PART - I (BIO-BOTANY)

SECTION – 1

1. (d)
2. (a)
3. (d)
4. (b)
5. (b)
6. (c)
7. (a)
8. (d)

SECTION - 2

9. Multiple alleles are three or more alternative forms of the same gene that exist at the same locus on homologous chromosomes in a population, though only two alleles can be present in an individual at a time.
Example:
The ABO blood group system in humans has three alleles: I^A, I^B, and i.
10. Chemicals used in gene transfer:
- Calcium chloride ($CaCl_2$)
- Polyethylene glycol (PEG)
11. Co-evolution is the process in which two or more species that are closely associated influence each other's evolution, leading to mutual adaptations over time.
Example:
Co-evolution of flowers and their pollinators.
12. The pyramid of energy is always upright because:
- Energy flow is unidirectional (from producers to consumers).
- At each trophic level, a large part of energy is lost as heat during respiration and metabolic activities.
- Only about 10% of energy is transferred to the next trophic level (10% law).
Hence, energy decreases progressively at higher trophic levels, making the pyramid of energy always upright.
13. Primary Introduction (Direct): -
- Process: A new plant variety is brought to a new environment and, if well-suited, is released directly for commercial farming.
- Modification: No significant alteration to the original genotype occurs.
- Example: Introducing IR8 rice from the Philippines to India for direct cultivation.
Secondary Introduction (Indirect): -
- Process: The introduced variety is used as parent material for further breeding.
- Modification: Involves selection to find superior individuals or hybridization to transfer desirable genes (like disease resistance, yield) into local varieties.
- Example: Developing wheat varieties like Kalyan Sona and Sonalika from material introduced from Mexico.
14. The humours responsible for the health of human beings (according to the ancient theory of humours) are:
- Blood
- Phlegm
- Yellow bile
- Black bile
Good health was believed to depend on the proper balance of these four humours.

SECTION - 3

15. Man-made cereal: Triticale
How it is formed: -
Triticale is produced by hybridization of wheat (Triticum) and rye (Secale), combining the high yield of wheat with the hardiness of rye.
16. Materials used to grow Spirulina:
- Wastewater / sewage
- Industrial effluents rich in nutrients
- Mineral-rich alkaline water (with carbon source like sodium bicarbonate)
17. Cladode: -

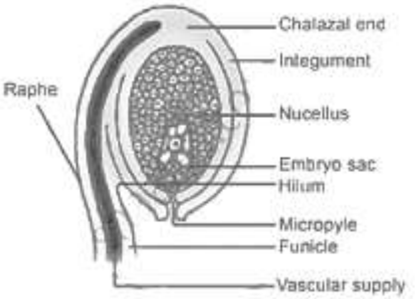
- Origin: A modified, flattened, green aerial stem or branch.
- Structure: Contains one or a few internodes, resembling a leaf but with limited growth.
- True Leaves: Often reduced to spines or scales, arising from the axil.
- Example: Asparagus, Butcher's Broom (Ruscus aculeatus).

Phyllode: -
- Origin: A modification of the leaf stalk (petiole) or rachis.
- Structure: A flattened, leaf-like structure that performs photosynthesis.
- True Leaves: Usually absent or very small and scale-like.
- Example: Acacia auriculiformis, Parkinsonia aculeata.

Key Distinction: -
- Cladode: A stem modification.
- Phyllode: A leaf (petiole/rachis) modification.

18. Examples of plants cultivated in commercial agroforestry:
- Teak (Tectona grandis)
- Eucalyptus
- Poplar (Populus)
- Casuarina

19.



The ovule is also called megasporangium and is protected by one or two covering called integuments. A mature ovule consists of a Raphe stalk and a body. The stalk or the funiculus (also called funicle) is present at the base and it attaches the ovule to the placenta. The point of attachment of the funicle to the body of the ovule is known as the hilum. It represents the junction ovule and funicle. In an inverted ovule, the funicle is adnate to the body of the ovule forming a ridge called raphe. The body of the ovule is made up of a central mass of parenchymatous tissue called nucellus which has large reserve food materials. The nucellus is enveloped by one or two protective coverings called integuments. Integument encloses the nucellus completely except at the top where it is free and forms a pore called the micropyle.

The ovule with one or two integuments is said to be unitegmic or bitegmic ovules respectively. The basal region of the body of the ovule where the nucellus, the integument, and the funicle meet or merge is called chalaza. There is a large, oval, saclike structure in the nucellus toward the micropylar end called embryo sac or female gametophyte. It develops from the functional megaspore formed within the nucellus. In some species(unitegmic tenuinucellate) the inner layer of the integument may become specialized to perform the nutritive function for the embryo sac and is called endothelium or integumentary tapetum (Example: Asteraceae)

SECTION – 4

20. **(a)** Microsporogenesis is the process of formation of microspores (pollen grains) from microspore mother cells (MMCs) in the anther of flowering plants.

Steps involved in Microsporogenesis

(i). Formation of Microspore Mother Cells (MMCs): -
- In the pollen sac (microsporangium) of the anther, certain hypodermal cells differentiate into archesporial cells.
- These cells divide to form sporogenous tissue, whose cells function as microspore mother cells (2n).

(ii). Meiotic division: -
- Each microspore mother cell undergoes meiosis (Meiosis I and II).
- This results in four haploid (n) microspores.

(iii). Formation of Microspore Tetrad: -
- The four microspores remain temporarily held together in a group called a tetrad.
- The tetrads may be tetrahedral, isobilateral, linear, or T-shaped, depending on the species.

(iv). Separation of Microspores: -

- The callose wall surrounding the tetrad dissolves with the help of the enzyme callase secreted by the tapetum.
- Individual microspores are released into the anther cavity.

(v). Development into Pollen Grains: -

- Each microspore enlarges and develops into a pollen grain, which later participates in male gametophyte formation.

OR

(b) Dominant epistasis is a type of gene interaction in which a dominant allele of one gene masks or suppresses the expression of another gene located at a different locus.

Key feature: -

- Presence of one dominant allele of the epistatic gene is sufficient to inhibit the expression of the other gene.

Example: -Fruit colour in summer squash (*Cucurbita pepo*)

- Gene W (dominant) inhibits pigment formation → white fruit
- Gene Y controls colour:
- Y → yellow
- y → green

Genotypes and phenotypes:

- W– – – → White (dominant epistasis)
- wwY– → Yellow
- wwyy → Green

Phenotypic ratio in F_2 generation:

12 White: 3 Yellow: 1 Green

21. **(a)** Basic concepts involved in Plant Tissue Culture

(i). Totipotency: -

Every living plant cell has the ability to regenerate into a complete plant when provided with suitable nutrients and conditions.

(ii). Explant: -

A small piece of plant tissue (leaf, stem, root, meristem, etc.) taken from a healthy plant and used to initiate culture.

(iii). Aseptic conditions: -

Cultures must be maintained in sterile conditions to prevent contamination by microorganisms.

(iv). Culture medium: -

A nutrient medium (e.g., MS medium) containing minerals, vitamins, sugar, and plant growth regulators to support growth.

(v). Plant growth regulators: -

Auxins and cytokinins control cell division, differentiation, and organ formation.

(vi). Callus formation: -

An unorganized mass of actively dividing cells formed from explants under suitable conditions.

(vii). Differentiation and redifferentiation: -

Callus cells differentiate to form organs (roots and shoots) and later redifferentiate to form a complete plant.

(viii). Hardening: -

Gradual acclimatization of tissue-cultured plants to external environmental conditions before transfer to soil.

OR

(b) Main Types of Succession

Primary Succession: -

- Where: Lifeless areas, new land (e.g., lava flows, glacial moraines).
- Start: Begins from scratch with no soil or existing life.
- Process: Slow; pioneer species (like lichens, mosses) create soil, allowing more complex plants to grow.

Secondary Succession: -

- Where: Disturbed ecosystems (e.g., forests after fires, cleared fields).
- Start: Soil and some organic matter/seeds remain.
- Process: Faster than primary, as soil is already present.

Other Classifications: -

Autoganic succession: Succession driven by the organisms themselves (e.g., plants changing the soil).

Alloganic succession: Succession driven by external factors like climate, fire, or floods.

Hydroseres/Xeroseres: Based on starting conditions: water (hydroseres) or dry (xeroseres, like on rock or sand).

PART - II (BIO-ZOOLOGY)
SECTION - 1

22. (d)
23. (d)
24. (b)
25. (d)
26. (b)
27. (d)
28. (a)
29. (b)

SECTION – 2

30. Parthenogenesis is a form of asexual reproduction in which an unfertilized egg develops into a new individual.
Example: -
- Honeybee (male drones develop from unfertilized eggs)
- Aphids and some lizards

31. Amniocentesis is a prenatal diagnostic technique in which a small amount of amniotic fluid surrounding the fetus is withdrawn and examined.
Purpose: -
- To detect genetic disorders
- To identify chromosomal abnormalities
- To assess fetal health

32. The central dogma of protein synthesis is:
DNA → RNA → Protein
Genetic information flows from DNA to RNA (transcription) and from RNA to protein (translation).

33. A vaccine is a biological preparation that stimulates the immune system to produce immunity against a specific disease by inducing the formation of antibodies and memory cells, without causing the disease.
Examples: BCG, polio vaccine, measles vaccine.

34. Co-extinction is the process in which the extinction of one species leads to the extinction of another species that is ecologically dependent on it.
Example: -
Extinction of a host species causing extinction of its parasites, or loss of a plant species leading to extinction of its specialized pollinator.

35. Biomagnification refers to the progressive increase in concentration of non-biodegradable, toxic substances (such as pesticides or heavy metals) at successive trophic levels of a food chain.
Example: -
Increase in concentration of DDT or mercury from plankton → fish → birds/humans.

SECTION - 3

36. Salient features of Mutation Theory (Hugo de Vries)
- Mutations are sudden, discontinuous variations appearing in organisms.
- Mutations are heritable and can be passed to the next generation.
- Evolution occurs by accumulation of mutations, not by small continuous variations.
- Mutations arise randomly and are directionless.
- New species may arise by single or few mutations.
- Natural selection only preserves useful mutations; it does not create variations.

37. Short Notes on Microbial Fuel Cell: -
- Microorganisms (mainly bacteria) oxidize organic substrates such as sewage or waste.
- During metabolism, electrons and protons are released.
- Electrons are transferred to the anode, flow through an external circuit, and generate electric current.
- Protons move to the cathode, where they combine with oxygen to form water.
- MFCs help in wastewater treatment along with energy production.
- They are eco-friendly and reduce pollution.

38. Somatic Cell Gene Therapy: -

- Target Cells: Non-reproductive cells (somatic cells) like bone marrow, muscle, or skin cells.
- Inheritance: The genetic changes are confined to the treated individual and are *not* passed to their children.
- Purpose: To correct genetic defects in the patient to treat or cure diseases.
- Status: Widely used and ethically accepted for therapeutic purposes.

Germline Gene Therapy: -
- Target Cells: Reproductive cells (germ cells) – sperm or egg cells.
- Inheritance: The genetic alteration is incorporated into the DNA of the reproductive cells, making the change permanent and heritable by all future offspring.
- Purpose: To correct genetic defects in a way that prevents the disease from ever appearing in descendants.
- Status: Highly controversial and generally banned due to ethical concerns about altering the human gene pool.

39. Five causes of biodiversity loss: -

(i) Habitat destruction – deforestation, urbanization, mining.
(ii) Pollution – air, water, and soil contamination.
(iii) Overexploitation – overhunting, overfishing, overharvesting of resources.
(iv) Invasive species – introduction of non-native species that outcompete native species.
(v) Climate change – global warming, altered rainfall, and changing ecosystems.

40. Step (1): F1 Generation Cross: -

The parental (P) cross is between a normal man (X^HY) and a heterozygous haemophiliac woman (X^HX^h). The possible gametes are X^H and Y for the man, and X^H and X^h for the woman. The flow chart representation (Punnett square) for the F1 generation is as follows:=

Gametes	X^H	X^h
X^H	X^HX^H	X^HX^h
Y	X^HY	X^hY

F1 Genotypes and Phenotypes:
- X^HX^H(25%) : Normal female
- X^HX^h(25%) : Carrier female (normal phenotype)
- X^HY(25%) : Normal male
- X^hY(25%) : Haemophiliac male

Step (2): F2 Generation Cross

To determine the F2 generation results, we assume a representative cross between an F1 carrier female (X^HX^h) and an F1 haemophiliac male (X^hY). The possible gametes are X^H and X^h for the female, and X^h and Y for the male. The flow chart representation (Punnett square) for this F2 cross is as follows:

Gametes	X^h	Y
X^H	X^HX^h	X^HY
X^h	X^hX^h	X^hY

F2 Genotypes and Phenotypes (from this specific cross):
- X^HX^h(25%) : Carrier female (normal phenotype)
- X^HY(25%) : Normal male
- X^hX^h(25%) : Haemophiliac female
- X^hY(25%) : Haemophiliac male

Answer: -

The results for the F1 and F2 generations are detailed in the steps above, summarized as follows: the F1 generation has 25% normal females, 25% carrier females, 25% normal males, and 25% haemophiliac males; the representative F2 cross (carrier female × haemophiliac male) produces 25% carrier females, 25% normal males, 25% haemophiliac females, and 25% haemophiliac males.

SECTION - 4

41. **(a)** Fertilization Process

(i) Sperm Capacitation & Acrosome Reaction: Sperm travel through the female tract, becoming hyperactive (capacitated). The acrosome (cap on the sperm head) releases enzymes to digest the egg's protective layers (corona radiata, zona pellucida).

(ii). Zona Pellucida Binding: A sperm binds to receptors on the zona pellucida, triggering the acrosome reaction.
(iii). Gamete Membrane Fusion: The sperm's membrane fuses with the egg's plasma membrane, allowing the sperm nucleus and centriole to enter the egg.
(iii). Egg Activation: Sperm entry triggers rapid metabolic changes in the egg, initiating development.
(iv). Pronuclear Formation: The sperm and egg nuclei decondense to form male and female pronuclei.
(v). Zygote Formation: The pronuclei fuse, creating a single-celled zygote with a complete set of chromosomes.
Prevention of Polyspermy
- Cortial Reaction (Slow Block): This is the main mechanism in humans, initiated after sperm entry.
- Calcium ions flood the egg, causing cortical granules (vesicles beneath the egg's plasma membrane) to fuse with the membrane and release their contents.
- These released enzymes, particularly serine proteases, modify the zona pellucida, causing it to harden and preventing further sperm binding.
-They also modify the egg's plasma membrane, reducing its fusibility to additional sperm.

OR

(b) Key Components of the Lac Operon: -
- Regulatory Gene (lacl): Codes for the repressor protein.
- Promoter (P): Binding site for RNA polymerase.
- Operator (O): DNA sequence where the repressor binds, located between the promoter and structural genes.
- Structural Genes (lacZ, lacY, lacA): Code for enzymes:
- lacz: Beta-galactosidase (breaks down lactose).
- lacY: Lactose permease (transports lactose into the cell).
- laca: Transacetylase (aids in metabolism).

Regulation Mechanism: -
(i). Lactose Absent (Operon OFF):
(ii). The lacI gene produces a repressor protein.
(iii). The repressor binds to the operator (O) region.
(iv). This blocks RNA polymerase at the promoter (P), preventing transcription of lacz, lacy, and laca.
(v). Lactose Present (Operon ON):
(vi). Lactose enters the cell and is converted to allolactose, which acts as the inducer.
(vii). Allolactose binds to the repressor protein, changing its shape and making it unable to bind to the operator.
(viii). With the operator free, RNA polymerase binds to the promoter and transcribes the structural genes, producing enzymes for lactose metabolism.

42. (a) Structure of Immunoglobulin (lg)

Immunoglobulins are glycoproteins produced by plasma cells in response to antigens. They play a key role in humoral immunity.

(i) General Structure: -
- Y-shaped molecule composed of four polypeptide chains:
- Two heavy (H) chains - long chains
- Two light (L) chains - short chains
- Chains are linked by disulfide (-S-S-) bonds.

2. Functional Regions
(i). Fab region (Fragment antigen-binding)
- Tips of the Y arms
- Contains variable (V) regions of heavy and light chains
- Binds specifically to the antigen

(ii) Fc region (Fragment crystallizable)
- Stem of the Y
- Contains constant (C) region of heavy chains
- Mediates effector functions like opsonization and complement activation

3. Variable and Constant Regions
- Variable region (V):
- Found in both H and L chains at the tips of Y
- Responsible for antigen specificity
- Constant region (C):
- Rest of the H and L chains
- Determines class of antibody (lgG, lgM, lg A, lqE, lgD)

4. Disulfide Bonds
- Hold H and L chains together
- Provide stability to the molecule

5. Hinge Region
- Flexible segment between Fab and Fc
- Allows movement of Fab arms for antigen binding

Diagram (Simplified Y-Shape)

```
        Fab                  Fab
       /  \                 /  \
      /    \               /    \
   Light   Heavy      Heavy    Light
   Chain   Chain      Chain    Chain
      \    /               \    /
       \  /                 \  /
        ---   Hinge region ---
        Fc (Constant region)
```

Labels you can include:
- Fab (antigen-binding fragment)
- Fc (crystallizable fragment)
- Heavy chain
- Light chain
- Variable region
- Constant region
- Disulfide bonds
- Hinge region

OR

(b) Properties of Soil: -

Soil has physical, chemical, and biological properties that determine its fertility and suitability for plants.

(i) . Physical Properties: -
- Texture: Proportion of sand, silt, and clay; affects water retention, aeration, and root growth.
- Structure: Arrangement of soil particles into aggregates; influences porosity and permeability.
- Color: Indicates organic matter and mineral content (dark = rich in humus, light = poor).
- Porosity: Volume of spaces between particles; affects air and water movement.
- Water-holding capacity: Ability to retain water for plants; clay soils hold more water than sandy soils.

(ii). Chemical Properties: -
- pH: Acidity or alkalinity of soil; most plants grow best at pH 6–7.5.
- Cation Exchange Capacity (CEC): Ability to hold and exchange essential nutrients like Ca^{2+}, Mg^{2+}, and K^{+}.
- Nutrient content: Presence of essential minerals like nitrogen, phosphorus, potassium, calcium, magnesium, and iron.

(iii). Biological Properties: -
- Microorganisms: Bacteria, fungi, actinomycetes help in decomposition, nitrogen fixation, and nutrient cycling.
- Organic matter (humus): Improves fertility, structure, and water retention.
- Soil fauna: Earthworms and insects help aeration and mixing of soil.