of 51 amino acids arranged in two polypeptide chains. A having 21 amino acids and B with 30 amino acids. The two polypeptide chains are interconnected by two disulphide bridges or S-S linkages. An S-S linkage also occurs in A chain. The hormone develops from a storage product called proinsulin. Proinsulin has three chains, A, B and C. C-chain with 33 amino acids is removed prior to insulin formation. Insulin is produced by the beta cells of the islets of Langerhans of the pancreas. The gene for this protein synthesis is located on chromosome 11. In mammals, including humans, insulin is synthesised as a pro-hormone which contains an extra stretch called the C peptide. This C peptide is not present in the mature insulin and is removed during maturation into insulin. The main challenge for production of insulin using rDNA technique was getting insulin assembled into a mature form. In 1983, Eli Lilly an American company, first prepared two DNA sequences corresponding to A and B chains of human insulin and introduced them in plasmids of Escherichia coli to produce insulin chains. Chains A and B were produced separately, extracted and combined by creating disulfide bonds to form human insulin (humulin).

The recombinant DNA technology process has made great impact in the area of healthcare by mass production of safe and more effective therapeutic drugs. Further, the recombinant therapeutics do not induce unwanted immunological responses.

OR

25. (a) The restriction modification system consists of two components; (i) A restriction enzyme which identifies the introduced foreign DNA and cuts into pieces called restriction endonucleases. The term 'restriction' refers to the function of these enzymes in restricting the propagation of foreign DNA of bacteriophages (viruses that attack bacteria) in the host bacterium. (ii) The second component is a modification enzyme that adds a methyl group to one or two bases usually 'within' the sequence reorganised by the restriction enzyme. Once a base in a DNA sequence is modified by addition of a methyl group, the restriction enzymes fail to recognise and could not cut that DNA. This is how a bacterium modifies and therefore, protects its own chromosomal DNA from cleavage by these restriction enzymes.

OR

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The recombinant DNA technology process has made great impact in the area of healthcare by mass production of safe and more effective therapeutic drugs. Further, the recombinant therapeutics do not induce unwanted immunological responses.
Crops in which foreign genes have been introduced through genetic engineering are called genetically modified (GM) crops. GM crops contain and express one or more useful foreign genes or transgenes. The technique of GM crops has two advantages:

(i) Any gene from any organism or a synthetic gene can be incorporated.
(ii) Change in genotype is precisely controlled. This technology is superior to breeding programmes because in breeding only the already present genes are reshuffled and that changes would occur in all traits for which the parents are different.

Disadvantages of GM plants are:

(i) Bt toxins expressed in pollen grains of transgenic crops are harmful for useful varieties of insects, e.g., honeybees and butterflies.
(ii) Reduced effectiveness of pesticides, as some populations of mosquitoes developed resistance to the now-banned pesticide DDT. Insects might become resistant to Bt or other crops that have been genetically modified to produce their own pesticides.
(iii) The foods produced by transgenic crops cause toxicity and produce allergies.
(iv) The bacteria present in human alimentary canal can become resistant to antibiotics by taking up antibiotic resistant gene present in genetically modified food and may become difficult to manage.

26. (a) (i) ‘Flavr Savr’ is a transgenic tomato. In transgenic tomato, expression of native tomato gene has been blocked. This gene produces enzyme polygalacturonase which promotes softening of food. The non-availability of this enzyme prevents over ripening and thus fruit remains fresh for longer time. It also retains flavour, superior taste and higher quantity of total soluble solids. So, it prevents post harvest and over-ripening losses. Thus, it is preferred over normal native variety.

(ii) ANDI - DNA of a flourescent jelly fish was introduced into an unfertilised egg of a Rhesus monkey in the test tube. The diploid egg underwent cleavage and the early embryo was implanted in a surrogate mother. It has been named ANDI, the acronym of ‘inserted DNA’. This work would be helpful for curing diseases such as breast cancer, Alzheimer’s disease, diabetes and AIDS.

(iii) Tracy, the transgenic ewe was born in Scotland. Transgenic sheep have been produced to achieve better growth and meat production. For example, human genes for blood clotting factor IX and for α1-antitrypsin have been transferred in sheep and expressed in mammary tissue. This was achieved by fusing the genes with the mammary tissue-specific promoter of the bovine β-lactoglobulin gene. Human growth hormone gene has also been introduced in sheep in order to promote growth and meat production. However, they also showed several undesirable effects like joint pathology, skeletal defects, gastric ulcers, infertility, etc.
(b) Transgenic chicken is resistant to avian leukosis virus (ALV).

(a) The direct or vectorless gene transfer involves following methods:

(i) Electroporation: In this method, electrical impulses induce transient pores in the plasma membrane of host cell by using lysozyme or calcium chloride through which foreign DNA molecules are incorporated into cells.

(ii) Biolistic method or (Gene Gun method): Biolistic is a means of introducing DNA into cells that involves bombardment of cells with high-velocity microprojectiles coated with DNA. In this method tungsten or gold particles, coated with foreign DNA are bombarded into target cells at a very high velocity.

(iii) Microinjection: It is the introduction of foreign gene directly into nucleus of plant cell or animal cell by using microneedles or micropipettes.

(iv) Chemical mediated gene transfer: In this method polyethylene glycol (PEG) help foreign DNA to enter the host cell.

(b)
Dolly: The First Cloned Mammal

Dolly, a Finn Dorset sheep was the first mammal to be cloned from adult cell. It was born on 5th of July, 1996 at the Roslin Institute in Edinburgh, Scotland by Scotsman Ian Wilmut. She lived, mated and produced normal offsprings in her six years of life span, proving that cloned animals can also reproduce. She was euthanased on February’ 14, 2003 after she suffered from sheep pulmonary adenomatosis and arthritis.

1. ADULT FINN DORSET EWE
An udder cell is taken from adult Finn Dorset ewe.

2. REPROGRAMMING OF ADULT DONOR CELL
Cells taken from the udder are placed in a culture medium with very low concentration of nutrients and starved. The cells stop dividing but are still alive. They switch off their active genes and reprogram themselves.

3. ADULT SCOTTISH BLACKFACE EWE
An unfertilised egg cell is taken from a Scottish Blackface ewe.

4. REMOVAL OF NUCLEUS FROM EGG CELL
The nucleus along with its DNA is sucked out, leaving an empty egg cell containing all the cellular machinery required to produce an embryo.

5. FUSION OF TWO CELLS
The two cells (adult donor and egg cell) are placed next to each other and an electric pulse is applied. It causes them to fuse together like soap bubbles. A second pulse mimics the burst of energy at natural fertilisation, thus, initiating cell division.

6. EMBRYO FORMATION
The fused cell begins to divide normally to form an embryo which is implanted into the uterus of a surrogate mother, another Scottish Blackface ewe.

7. EMBRYO IMPLANTATION
After the gestation period, the pregnant Blackface ewe gives birth to a baby Finn Dorset lamb, named Dolly, which is a clone of the original donor.

8. CLONED LAMB
The implanted embryo develops into a normal healthy lamb-named Dolly.

Despite being a clone, Dolly is not genetically identical to her genetic mother as the mitochondrial (cytoplasmic) inheritance is from egg donor mother.
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Winners’ names will be published in next issue.

**ACROSS**
1. Severe disfigurement in adults due to excess secretion of growth hormone. (10)
2. A complex polysaccharide that makes the exoskeleton of arthropods. (6)
3. A group of parasitic fungi that infects the leaves and stem of cereal crops and belongs to Class Basidiomycota. (5)
4. Geological era in which dinosaurs became the dominant life form. (8)
5. Oxidation of glucose without the help of oxygen in the cytoplasm. (10)
6. The process of self destruction of a cell. (9)
7. Main constituent of cell wall and its fibrous nature leads to its use in textile industry. (9)
8. A Swedish botanist who proposed the two kingdom classification. (8)
9. The end of a chromosome which consists of tandemly repeated short DNA sequences that ensure complete replication of DNA. (8)
10. A mutant gene that leads to uncontrolled cell proliferation and causes cancer. (8)
11. A small spherical organelle in plant cell that synthesises and store lipids. (8)
12. A type of white blood cell whose major function is to regulate the allergic responses. (10)
13. An enzyme that breaks down the milk sugar. (7)
14. A species whose impact on its community is more and it plays a crucial role in the community. (8)
15. The smooth, white and extremely hard covering over the crown of a tooth. (6)
16. A type of inheritance that is determined by the genes on Y chromosome and hence present only in males. (9)
17. A malt whisky or grain whisky, made in Scotland. (6)
18. A cyanobacteria that is used as biofertiliser. (6)
19. The process of shedding outer cuticle in arthropods. (7)
20. The final chamber of the stomach of ruminants. (8)
21. A glandular sticky part of the flower that receives the pollen. (6)
22. A structure formed from microtubules during cell division that moves chromosomes apart. (7)
23. A super class of vertebrate animals having four limbs. (9)
24. The duct in human female that passes the ovum from an ovary to the uterus. (7)
25. A sugary liquid produced in plants that attracts insects. (6)
26. The largest part of vertebrate brain that helps in learning process. (8)
27. A small spherical organelle in plant cell that synthesises and store lipids. (8)
28. A sugary liquid produced in plants that attracts insects. (6)
29. A part of the inner ear that transforms sound waves into nerve impulse. (7)

**DOWN**
2. A complex polysaccharide that makes the exoskeleton of arthropods. (6)
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11. A small spherical organelle in plant cell that synthesises and store lipids. (8)
12. A class of enzyme that catalyses the cleavage of bonds without hydrolysis or oxidation. (5)
13. A singular word for any dividing wall in a plant or animal. (6)
14. A structure formed from microtubules during cell division that moves chromosomes apart. (7)
15. A super class of vertebrate animals having four limbs. (9)
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