1. **(d)** • Plant not requiring emasculation
   • Explanation: Emasculation is the removal of male reproductive parts (anthers) from a bisexual flower to prevent self-pollination. Since papaya is a dioecious plant bearing unisexual flowers, its female flowers do not contain anthers, making emasculation unnecessary.
2. **(c)** • Component not part of the immune system
   • Red Blood Cells (erythrocytes) function primarily to transport oxygen throughout the body. Lymphocytes, plasma proteins (like antibodies), and bone marrow are all fundamental elements of the immune system.
3. **(b)** • Correct statements regarding the menstrual cycle
   • Statement (I) is correct because the corpus luteum secretes high amounts of progesterone.
   • Statement (III) is correct as the LH surge triggers ovulation (rupture of the Graafian follicle).
   • Statement (II) is wrong because both LH and FSH peak mid-cycle.
   • Statement (IV) is wrong because the luteal phase is called the secretory phase.
4. **(b)** • Mismatched pair
   • This pair is mismatched because India possesses incredible genetic diversity in agriculture, housing more than 50,000 genetically different strains of rice.
5. **(a)** • Production of Pomato
   • Pomato is a somatic hybrid created by fusing the protoplasts of a tomato plant and a potato plant.
6. **(a)** Stratification is the vertical distribution of different species occupying different levels in an ecosystem. For example, in a forest, tall trees occupy the top layer, shrubs occupy the middle layer, and herbs/grasses occupy the bottom layer.
7. **(a)** The sacred groves of Meghalaya are found in the Khasi and Jaintia Hills. The other options (Bastar, Chanda, and Sarguja) are located in Central India (Madhya Pradesh and Chhattisgarh).
8. **(b)** The diagram illustrates Mendel's Law of Independent Assortment. It shows how different pairs of homologous chromosomes align randomly during Metaphase I, resulting in multiple equally probable genetic combinations in the final gametes.
9. **(c)** (A) Biolistic gun → (V) Plant cell: Used to introduce alien DNA into plant cells by bombarding them with high-velocity micro-particles.
   (B) Chitinase → (IV) Fungal cell: An enzyme used to break open fungal cell walls to isolate DNA.
   (C) Ti → (II) Tumour inducing: The Ti (Tumour inducing) plasmid of Agrobacterium tumefaciens modifies plant cells.
   (D) Ca^{++} → (I) Bacterial cell: Divalent calcium ions increase the efficiency with which DNA enters a bacterial cell.
10. **(d)** Jean-Baptiste Lamarck proposed the theory of inheritance of acquired characters, which states that organs used frequently become more developed, while disused organs degenerate over generations.
11. **(b)** This statement is incorrect because plasmids contain their own origin of replication (ori) and replicate independently (autonomously) of the bacterial chromosomal DNA.
12. **(b)** Ovaries are held in place within the pelvic cavity by specialized folds of peritoneum called ligaments (such as the ovarian ligament and the suspensory ligament).
13. **(a)** During the Industrial Revolution, soot killed or covered lichens and darkened tree trunks, so the dark (melanised) moths were better camouflaged against predators and thus had higher survival and reproductive success, an example of natural selection; when pollution later declined, the light form regained advantage.
    So, Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation for Assertion (A).
14. **(a)** Rosie was the first transgenic cow to produce milk enriched with the human protein alpha-lactalbumin (reported at $\sim 2.4\ g/L$), a milestone achieved in 1997.
    Alpha-lactalbumin is a dominant whey protein in human milk, and increasing its proportion in bovine milk makes the protein composition closer to human milk, so Rosie's milk was considered a more nutritionally balanced product for human infants than ordinary cow milk.
    So, Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation for Assertion (A).
15. **(c)** Flocs are aggregates of microorganisms, primarily bacteria, held together with filamentous organisms and extracellular polymers that form during secondary treatment. The aeration tank aerobically breaks down organic matter (with oxygen supplied); anaerobic digestion of sludge occurs later in separate anaerobic digesters, not in the aerobic secondary treatment.

16. **(d)** The assertion is false, and the reason is true. In most terrestrial ecosystems, a large part of primary production becomes litter and dead organic matter and is processed mainly by the detritus (decomposer) food chain rather than by the grazing chain; microbes/saprotrophs obtain energy by decomposing dead remains. us chains are often linked (via herbivore faeces, carcasses, trophic links and food-web connections), so the reason is correct, but it does not make the assertion true.

17. **(A)** The antibody-mediated immune reaction in which B-lymphocytes (plasma cells) produce antibodies that circulate in body fluids to neutralise pathogens and toxins.

(B) IgG and IgM are two types of antibodies found to give a humoral immune response in humans.

18. **(A) (i)** They store seeds in a dormant state to keep them viable for later sowing and to provide a year-round food supply until the next cropping season.

(ii) Pea seed is non-albuminous (endosperm is consumed during embryo development; food is stored in thick cotyledons), whereas castor seed is albuminous (endosperm persists in the mature seed and serves as the storage tissue).

OR

(B) The primary oocyte completes its first meiotic division within the Graafian follicle (also known as the mature tertiary follicle).

Products of the First Meiotic Division

(1) First Polar Body: A tiny, haploid cell that contains very little cytoplasm and typically degenerates.

(2) Secondary Oocyte: A large, haploid cell that retains the bulk of the nutrient-rich cytoplasm.

19. **(A)** Sequence Identification and Enzyme Name

• Name of sequence: These are called Palindromic Nucleotide Sequences. In DNA, a palindrome is a sequence of base pairs that reads the same on both strands when the reading orientation (5′ to 3′) is kept the same.

• Enzyme: The enzymes that recognise these specific sequences are Restriction Endonucleases. Specifically, the sequence 5'-GAATTC-3' is recognised by the enzyme EcoRI.

(B) Mechanism of Function

• Binding and Cutting

• Specific Cleavage

• Sticky Ends

20. **(A) (I)** Type of heterogamety: Male heterogamety (XX/XO system)

Example: grasshopper

(II) Type of heterogamety: Female heterogamety (ZW/ZZ system)

Example: chicken (birds).

OR

(B) (i)

DNA nucleotide	RNA nucleotide
(I) Contains the deoxyribose type of pentose sugar.	(I) Contains oxyribose, a type of pentose sugar.
(II) It is double-stated.	(II) It is basically single-stranded, but due to its long length, it appears folded.
(III) It is genetic material in prokaryotes and eukaryotes.	(III) It is genetic material only in some viruses.

(IV) It helps in the inheritance of genetic information.	(IV) It helps in the inheritance of genetic information in viruses & protein synthesis in prokaryotes & Eukaryotes.

(ii) (1) N-glycosidic bond
(2) Phosphoester bond

21. **(A) (i)** Inverted pyramid of biomass (standing crop). It occurs in aquatic ecosystems, e.g., phytoplankton (producers) have a low standing crop but very high turnover, while consumers (zooplankton/fish) have greater accumulated biomass, so the biomass pyramid is inverted.

(ii) It assumes a simple food chain and cannot represent food webs or species that occupy more than one trophic level.

• Decomposers/saprophytes are excluded, and thus their role in energy/matter cycling is not shown.

OR

(B) (i) Loss of species richness and abundance (fewer species and smaller populations). For example, removing key groups (e.g., all producers) reduces primary productivity and removes food/energy for higher trophic levels.

• Local extinctions and secondary extinctions (species that depend closely on lost species hosts, pollinators or specialist predators may also disappear).

(ii) (1) Habitat destruction and fragmentation: conversion of natural habitat (clearing, development, fires, overgrazing, soil changes) removes the places species need to live, breed, and feed, and fragments populations, causing them to decline or go locally extinct.

(2) Invasion by alien (non-native) species: Aggressive introduced species can outcompete, prey on, or chemically inhibit native species, leading to declines or elimination of local species.

22. **(A)** No. Pollen viability varies with species and environmental conditions (temperature, humidity). For example, pollen of cereals such as rice and wheat loses viability within about 30 minutes of release, whereas pollen of some members of Rosaceae, Leguminosae and Solanaceae may remain viable for months.

(B) Pollen grains are dried and stored at ultra-low temperatures in liquid nitrogen (about $-196^{\circ}C$), thereby preserving their viability for years in pollen banks.

23. **(A)** A pedigree is a record of the inheritance of specific genetic features for two or more generations, shown as a family tree. The pedigree analysis examines a pedigree to determine the transmission of a particular trait and the probability of that trait being absent or present in a homozygous or heterozygous state in a given individual.

• Pedigree analysis is important because it reveals the mode of inheritance of a trait and helps identify affected individuals and carriers for diagnosis and genetic counselling.

(B) (i) Autosomal recessive.

(ii) Example: Phenylketonuria (PKU).

24. **(A)** Sum total of all the allelic frequencies is 1 . Let there be two alleles A and a in a population. The frequencies of alleles A and a are ' p ' and 'q' respectively.

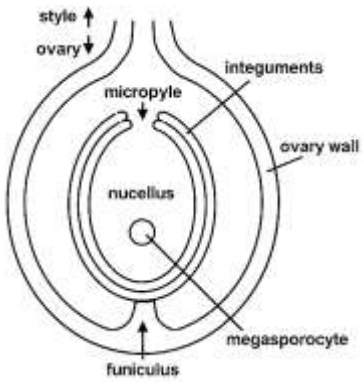
The frequency of AA individuals in a population is p^2 and it can be explained that the probability that an allele A with a frequency of p would appear on both the chromosomes of a diploid individual is simply the product of the probabilities, i.e., p^2.

Similarly, the frequency of aa is q^2 and that of Aa is 2 pq .

$(p^2 + 2pq + q^2) = 1$ where p^2 represents the frequency of the homozygous dominant genotype, $2pq$ represents the frequency of the heterozygous genotype and q^2 represents the frequency of the homozygous recessive.

(B) Factors that affect Hardy-Weinberg equilibrium or genetic equilibrium:
(1) Gene migration or gene flow
(2) Genetic drift
(3) Mutation
(4) Genetic recombination
(5) Natural Selection

25.



26. **(A)** The scientific name of the plant form which opioids are extracted is Papaver somniferum (poppy plant).
Opioids are extracted from the latex of poppy plant.
Opioids are commonly called smack.
It is chemically diacetylmorphine.
(B) Morphine and heroin are related as heroin is chemically derived from morphine. Morphine is extracted from the latex of the poppy plant (Papaver somniferum), and heroin is obtained by acetylation of morphine.
(1) They act on the Central Nervous System (CNS) as a depressant.
(2) provide pain relief, exhilaration, and drowsiness, but they can also cause addiction and respiratory collapse.

27. **(A)** The cry (crystal) gene from Bacillus thuringiensis (encoding Cry or δ-endotoxin proteins, e.g., cry1Ab).
(B) Bt produces Cry (Bt) toxin as an inactive crystal. When insect larvae ingest it, the alkaline gut activates the toxin; the activated toxin binds midgut epithelial cells and forms pores, causing cell swelling, lysis, gut paralysis, cessation of feeding and death of the larva.
(C) Field B corn is genetically modified (transgenic) to carry the Bt cry gene inserted into the plant genome. The plants express the Bt (Cry) toxin in their tissues, so larvae that feed on them ingest the toxin and are killed, conferring resistance to corn borer.

28. **(A)** You will get no (or very faint) bands after EtBr staining; the DNA will have migrated out of the gel instead of into it (or will remain as a faint smear near/outside the gel).
Reason: DNA is negatively charged and migrates toward the positive (anode); in the first drawing, the wells are oriented toward the anode so the fragments move out of the gel. Ethidium bromide only makes whatever DNA remains in the gel fluoresce, so if the DNA is left in the gel, you see nothing.
(B) Change made: the gel/electrode arrangement was reversed so the wells are now next to the negative electrode (cathode) and the electric field directs DNA from the wells into the gel toward the positive electrode. Why the 100 bp band appears at X : smaller fragments migrate faster through agarose, so the 100 bp fragment travels farthest from the wells and appears at position X (the furthest/expected position for the smallest fragment). The need to correct electrode orientation is the same reason given above for the original lack of bands.

29. **(A)** Competitive exclusion (observed as competitive release).
Definition: when one species (Balanus) outcompetes and excludes another (Chthamalus) from part of its habitat; removing the dominant species allows the inferior competitor to expand into that area.

OR

(A) Competitive Exclusion (Gause) principle: Two species competing for the same limiting resources cannot stably coexist; the better competitor will exclude the other.
(B) Two herbivorous fish species feed on the same phytoplankton they compete for the same food resource.
(C) By niche partitioning/resource partitioning, species use different parts of a resource or use it at different times (e.g., two coexisting species may feed on the same food but at different depths/times or occupy different microhabitats). This separation of niches reduces direct competition and allows coexistence.

30. **(A)** Cross I: parents are true-breeding (homozygous) for opposite traits, one TT (tall) × one tt (dwarf), so all F1 are tall (Tt).

OR

(A) These graphs represent a monohybrid Mendelian cross (dominant-recessive trait).
(B) Cross III shows 250 tall: 250 dwarf (1:1). This is a test-cross of a heterozygote (Tt) crossed with a homozygous recessive (tt), giving 1:1 progeny. Test crosses are used to determine whether an individual showing the dominant phenotype is homozygous or heterozygous and to confirm Mendelian segregation.

(C) From I and II, we conclude that tallness is dominant to dwarfness and alleles segregate, so the F2 shows a 3:1 phenotypic ratio (tall: dwarf), illustrating Mendel's law of segregation.

31. (A) (1) Site of fertilization: Fertilization normally occurs in the ampullary (ampulla) region of the fallopian (uterine) tube.

(2) Arrival of gametes: Around ovulation, the secondary oocyte is released from the ovary, picked up by the fimbriae, and transported into the uterine tube. Motile sperm swim from the vagina through the cervix and uterus into the uterine tube, so that sperm and oocyte meet in the ampulla.

(3) Sperm preparation and entry: Sperm undergo capacitation in the female tract (functional changes that enable fertilisation), and then the acrosome reaction allows enzymes to digest the zona pellucida so a sperm can penetrate to the oocyte membrane.

(4) Fusion and prevention of polyspermy: A single sperm fuses with the oocyte membrane, triggering cortical granule release and changes in the zona pellucida that block entry of additional sperm (preventing polyspermy). The sperm nucleus and oocyte nucleus undergo events that produce haploid male and female pronuclei.

(5) Formation of the zygote (syngamy): Male and female pronuclei fuse to form a diploid zygote (the first embryonic cell). This is the moment the chromosome complement of the embryo is established.

(6) Cleavage (early mitotic divisions): The zygote undergoes repeated mitotic (cleavage) divisions as it is transported through the isthmus of the uterine tube toward the uterus, producing 2-, 4-, 8-, 16-cell stages (blastomeres).

(7) Morula: Continued cleavage yields a compacted morula (about $8-16$ blastomeres). The embryo is still surrounded by the zona pellucida as it moves toward the uterine cavity.

(8) Blastocyst formation: Fluid accumulates within the morula to form a blastocyst: an outer trophoblast layer and an inner cell mass (embryoblast). The blastocyst stage is the stage competent to attach to the endometrium.

(9) Attachment and implantation: The trophoblast of the blastocyst adheres to the endometrial epithelium of the uterus (attachment/apposition), then trophoblast cells proliferate and invade into the endometrium so the blastocyst becomes embedded (implantation). As implantation proceeds, the trophoblast contributes to the formation of chorionic villi and the developing placenta.

OR

(B) (i) (I) Retrieve sperm surgically from the epididymis/testis (e.g., PESA/MESA/TESE) and perform intracytoplasmic sperm injection (ICSI) so a retrieved single sperm is injected into the oocyte.

(II) Bypass the blocked fallopian tube with in-vitro fertilisation (IVF) and embryo transfer (ET).

(III) Use IVF with intracytoplasmic sperm injection (ICSI) to overcome low sperm count and poor motility; (IUI/AI is an option only for milder male-factor cases).

(ii) Two reasons they are effective contraceptives:

(1) The released copper ions are spermicidal; they suppress sperm motility and reduce sperm fertilizing capacity.

(2) Copper IUDs increase phagocytosis of sperm within the uterus, so fewer sperm survive to reach and fertilize an egg.

32. (A) (i) They relied mainly on

(1) Chargaff's rules (that $A = T$ and $C = G$) were discovered by Erwin Chargaff.

(2) DNA X-ray diffraction data showing a helical form produced by Rosalind Franklin and Maurice Wilkins. Chargaff's base-composition rules implied specific base-pairing, and the X-ray patterns indicated a regular helical geometry; together, these allowed Watson and Crick to build the double-helix model.

(ii) (1) Two polynucleotide strands: DNA consists of two long chains of nucleotides running alongside each other.

(2) Antiparallel orientation: the two strands run in opposite directions (one $5' \rightarrow 3'$, the other $3' \rightarrow 5'$).

(3) Right-handed double helix (B-form): the common form is a right-handed helix.

(4) Complementary base pairing: bases pair specifically adenine (A) with thymine (T) and guanine (G) with cytosine (C) via hydrogen bonds ($A - T = 2$H-bonds; $G - C = 3$H-bonds).

OR

(B) 5′-ATG ACC GTA TTT TCT GTA GTG CCC GTA CTT CAG GCA TAA-3' = CODING

(i) 3′-TAC TGG CAT AAA AGA CAT CAC GGG CAT GAA GTC CGT ATT-5' = TEMPLATE 5′-AUG ACC GUA UUU UCU GUA GUG CCC GUA CUU CAG GCA UAA-3'

(ii) (1) In a bacterium 5′-AUG ACC GUA UUU UCU GUA GUG CCC GUA CUU CAG GCA UAA-3'

(2) In humans 5 '-mGpppAUG ACC UUU UCU GUG CCC CUU CAG GCA UAA - Poly A tail-3'

(iii) 9 amino acids in the polypeptide because UAA is a stop/terminator codon and does not code for any amino acid.

33. (A) (i) Plasmodium falciparum.

(ii) The female Anopheles mosquito

Changes that take place:
• Gametocytes (from infected human blood) develop into male (micro-) and female (macro-) gametes in the mosquito midgut.
• Microgametogenesis (exflagellation) produces motile microgametes; macrogametocytes become macrogametes.
• Fertilization of micro- and macrogametes produces a diploid zygote, which becomes a motile ookinete.
• Ookinete penetrates the gut wall and forms an oocyst on the outer gut surface; sporogony in the oocyst produces many sporozoites.
• Sporozoites are released and migrate to the mosquito's salivary glands, ready to infect the next human.
(iii) After entering the bloodstream, the merozoites invade red blood cells (RBCs) and undergo asexual development (trophozoite → schizont). Rupture of infected RBCs releases new merozoites and parasite-derived toxins, causing periodic fever and chills and loss of RBCs (hemolytic anaemia). Infected RBCs express parasite proteins that mediate cytoadherence and sequestration in capillaries, blocking microcirculation and causing tissue ischemia, a key mechanism behind severe complications such as cerebral malaria.
(iv) Effective preventive measures-
• Use of long-lasting insecticide-treated bed nets (LLINs) to prevent mosquito bites at night.
• Vector control indoor residual spraying (IRS) and removal/management of mosquito breeding sites (stagnant water) to reduce the mosquito population.

OR

(B) (i) Biofertilizers are living microorganisms that enhance soil nutrient quality by fixing atmospheric nitrogen or mobilizing nutrients, promoting plant growth naturally without chemicals.
(ii) Biofertilisers are living microorganisms that enrich soil nutrients and improve plant growth.
(1) Rhizobium: Forms root nodules on legumes and fixes atmospheric N 2 into plant-available nitrogen, raising soil N .
(2) Azotobacter/Azospirillum: Fix atmospheric N in the rhizosphere or inside roots of non-legumes, supplying N and promoting root growth.
(3) Mycorrhizal fungi: Extend root uptake via fungal hyphae, increase phosphorus and micronutrient uptake, improve water uptake and soil structure.
(iii) They enrich soil nutrients naturally (e.g., fix atmospheric N , solubilize P), improving soil fertility.
• They are eco-friendly and reduce dependence on chemical fertilizers, helping maintain long-term soil health.

34. (d) • Repetitive DNA sequences have different base composition and buoyant densities compared to singlecopy DNA.
• Density gradient centrifugation (using CsCl) separates DNA based on density, allowing repetitive DNA to be isolated from bulk genomic DNA.

35. (a) Latitudinal gradients show that biodiversity is highest in the tropics and decreases towards the poles. For context regarding the other incorrect choices: Colombia has around 1,400 bird species, New York has 105, and India has more than 1,200.

36. (b) (1) In a standard Mendelian dihybrid cross, the parental phenotypes are the two original true-breeding traits (e.g., Round-Yellow and Wrinkled-Green).
(2) The F_2 phenotypic ratio is $9:3:3:1$, where 9 (dominant for both) and 1 (recessive for both) exhibit the parental phenotypes.
(3) Total parental phenotypes in $F_2 = 9 + 1 = 10$ out of 16 .
(4) Out of 2400 individuals:
Number of parental phenotypes $= \frac{10}{16} \times 2400 = 1500$

37. (d) The Abingdon tortoise became extinct within a decade after goats were introduced to the island. This happened due to resource competition, as goats had a much higher browsing efficiency than the tortoises.

38. (b) Structures with the same basic anatomical design and evolutionary origin but modified to perform different functions are called homologous organs. Homology is proof of divergent evolution, which indicates a shared common ancestry.

39. (b) • Nirodh (Condoms)
(I) Prevention of STIs: Correct. Condoms provide a physical barrier that helps prevent the transmission of many sexually transmitted infections.
(II) Phagocytosis of sperms: Incorrect. This is a mechanism associated with IUDs (Intrauterine Devices), not condoms.
(III) Male contraceptive device: Correct. Nirodh is a barrier method used by males.

(IV) Acts as chemical barrier: Incorrect. Condoms are mechanical/physical barriers. Spermicidal creams act as chemical barriers.
(V) Physiological changes in cervical mucus: Incorrect. This is typically associated with oral contraceptive pills.

40. (b) • DNA Replication
This follows the semi-conservative model of DNA replication.
• Generation 0: 1 bacterium with 2 radioactive DNA strands.
• Generation 1: Both daughter cells have one radioactive strand and one new non-radioactive strand (100% of bacteria have radioactive DNA).
• Generation 2: *The two radioactive strands from the parents end up in two separate daughter cells.
• The other two daughter cells receive only non-radioactive strands.
• Result: Out of 4 cells, 2 contain radioactive DNA. 2/4 - 50%.

41. (b) • Role of Histamine
Mast cells release histamine as part of the inflammatory response. Histamine causes vasodilation and increased capillary permeability, which leads to the classic symptoms of an allergic reaction (such as swelling, redness, and itching).

42. (c)• Visualizing DNA Bands
Ethidium bromide is an intercalating agent that binds to DNA. When exposed to UV light, it fluoresces, allowing researchers to visualize the location of DNA bands in an agarose gel.

43. (b) • 'A' (Meiosis-1): The diploid (2n) Megaspore Mother Cell undergoes the first meiotic division (Meiosis-1) to form a haploid (n) Megaspore Dyad.
• 'B' (Meiosis-II): The Megaspore Dyad undergoes the second meiotic division (Meiosis-II) to produce a linear Megaspore Tetrad containing four haploid megaspores.
• ' C ' (No division): In most angiosperms, three out of the four megaspores degenerate, and only one remains functional. This process does not involve any cell division.
• 'D' (Mitosis): The single Functional Megaspore undergoes three sequential mitotic divisions (nuclear divisions followed by cellular organization) to form the 7 -celled, 8 -nucleate Embryo Sac (female gametophyte).

44. (b) • Agrobacterium tumefaciens is a natural soil bacterium that is highly efficient at infecting dicotyledonous plants.
• It contains a large Ti plasmid (Tumor-inducing plasmid) which delivers a specific segment of DNA (T-DNA) directly into the host plant's genome.
• In biotechnology, this Ti plasmid is modified ("disarmed") by removing the tumorcausing genes and replacing them with desired genes (such as nematode-specific genes using RNA interference technology) to make tobacco plants resistant to pests like Meloidogyne incognita.

45. (c) Decomposition rate depends heavily on the chemical composition of the organic matter (detritus) in the soil:
• Faster Decomposition: Occurs when the detritus is rich in nitrogen (3) and watersoluble substances like sugars (4).
• Slower Decomposition: Occurs when the detritus is rich in complex polymers like lignin (1) and chitin (2), which are difficult for microbes to break down.
Analyzing the Graph:
• Soil Sample (III) (Soil C): Contains the highest amount of Nitrogen (~ 18%) and a very high amount of Sugar (21%), alongside lower levels of chitin and lignin compared to the other samples.
• Soil Sample (I) (Soil A): Has a low level of Nitrogen (~ 5%).
• Soil Sample (II) (Soil B): Has the highest levels of both lignin and chitin, making it decompose the slowest.
Therefore, Soil Sample (III) will undergo the fastest decomposition.

46. (c) • Assertion (A): Apomixis leads to production of genetically identical offsprings.
• Reason (R): Apomixis involves fertilization between two genetically similar plants.
• Explanation: Apomixis is a type of asexual reproduction that produces seeds without fertilization, creating clones of the female parent plant. Because no fertilization occurs, the Reason is incorrect.

47. (a) • Assertion (A): Microbes are used for commercial production of alcohol and beverages.
• Reason (R): Yeast converts glucose into ethanol and carbon dioxide during fermentation.
• Explanation: Microbes like yeast (Saccharomyces cerevisiae) are widely used in industries. Yeast performs anaerobic fermentation to turn sugars into ethanol, making it the exact reason why it is used to produce alcohol.

48. (a) • Assertion (A): IUCN Red List helps in identifying and protecting endangered species worldwide.
• Reason (R): The list includes the species facing risk of extinction.

• Explanation: The IUCN Red List catalogues species that are vulnerable, endangered, or critically endangered. This inventory provides the essential data needed to focus global conservation efforts.

49. **(c)** • Assertion (A): DNA Ligase is used to join DNA fragments.
• Reason (R): It catalyses the formation of glycosidic bonds between nucleotides.
• Explanation: DNA Ligase is a molecular glue used to link DNA strands together. However, it catalyzes the formation of phosphodiester bonds between the sugarphosphate backbones, not glycosidic bonds.

50. **(A) (i)** Effect on the haemoglobin chain
• Glutamic acid (Glu) is replaced by Valine (Val).
• This occurs at the sixth position of the chain.
(ii) Condition and Effects
• Condition: Sickle-cell anemia.
• Effects:
• Hemoglobin polymerizes under low oxygen tension.
• Red blood cells change shape.
• Biconcave discs become sickle-shaped.
• Clogs blood capillaries.
• Obstructs oxygen transport.

OR

(B) Reasons for DNA stability over RNA:
• Chemical Stability: DNA contains deoxyribose sugar. It lacks the reactive 2′ - OH group found in RNA.
• Presence of Thymine: DNA uses thymine instead of uracil. Thymine provides greater resistance to mutations.
• Double-Stranded Structure: Hydrogen bonds between base pairs resist degradation. It allows active repair mechanisms.

51. Microinjection:
• Injects recombinant DNA directly into the cell nucleus.
• Uses a microscopic needle.
• Commonly used for animal cells.
Gene Gun (Biolistics):
• Bombards cells with high-velocity microparticles.
• Uses gold or tungsten coated with DNA.
• Commonly used for plant cells.

52. Further Processes:
• Effluent moves to a settling tank.
• Bacterial flocs sediment to form activated sludge.
• Sludge is pumped into anaerobic sludge digesters.
• Anaerobic bacteria digest fungi and bacteria.
Important Outcome
• Biogas Production: Produces methane, hydrogen sulfide, and carbon dioxide. It serves as an energy source.
• Clean Effluent: Safely releases treated water into natural rivers.

53. **(A)** Two alternative parameters used to measure population density are percent cover (biomass) and relative density.
(1) Percent Cover / Biomass
• Justification: Used when counting individuals is difficult or gives a misleading picture of ecological dominance.
• Example: A single huge banyan tree vs. 200 tiny Parthenium weeds. The weed count is higher, but the banyan tree has a vastly superior ecological impact. Thus, percent cover or biomass is a more accurate measure.
(2) Relative Density
• Justification: Used when the total population is vast, and an absolute count is practically impossible or too time-consuming.
• Example: The number of fish caught per trap is used to estimate the total fish population density in a large lake.
(3) Indirect Estimation
• Justification: Used for elusive, rare, or dangerous animals where visual sighting is difficult.
• Example: Estimating the tiger population in national parks using pugmarks and fecal pellets.

OR

(B) High biodiversity in the Amazonian rain forest is driven by tropical stability, low seasonality, and high solar energy.

• Evolutionary Time: Tropical regions remained relatively undisturbed for millions of years, unlike temperate regions affected by frequent glaciations. This allowed uninterrupted time for species diversification.
• Constant Environment: Tropical environments are less seasonal, more constant, and highly predictable. This predictability promotes niche specialization, leading to greater species diversity.
• Solar Energy: These regions receive maximum solar energy, contributing to higher primary productivity, which indirectly supports a broader range of species.

54. **(A) (i)** The placenta connects the fetus to the uterine wall of the mother.

(ii) Role in Nutrition: It facilitates the supply of oxygen and nutrients (glucose, amino acids, vitamins) from the mother's blood to the developing fetus, and helps remove carbon dioxide and waste products excreted by the fetus.
• Role in Hormonal Regulation: It acts as a temporary endocrine tissue. It secretes essential pregnancy-maintaining hormones, including human chorionic gonadotropin (hCG), human placental lactogen (hPL), estrogens, and progesterone.

OR

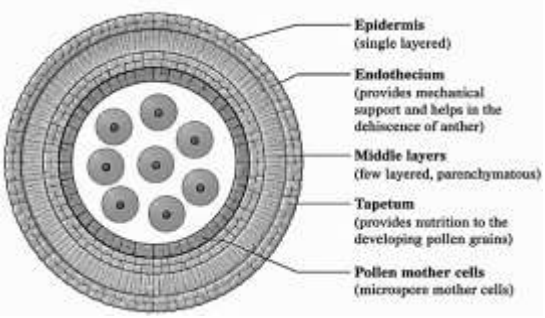
(B) (i) All copulations do not lead to pregnancy: Fertilization can only occur if the sperm and ovum are transported simultaneously to the ampullary region of the fallopian tube. Since ovulation occurs only once during a specific phase of the menstrual cycle, most copulations do not align with this brief fertile window.
(ii) Meiosis I in spermatogenesis vs. oogenesis:
• Spermatogenesis: Meiosis I is an equal division, producing two equal-sized haploid secondary spermatocytes continuously starting at puberty.
• Oogenesis: Meiosis I is a highly unequal division, producing a large haploid secondary oocyte and a tiny, non-functional first polar body. It initiates during the embryonic stage and remains suspended until puberty.

55. Traditional breeding techniques are slow, labor-intensive, and limited by seasonal constraints, which led to the adoption of micropropagation.

(A) Two advantages of micropropagation:
• Rapid Multiplication: Thousands of plants can be grown in a very short period from a tiny tissue sample (explant).
• Disease-free Plants: Healthy, virus-free plants can be recovered from an infected parent plant by culturing the meristem (apical or axillary).
•Genetically Identical (Somaclones): The offspring are exact clones of the parent plant, preserving desirable commercial traits.
(B) Two examples where it is commercially adopted:
• Banana
• Tomato
• Potato

56. **(A)** Scientific Name
•Direct Answer: Drosophila melanogaster (commonly known as the fruit fly).
(B) Four reasons why it is an ideal experimental model:
• Simple Medium: They can be easily grown and maintained on a simple synthetic medium in a laboratory.
• Short Life Cycle: They complete their entire life cycle within about two weeks.
• High Progeny: A single mating produces a large number of offspring.
• Clear Sexual Dimorphism: Male and female flies are easily distinguishable by size and distinct physical features.
• Visible Variations: They possess numerous distinct hereditary variations that are easily visible under a low-power microscope.

57. A microsporangium wall consists of four distinct cellular layers protecting and nourishing the internal sporogenous tissue.



Enlarged Sectional View of one Microsporangium Wal

Functions of the Outermost and Innermost Layers:
• Outermost Layer (Epidermis): Provides protection to the developing microsporangium and helps in the dehiscence (splitting open) of the mature anther to release pollen grains.
• Innermost Layer (Tapetum): Nourishes the developing pollen grains. Its cells typically possess dense cytoplasm and contain more than one nucleus.s

58. **(A)** Procedure Name, Explanation, Advantage, and Disadvantage
• Name: Amniocentesis
• Explanation: It is a prenatal diagnostic technique where a small amount of amniotic fluid containing fetal cells is withdrawn from the amniotic cavity using a hypodermic needle. These fetal cells are cultured and examined biochemically and chromosomally (karyotyping).
• Advantage: It detects genetic abnormalities or chromosomal disorders in the fetus early in pregnancy, such as Down's syndrome, Edwards syndrome, or metabolic defects like phenylketonuria.
• Disadvantage: It is frequently misused for pre-natal sex determination, leading to female foeticide.
(B) Difference between 'Saheli' and other oral contraceptive pills
• Composition: Traditional oral pills contain either synthetic progestogens alone or a combination of progestogen and estrogen. In contrast, "Saheli" is a non-steroidal preparation containing a molecule called centchroman.
• Advantage: It is a "once-a-week" pill (unlike daily steroidal pills) with very high contraceptive value and minimal hormonal side effects like nausea or weight gain.

59. **(A)** Aim of S.L. Miller's Experiment
• Aim: To experimentally test and provide evidence for the chemical evolution theory of life (proposed by Oparin and Haldane), demonstrating that organic molecules could form from inorganic constituents under primitive Earth conditions.
(B) Gases Used and Source of Energy
• Gases used: Methane (CH_4), Ammonia (NH_3), Hydrogen (H_2), and Water vapor (H_20) in a $2:1:2$ ratio.
• Source of energy: Electric discharge (sparks generated by electrodes) inside a closed flask to simulate lightning.

60. **(A)** Definition of Genetic Code
• Genetic Code: The set of rules by which information encoded within genetic material (DNA or mRNA sequences) is translated into proteins by living cells. It consists of nucleotide triplets called codons.
(B) Need to Propose a Genetic Code
• Reason: Since DNA/RNA consists of only 4 distinct nitrogenous bases while proteins are constructed from 20 different amino acids, scientists realized a direct one-to-one mapping was mathematically impossible. A code system was necessary to explain how 4 bases direct the synthesis of 20 distinct amino acids.
(C) Universality of the Genetic Code
• Reason: The genetic code is universal because a specific codon codes for the exact same amino acid across nearly all known organisms, from simple bacteria to complex human beings (e.g., UUU codes for Phenylalanine in both E. coli and humans).

61. **(A)** Mechanisms of Body Protection
• Explanation: The body relies on its innate immunity system, which provides a nonspecific defense framework. It features physical, physiological, cellular, and cytokine barriers that block, trap, and eliminate foreign invaders before they can multiply and cause disease.
(B) Two Barriers of Immunity
(1) Physical Barrier: The mucus coating lining the respiratory tract traps inhaled dust and pathogens, preventing them from entering deeper tissues.
(2) Physiological Barrier: Lysozyme enzymes found in tears and saliva, along with the acidic environment of bodily secretions, directly kill or inhibit the growth of invading microorganisms.

62. **(A)** Core Technique
The core technique of biotechnology that alters genetic material is Genetic Engineering (or Recombinant DNA technology).
(B) Plasmid and its Importance
• Plasmid: A small, circular, double-stranded, extrachromosomal DNA molecule that replicates autonomously inside a bacterial cell.
• Importance: It serves as a cloning vector to carry and deliver foreign genes into a host organism.
(C) Isolation Experiment
• Gene Isolated: Antibiotic resistance gene
• Source Bacterium: Salmonella typhimurium

OR

(C) Exonuclease vs. Endonuclease
• Exonuclease: Cleaves nucleotides one by one from the terminal ends (5′ or 3′ ends) of a DNA strand.
• Endonuclease: Cleaves phosphodiester bonds at specific locations within the DNA strand.

63. (A) Abiotic Components
Two abiotic factors present in a pond ecosystem include:
(1) Sunlight (Solar radiation)
(2) Water (along with dissolved gases and inorganic/organic nutrients at the bottom)
(B) Producers vs. Decomposers
• Producers (Autotrophs): Capture solar energy to convert inorganic nutrients into complex organic food via photosynthesis.
• Decomposers (Saprotrophs): Breakdown complex dead organic matter into simple inorganic substances, recycling nutrients back into the soil and water.
(C) Simple Pond Food Chain
Phytoplankton ⟶ Zooplankton ⟶ Small Fish Big Fish/Predatory Bird
• Trophic Level 1: Phytoplankton (Producers)
• Trophic Level 2: Zooplankton (Primary Consumers)
• Trophic Level 3: Small Fish (Secondary Consumers)
• Trophic Level 4: Big Fish / Bird (Tertiary Consumers)

OR

(C) Energy Transfer Efficiency
Energy transfer is limited according to Lindeman's 10% Law of Energy Transfer. Only about 10% of the energy is transferred from one trophic level to the next. The remaining 90% of energy is lost as heat during respiration, metabolic activities, and via undigested matter.

64. (A) (i) Role of Stigma in Pollen-Pistil Interaction
• Landing Platform: Acts as the receptive site where pollen grains land during pollination.
• Pollen Recognition: Determines the compatibility of pollen; accepts compatible pollen of the same species and rejects incompatible/foreign pollen.
• Germination Support: Secretes moisture, sugars, and nutrients required for the hydration and germination of compatible pollen grains.
(ii) Post-Pollination Events Leading to Double Fertilization
(1) Pollen Germination: The 2 -celled pollen grain (containing a vegetative cell and a generative cell) absorbs moisture on the stigma and germinates to form a pollen tube through a germ pore.
(2) Growth & Division: As the pollen tube grows down through the style toward the ovary, the generative cell divides mitotically to form two distinct male gametes.
(3) Entry into Ovule: The pollen tube enters the ovary and finds its way into the ovule, typically through the microscopic opening called the micropyle.
(4) Entry into Synergid: The filiform apparatus of a synergid guides the pollen tube into its cytoplasm, where the tube tip ruptures to release the two male gametes.
(5) Double Fertilization:
• Syngamy: One male gamete fuses with the egg cell nucleus to form a diploid zygote(2n)
• Triple Fusion: The second male gamete fuses with the two polar nuclei in the central cell to form a triploid Primary Endosperm Nucleus (PEN) (3n).

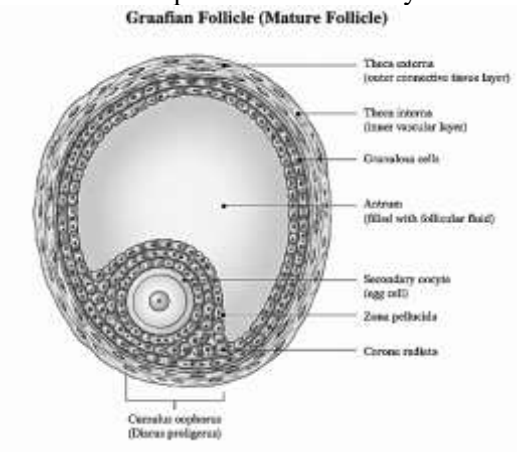
OR

(B) (i) Menstrual Phase
• Duration: Usually lasts for about 3 to 5 days.
• Cause: Occurs only when the released ovum is not fertilized, leading to a sharp decline in progesterone levels.
• Mechanism: The internal lining of the uterus (endometrium) breaks down along with its blood vessels, resulting in menstrual flow exiting through the vagina.
(ii) Cell Proliferation: During this phase, the endometrium of the uterus heals and repairs itself.
• Regeneration: The uterine wall thickens and grows back through rapid cell division (proliferation), stimulated by rising levels of estrogen secreted by growing ovarian follicles.
(iii) Events in Graafian Follicle During and After Ovulation
• At Ovulation: High concentrations of LH (LH surge) cause the mature Graafian follicle to rupture, releasing the secondary oocyte (ovum) into the fallopian tube.

• After Ovulation: The remnants of the ruptured Graafian follicle transform into a yellow endocrine structure called the corpus luteum, which starts secreting large amounts of progesterone to maintain pregnancy.

(iv) Diagram of a Mature Graafian Follicle

Below is a simplified schematic layout of a mature Graafian follicle detailing the placement of required labels:



65. **(A)** mRNA processing and mutation

(i) Steps to make fully processed mRNA (Eukaryotes):

(1) Transcription: DNA → pre-mRNA by RNA polymerase II

(2) 5' capping: Addition of 7-methylguanosine cap at 5' end for stability and ribosome binding

(3) Polyadenylation: Addition of poly-A tail at 3′ end for stability and nuclear export

(4) Splicing: Removal of introns by spliceosome; exons joined together

(ii) Impact of RNA polymerase I/III mutation:

• RNA Pol I → rRNA synthesis affected → ribosome formation impaired - protein synthesis reduced

• RNA Pol III → tRNA synthesis affected → amino acid delivery impaired - polypeptide synthesis reduced

OR

(B) Coat colour in cattle

(i) Co-dominance vs incomplete dominance:

• Observation: Calf shows equal red and white hairs → Co-dominance

• Both alleles expressed fully in heterozygote

• In incomplete dominance, heterozygote shows blended phenotype (e.g. pink flower from red × white)

(ii) F_2 generation phenotypes:

(1) Red dominant over white:

• F_2 ratio -3 Red : 1 White

(2) Red incompletely dominant:

• F_2 ratio -1 Red : 2 Pink: 1 White

66. **(A) (i)** Disease & Causative Agent

• Disease: AIDS (Acquired Immuno Deficiency Syndrome)

• Causative Agent: HIV (Human Immunodeficiency Virus)

(ii) Mechanism of Action on the Immune System

(1) Entry: The virus enters the body and invades macrophages and Helper Tlymphocytes (T_H cells).

(2) Replication: The viral RNA genome replicates into viral DNA using the host's machinery and the enzyme reverse transcriptase.

(3) Integration: The viral DNA incorporates into the host cell's genome, forcing it to produce countless new viral particles.

(4) Depletion: Newly emerged viruses exit the host cell and destroy other Helper Tlymphocytes. This results in a drastic decline in T_H cell counts, crippling the body's adaptive immunity.

(iii) Major Modes of Transmission

• Unprotected sexual contact with an infected individual.

• Transfusion of contaminated blood or blood products.

• Sharing infected needles or syringes.

• Transmission from an infected mother to her fetus via the placenta.

OR

(B) (i) Microbes as Effective Biocontrol Agents

• They are highly species-specific and minimize damage to beneficial non-target organisms, humans, and wildlife.

• They are completely biodegradable, leaving no toxic chemical residues in the soil, water tables, or food chain.
(ii) Role of Microbes in Pest Control
(1) A Bacterium (Bacillus thuringiensis / Bt)
• Pests Controlled: Butterfly caterpillars, moth larvae, and beetles.
• Role: When eaten by larvae, it releases crystalline toxic proteins in their alkaline midgut, inducing pore formation, cell lysis, and larval death.
(2) A Fungus (Trichoderma species)
• Diseases Controlled: Soil-borne and root-borne fungal plant pathogens (e.g., root rot, wilt).
• Role: It acts as a free-living root symbiont that directly attacks pathogens through competition, enzyme secretion, or antibiosis.
(3) A Virus (Baculoviruses / Nucleopolyhedrovirus)
• Pests Controlled: Insects and complex arthropod pests.
• Role: They act as narrow-spectrum bio-insecticides that infect and selectively kill target insect groups without causing any ecological damage.

67. (d) • Trigger: Fully developed fetus and placenta initiate mild uterine contractions.
• Reflex: These contractions stimulate the mother's central nervous system.
• Release: The maternal posterior pituitary gland releases oxytocin.
• Action: Oxytocin causes stronger uterine contractions to facilitate childbirth.

68. (c) • Structural Feature: Stratification represents the vertical distribution of different species (e.g., trees, shrubs, herbs).
• Functional Units: Productivity, decomposition, energy flow, and nutrient cycling are functional aspects.
• Distinction: Stratification is a structural component, not a functional process.

69. (a) Correct Matching
• (A) Primers → (III) Chemically synthesized oligonucleotides: Short DNA strands used in PCR.
• (B) Insertional inactivation → (I) β-galactosidase: A method to screen recombinants by disabling this enzyme gene.
• (C) Bioreactor → (IV) Large scale production: Large vessels used for growing biomass and microbial products.
• (D) Downstream processing → (II) To separate and purify products: The final steps to recover and purify biosynthetic products.

70. (b) Golden rice is a genetically modified (transgenic) variety of rice (Oryza sativa) engineered to produce beta-carotene, a precursor of Vitamin A, in the edible parts of the rice grain (the endosperm).
Normal rice does not produce beta-carotene in its endosperm. By introducing genes from other organisms (such as daffodils and a bacterium), scientists enabled the rice to synthesize this provitamin. It was specifically developed as a biofortification strategy to address Vitamin A deficiency in regions where rice is a staple food, which can otherwise lead to blindness and increased susceptibility to infections.

71. (c) • Polarity: DNA-dependent RNA polymerase catalyzes polymerization only in the $5' \rightarrow 3'$ direction.
Therefore, the template strand must have $3' \rightarrow 5'$ polarity, and the coding strand has $5' \rightarrow 3'$ polarity.
• Positions: By convention, the promoter and terminator are defined with respect to the coding strand:
• The Promoter is located at the $5'$-end (upstream) of the coding strand.
• The Terminator is located at the $3'$-end (downstream) of the coding strand.
• Image (c) correctly shows the template strand running $3' \rightarrow 5'$, the coding strand running $5' \rightarrow 3'$, the promoter at the $5'$ end of the coding strand, and the terminator at the $3'$ end.

72. (d) • The widespread use of antibiotics by humans creates a selection pressure that favors the survival of resistant bacterial strains.
• Since this evolutionary change is directly caused by human activities, it is a classic example of evolution by anthropogenic action.

73. (a) (I) True: Overproduction leads to a struggle for existence (competition for limited resources).
(II) True: Darwin stated that variations that are useful are passed on to progeny.
(III) False: The inheritance of acquired characters is a concept from Lamarck's theory, not Darwin's.
(IV) True: Natural selection favors individuals with advantageous/favourable traits (survival of the fittest).
(V) True: Over many generations, the continuous accumulation of favorable variations leads to the origin of new species.

74. (d) Ascariasis is caused by the intestinal roundworm Ascaris lumbricoides. Common symptoms include internal bleeding, muscular pain, fever, anemia, and intestinal blockage. Skin ulcers are not a symptom of this infection.

75. **(a)** The mass of living material (biomass) present at each trophic level at any given time is termed the standing crop. Conversely, "standing state" refers to the amount of non-living inorganic nutrients present in the ecosystem.

76. **(d)** A point mutation is a genetic mutation that alters, inserts, or deletes a single nucleotide base pair within a DNA sequence. Thus, a single nucleotide is the smallest mutable unit.

77. **(b)** (I) is correct because adolescents are highly susceptible to peer influences.
(II) is correct as repeated drug use elevates the tolerance threshold of body receptors.
(III) is correct because alcohol acts directly as a central nervous system depressant.
(IV) is incorrect because abuse deteriorates body systems rather than safely increasing energy.
(V) is incorrect because anabolic steroids increase aggressiveness and anxiety.

78. **(a)** Both Vallisneria and Hydrilla are aquatic plants that use water currents for pollination (hydrophily). While water lily and water hyacinth grow in water, their flowers emerge above the surface and are pollinated by insects or wind.

79. **(c)** • Assertion (A): Activated sludge contains large population of bacteria.
• Status: True. Activated sludge contains millions of aerobic bacteria and fungal filaments forming mesh-like structures (flocs).
• Reason (R): These bacteria help in anaerobic digestion of human waste in biogas plant.
• Status: False. The bacteria in activated sludge are aerobic. In anaerobic sludge digesters or biogas plants, a different set of anaerobic bacteria (like methanogens) are used to digest the organic matter and the aerobic microbes.
• Conclusion: Assertion (A) is true, but Reason (R) is false.

80. **(a)** • Assertion (A): Ecosystems require a constant supply of energy to synthesize the molecules they require.
• Status: True. Living organisms need a continuous input of energy to build molecules and maintain their highly organized structure.
• Reason (R): This is to counteract the universal tendency towards increasing disorderliness as per Second Law of Thermodynamics.
• Status: True. The Second Law of Thermodynamics states that systems naturally tend toward disorder (entropy). Energy input is required to counteract this and maintain biological order.
• Conclusion: Both statements are true, and the Reason correctly explains why a constant energy supply is required.

81. **(a)** • Assertion (A): DNA cannot pass through cell membrane of a bacterial cell.
• Status: True. Bacterial cell membranes cannot readily take up naked DNA molecules without chemical or electrical treatment (competence).
• Reason (R): DNA is a hydrophilic molecule.
• Status: True. Since DNA is negatively charged and hydrophilic (water-loving), it cannot naturally cross the hydrophobic (lipid-loving) core of the cell membrane.
• Conclusion: Both statements are true, and the hydrophilic nature of DNA is the exact reason why it cannot cross the membrane.

82. **(b)** • Assertion (A): Repetitive sequences are stretches of DNA sequences that are thought to have no direct coding functions.
• Status: True. Repetitive DNA makes up a large portion of the human genome and does not code for proteins.
• Reason (R): They shed light on chromosome structure, dynamics and evolution.
• Status: True. These sequences are highly valuable tools in understanding genomics, evolution, and chromosome behavior.
• Conclusion: Both statements are scientifically true, but the usefulness of repetitive DNA in studying evolution is not the reason why they lack coding functions.

83. **(A)** **(i)** Ringworm.
(ii) (1) Microsporum
(2) Trichophyton
(iii) Direct skin-to-skin contact.
• Sharing infected clothing or towels.
• Sharing contaminated combs.
• Contact with infected soil.

OR

(B) **(i)** Allergy.

(ii) IgE antibodies.
(iii) Chemical Released
• Histamine.
• Serotonin.
(iv) (1) Antihistamines
(2) Adrenaline

84. **(A) (i)** Brain capacity of 1400 cc .
• Buried their dead with rituals.
• Used animal hides for clothing.
(ii) (I) Homo erectus
(II) Homo habilis

OR

(B) Working Details:
• Let p = frequency of dominant allele (B)
• Let q = frequency of recessive allele (b)
• Frequency of blue-eyed individuals $(bb) = q^2 = 36\% = 0.36$
• Therefore, $q = \sqrt{0.36} = 0.6$
• Since $p + q = 1$, then $p = 1 - 0.6 = 0.4$
(i) Frequency of allele B(p)
0.4
(ii) Percentage of heterozygous individuals (2pq)
$2 \times 0.4 \times 0.6 = 0.48 \Longrightarrow 48\%$
(iii) Percentage of homozygous dominant individuals (p^2)
$(0.4)^2 = 0.16 \Longrightarrow 16\%$

85. Henking's Observation
• Tracked spermatogenesis in certain insects.
• Noted a specific nuclear structure.
• Found it in half of sperms.
• Other half lacked this structure.
• Termed this structure the ' X body'.
• Contribution to Sex Determination
• 'X body' was later identified as a chromosome.
• Named the X chromosome.
• Established the chromosomal basis of sex.
• Led to discovering the XO system.
• Sperms determine the offspring's sex.

86. **(A) (i)** Identification of Alphabets:
(I) Anode end: S (DNA is negatively charged and moves towards the positive anode, which is furthest from the wells).
(II) Lightest/Smallest DNA in matrix: R (Smaller DNA fragments move faster and travel the furthest distance from the wells).
(ii) Agarose Gel and its Use:
• What it is: Agarose is a natural linear polymer extracted from seaweeds.
• Why it is used: It provides a porous matrix that acts as a sieve, allowing DNA fragments to separate according to their size/molecular weight as they migrate under an electric field.

OR

(B) (i) Reason for Invisibility and Visualization Method:
• Reason: Pure DNA fragments cannot be seen directly under normal visible light because they are transparent and lack color. The student likely forgot to stain the gel.
• Visualization: The gel must be stained with a compound called ethidium bromide (EtBr) and then exposed to ultraviolet (UV) radiation. Under UV light, the DNA fragments appear as bright orange-colored bands.
(ii) Collection of a Specific DNA Fragment:
• The specific DNA fragment is collected through a process called elution.
• The desired DNA band is physically cut out from the agarose gel piece, and the DNA is then extracted and purified from the gel matrix.

87. **(A)** Full Form of GEAC:

• Genetic Engineering Appraisal Committee (formerly known as Genetic Engineering Approval Committee)

(B) Two Important Functions Related to Biotechnology:

(1) To evaluate and approve the validity and safety of research involving genetically modified (GM) organisms.

(2) To assess the environmental safety and bio-safety risks before approving the commercial release or field trials of GM crops and products into the public domain.

88. **(A)** • Adventive (Nucellar) Embryony: Cells of maternal diploid tissues like the nucellus or integuments surrounding the embryo sac start dividing, protrude into the embryo sac, and develop into embryos (e.g., Citrus, Mango).

• Diploid Parthenogenesis (Recurrent Agamospermy): A diploid egg cell is formed without reduction division (meiosis) and directly develops into an embryo without fertilization.

• Apospory: An embryo sac arises directly from a diploid vegetative cell of the nucellus, skipping meiosis, and the diploid egg cell inside develops autonomously into an embryo.

(B) Advantage of apomictic seeds for farmers:

• No Segregation of Traits: Farmers can reuse seeds harvested from hybrid crops year after year because apomixis prevents genetic segregation of desired hybrid traits. This eliminates the need to buy expensive hybrid seeds every season.

89. **(A)** Meaning of translation in protein synthesis:

• Translation is the cellular process by which the genetic information carried by messenger RNA (mRNA) is decoded to synthesize a specific sequence of amino acids, forming a functional polypeptide chain (protein).

(B) Charging of tRNA (Aminoacylation) and its importance:

• Explanation: Charging is the process where an amino acid is activated by ATP and covalently linked to its specific tRNA molecule at its 3′ end, catalyzed by the enzyme aminoacyl-tRNA synthetase.

• Importance: It provides the essential chemical energy required to form peptide bonds during elongation and ensures that the correct amino acid corresponds precisely to the mRNA codon during synthesis.

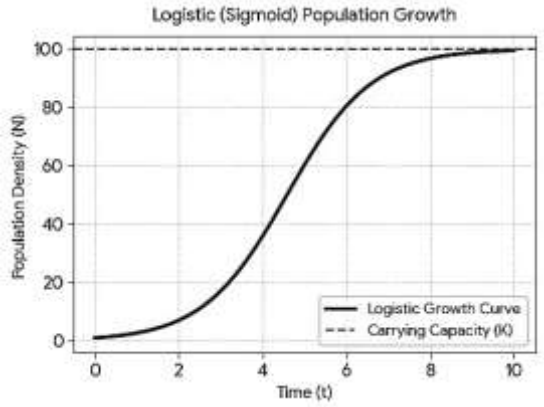
90. **(A)** Carrying capacity of a species in a habitat:

• Carrying capacity (K) is the maximum population size of a species that a given environment can sustainably support over time, limited by resources like food, space, water, and shelter.

(B) Growth curve taking carrying capacity into account:

• This is represented by the Logistic Growth Curve (Sigmoid or S-shaped curve).

• When resources are finite, population growth starts with a lag phase, followed by rapid acceleration (log phase), then deceleration, and finally reaches a stable plateau (asymptote) when the population size equals the carrying capacity (K).



• Mathematical Equation:

$$\frac{dN}{dt} = rN\left(\frac{K - N}{K}\right)$$

(Where N = Population density, r = Intrinsic rate of natural increase, K = Carrying capacity)

91. **(A)** Steps carried out in the IVF technique:

(1) Ovarian Stimulation: Hormonal medications are administered to stimulate the production of multiple mature eggs.

(2) Egg Retrieval: Mature eggs are surgically collected from the ovaries under ultrasound guidance.

(3) Sperm Collection: A fresh or frozen semen sample is collected from the partner or a donor.

(4) In Vitro Fertilization: Eggs and sperm are placed together in a laboratory petri dish to achieve fertilization.

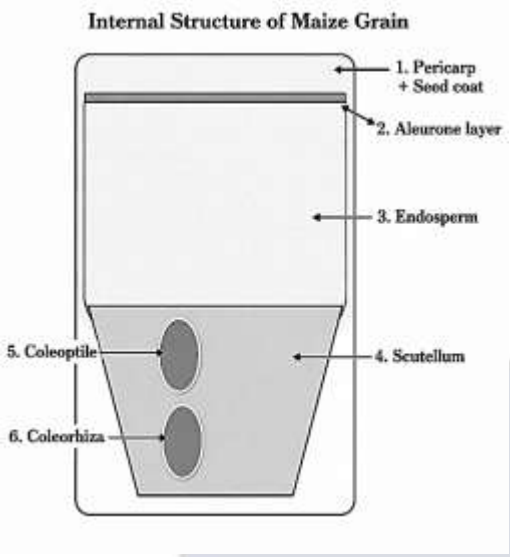
(5) Embryo Transfer: The resulting healthy embryos are transferred directly into the woman's uterus for implantation.

(B) Is GIFT considered a type of IVF?

• No, Gamete Intra Fallopian Transfer (GIFT) is not a type of IVF.

• Justification: In IVF, fertilization occurs outside the body (in vitro) in a laboratory environment. In GIFT, unfertilized eggs and washed sperm are transferred directly into the fallopian tubes, meaning fertilization happens naturally inside the female body (in vivo).

92. Internal Structure of a Maize Grain (Labeled Components):



• 5 Key Parts labeled above:

(1) Pericarp fused with Seed Coat: Protective outer cover.

(2) Aleurone Layer: Outer protein-rich layer of the endosperm.

(3) Endosperm: Main food storing tissue containing starch.

(4) Scutellum: Large shield-shaped single cotyledon.

(5) Coleoptile / Coleorhiza: Sheaths protecting the young shoot (plumule) and root (radicle).

93. **(A)** Agreement with the person:

• Yes, I agree with him.

• Justification: Cow dung naturally contains abundant methanogenic bacteria (Methanogens) originating from the rumen of cattle. Therefore, an external starter culture or inoculum is unnecessary.

(B) What happens to the biowaste inside the digester:

• The biowaste undergoes anaerobic breakdown by microbes. Complex organic matter is sequentially broken down into simpler soluble monomers, organic acids, and is finally converted into methane gas and carbon dioxide by methanogens.

(C) Useful by-products and their uses:

• Biogas: Used as a clean, sustainable fuel source for domestic cooking and lighting.

• Spent Slurry (Digestate): Used directly as nutrient-dense organic manure in agricultural fields to enhance soil structure and fertility.

94. Thomas Hunt Morgan used Drosophila melanogaster to demonstrate that genes located on the same chromosome are inherited together, a phenomenon that explains deviations from classic Mendelian ratios.

(A) Morgan's Experiment on Eye Colour and Body Colour

Morgan conducted dihybrid crosses to study the inheritance of eye colour and body colour, which are sex-linked traits located on the X chromosome.

• Parental Generation (P): He crossed yellow-bodied, white-eyed females (yw) with wild-type brown-bodied, red-eyed males (y^+w^+).

• First Filial Generation (F_1) : The F_1 offspring were intercrossed to observe the distribution of traits in the next generation.

• Second Filial Generation (F_2): Morgan observed the physical traits of the F_2 generation and counted the proportion of parental versus new trait combinations.

(B) Deviation from Mendelian Inheritance Pattern

Mendel's Law of Independent Assortment predicts a phenotypic ratio of 9: 3: 3: 1 in an F_2 dihybrid cross, where parental and non-parental types mix freely. Morgan's results deviated significantly:
• High Parental Frequency: An overwhelming 98.7% of the F_2 offspring retained the exact parental combinations of body colour and eye colour.
• Low Recombinant Frequency: Only 1.3% of the offspring showed new, non-parental combinations (recombinants).
• Conclusion: The two genes did not segregate independently because they were physically located close to one another on the same chromosome.
(C) Genetic Terms Used by Morgan
Morgan coined two foundational genetic terms to explain his observations:
(1) Linkage: This describes the physical association of genes on a chromosome. Genes that are closely linked tend to be inherited together, which keeps parental trait combinations intact across generations.
(2) Recombination: This describes the generation of non-parental gene combinations. It occurs when homologous chromosomes exchange genetic segments during meiosis (crossing over), occasionally breaking the linkage between genes.

95. (A) (i) At 10 minutes, the concentration of nicotine in the blood reaches its maximum/peak value of $45 mg/cm^3$. This is because continuous smoking (10 puffs/minute) up to this point leads to accumulation and maximum absorption of nicotine into the bloodstream.

OR

(ii) Carbon Monoxide (CO) Concentration: It will increase because cigarette smoke contains harmful gases like carbon monoxide which are continuously inhaled.
• Haem-bound Oxygen Concentration: It will decrease. Carbon monoxide has a much higher affinity for haemoglobin than oxygen, forming carboxyhaemoglobin and reducing the oxygen-carrying capacity of the blood.
(B) Nicotine stimulates the adrenal glands to release adrenaline into the bloodstream.
• Adrenaline causes vasoconstriction (narrowing of blood vessels), which increases resistance and raises blood pressure.
• It also directly stimulates the heart, leading to an increased heart rate.
(C) Class of compounds: Alkaloids (specifically, CNS stimulants).
• Other drug from the same class: Caffeine (or Cocaine / Morphine).

96. (A) Method with the highest number: Wildlife Sanctuaries (2500 species).
• Type of conservation: In situ conservation.
(B) Opposite methods: Zoological Parks and Botanical Gardens (which represent ex situ conservation).
• Difference between the two approaches:
• In situ conservation: Protecting and conserving threatened species within their natural habitats (e.g., Wildlife Sanctuaries, National Parks).
• Ex situ conservation: Protecting and conserving threatened species outside their natural habitats in man-made, controlled environments (e.g., Zoological Parks, Botanical Gardens).
(C) (i) Two main features of Biodiversity hotspots are:
(1) High species richness: They contain exceptionally high levels of biodiversity and species variety.
(2) High degree of endemism: They harbor a high number of endemic species (species found strictly in that location and nowhere else in the world).

OR

(ii) Category: In situ conservation (community-protected natural areas).
• How they help: Sacred groves are forest patches traditionally protected by local communities due to religious or cultural beliefs. This cultural taboo prevents hunting, logging, and habitat destruction, effectively preserving rare, threatened, and endemic plant and animal species in their pristine natural state.

97. (A) (i) Griffith's Transforming Principle Experiment
In 1928, Frederick Griffith performed experiments using Streptococcus pneumoniae (pneumonia-causing bacteria) and mice. He utilized two bacterial strains:
• S-strain (Smooth): Virulent (pathogenic) due to a mucous polysaccharide capsule.
• R-strain (Rough): Non-virulent (non-pathogenic) because it lacks a capsule.
Experimental Procedure:
(1) Live S-strain injected into mice → Mice die.
(2) Live R-strain injected into mice → Mice live.
(3) Heat-killed S-strain injected into mice → Mice live.

(4) Mixture of heat-killed S-strain and live R-strain injected into mice → Mice die.
(Living S-strain bacteria were isolated from the dead mice).
Significance:
Griffith concluded that the living R -strain bacteria had been transformed by a "transforming principle" from the heat-killed S-strain. This molecule allowed the Rstrain to develop a capsule and become virulent, proving that genetic information can be transferred between organisms.

(ii) Contribution of Avery, MacLeod, and McCarty
Oswald Avery, Colin MacLeod, and Maclyn McCarty (1933-44) purified biochemical components (proteins, RNA, DNA) from heat-killed S-strain bacteria to find the exact transforming molecule:

- Treatment with proteases (protein-digesting enzymes) did not stop transformation.
- Treatment with RNases (RNA-digesting enzymes) did not stop transformation.
- Treatment with DNases (DNA-digesting enzymes) completely inhibited transformation.
- Conclusion: They concluded that DNA is the hereditary material responsible for transformation.

OR

(B) (i) Genetic Crosses for Haemophilia
Genotypes used: Normal female (XX), Carrier female (XX^h), Normal male (XY), Haemophilic male (X^hY).

(I) Normal female (XX) × Haemophilic male (X^hY)

Gametes	X^k	Y
X	XXX^h (Carrier daughter)	XY (Normal son)
X	XX^h (Carrier daughter)	XY (Normal son)

- Phenotypic Outcome: 100% daughters are carriers; 100% sons are normal.

(II) Carrier female (XX^h) × Normal male (XY)

Gametes	X	Y
X	XX (Normal daughter)	XY (Normal son)
X^h	XX^h (Carrier daughter)	X^hY (Haemophilic son)

- Phenotypic Outcome: 50% daughters are normal, 50% daughters are carriers; 50% sons are normal, 50% sons are haemophilic.

(III) Carrier female (XX^h) × Haemophilic male (X^hY)

Gametes	X^h	Y
X	XX^h (Carrier daughter)	XY (Normal son)
X^h	X^hX^h (Haemophilic daughter)	X^hY (Haemophilic son)

- Phenotypic Outcome: 50% daughters are carriers, 50% daughters are haemophilic; 50% sons are normal, 50% sons are haemophilic.

(ii) Conclusions and Type of Inheritance

- Type of Inheritance: Haemophilia is an X-linked recessive disorder.
- Conclusions:
- Male Vulnerability: Males only have one X chromosome. If they receive a single X^h allele from their mother, they will express the disease (X^hY).
- Female Expression: Females must inherit two copies of the defective allele (X^hX^h) to show symptoms, requiring an affected father and at least a carrier mother.

• Criss-Cross Inheritance: The trait characteristically passes from an affected father to his grandsons through his carrier daughters.

98. **(A)** Biotechnology Principles and Tools

(i) Two core techniques of modern biotechnology:

(1) Genetic Engineering: The technique of altering the chemistry of genetic material (DNA and RNA) to introduce these into host organisms and thus change the phenotype of the host organism.

(2) Bioprocess Engineering: The maintenance of sterile conditions in chemical engineering processes to enable the growth of only the desired microbe or eukaryotic cell in large quantities for the manufacture of biotechnological products like antibiotics, vaccines, and enzymes.

(ii) Three key tools of Recombinant DNA technology:

(1) Restriction Enzymes: These act as "molecular scissors" to cut DNA at specific recognition sequences.

(2) Cloning Vectors: DNA molecules (like plasmids or bacteriophages) that carry foreign DNA fragments into a host cell for replication.

(3) Competent Host: The organism (e.g., E. coli) that receives the recombinant DNA and allows it to replicate.

OR

(B) Medical Diagnostics

(i) Conventional methods & disadvantages:

• Methods: Serum and urine analysis (detecting pathogens by presence of antigens or by detecting antibodies synthesized against the pathogen).

• Disadvantages: By the time a clinical symptom appears, the concentration of the pathogen is already very high, meaning conventional methods often fail to detect diseases at the early stages.

(ii) Biotechnology diagnostic techniques:

(1) PCR (Polymerase Chain Reaction): Can amplify minute amounts of pathogen DNA or RNA. detecting infections even when the pathogen concentration is very low.

(2) ELISA (Enzyme-Linked Immunosorbent Assay): Detects infections by spotting the presence of antigens (proteins, glycoproteins, etc.) or by detecting the antibodies produced against the pathogen.

(3) Recombinant DNA Technology: Used to create probes that identify specific genetic mutations or pathogens.

99. **(A)** **(i)** Trace the development of a gamete mother cell till ovulation:

(1) Oogonia formation: Gamete mother cells (oogonia) are formed within the fetal ovary before birth. No more oogonia are formed or added after birth.

(2) Primary Oocyte stage: Oogonia divide mitotically and enter prophase-1 of meiotic division, where they become temporarily arrested. These cells are called primary oocytes.

(3) Primary Follicle: Each primary oocyte gets surrounded by a single layer of granulosa cells.

(4) Secondary Follicle: More layers of granulosa cells and a new theca layer develop around the primary follicle.

(5) Tertiary Follicle: Characterized by a fluid-filled cavity called the antrum. Within this follicle, the primary occyte completes its first meiotic division to form a large haploid secondary oocyte and a tiny first polar body.

(6) Graafian Follicle: The tertiary follicle matures into a Graafian follicle. The secondary oocyte develops a new surrounding membrane called the zona pellucida.

(7) Ovulation: Under hormonal influence, the mature Graafian follicle ruptures to release the secondary oocyte from the ovary.

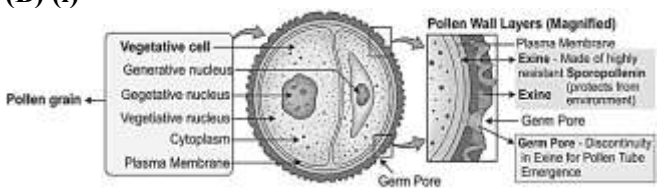
(ii) Two pituitary hormones that play an important role:

• Follicle Stimulating Hormone (FSH)

• Luteinizing Hormone (LH)

OR

(B) **(i)**



(ii) Three layers surrounding the cytoplasm (Innermost to Outermost):

(1) Plasma membrane

(2) Intine (inner cell wall)

(3) Exine (outer cell wall)

(iii) Organic material making the outermost layer and its advantage:

• Material: Sporopollenin.

• Advantage: It is one of the most resistant organic materials known. It protects the pollen from high temperatures, strong acids, and alkalis. It cannot be degraded by any known enzyme, allowing pollen grains to be preserved well as fossils.

(iv) The exine has prominent areas called germ pores where sporopollenin is absent.

• This discontinuity is essential to allow the pollen tube to grow out during pollen germination.

100. **(c)** • Microsporogenesis forms pollen grains from microspore mother cells.

• One microspore mother cell undergoes meiosis.

• This division produces four haploid microspores.

• Microspores develop into mature pollen grains.

• Calculation: $325 \text{ cells} \times 4 = 1300$ pollen grains.

101. **(a)**• Ovulation releases the ovum from the Graafian follicle.

• The empty follicle remains inside the ovary.

• LH transforms this remnant into the corpus luteum.

• This transformation happens right after ovulation.

• It marks the start of the secretory phase.

• The secretory phase is also called the luteal phase.

102. **(c)** • Intra Uterine Transfer (IUT): Embryos with more than 8 blastomeres are transferred directly into the uterus.

• Blocked Fallopian Tubes: Since the fallopian tubes are blocked, any technique requiring a functional fallopian tube (like ZIFT or GIFT) cannot be used.

• ZIFT: Used for early embryos up to 8 blastomeres, which are transferred into the fallopian tube.

103. **(b)** • Linkage Group: All the genes linearly arranged on a single chromosome inherit together as a single unit.

• Chromosome Correspondence: The number of linkage groups in an organism corresponds directly to its haploid number of chromosomes.

104. **(c)** Explanation Statement-by-Statement:

(I) Incorrect: Polycistronic mRNA is characteristic of prokaryotes, whereas eukaryotes have monocistronic mRNA.

(II) Correct: RNA polymerase II transcribes heterogenous nuclear RNA (hnRNA), which is the precursor to mRNA.

(III) Incorrect: Translation begins when the mRNA binds to the small (not large) subunit of the ribosome.

(IV) Correct: Stop codons (UAA, UAG, UGA) do not code for any amino acids and lack corresponding tRNAs.

105. **(b)** Fossil evidence shows that around 2 million years ago, Australopithecines lived in East African grasslands. They hunted with stone weapons but their diet consisted essentially of fruits.

106. **(d)** Nicotine stimulates the adrenal medulla to release Adrenaline (1) and Noradrenaline (III) into the bloodstream. Both of these hormones act to increase heart rate and elevate blood pressure.

107. **(b)** Bacillus thuringiensis (commonly known as Bt) is a bacterium used as a microbial biocontrol agent to control butterfly caterpillars and other insect pests without harming other animals.

108. **(d)** Based on evolutionary anatomical structures, diagram A shows a prominent brow ridge and projecting jaws characteristic of an adult chimpanzee, while diagram B shows the large, rounded cranium and flat face of an adult human.

109. **(c)** RNA interference (RNAi) is a cellular defense mechanism where gene expression is silenced using double-stranded RNA (dsRNA). The dsRNA binds to and triggers the degradation of specific complementary messenger RNA (mRNA) molecules, preventing translation.

110. **(d)** • Interspecific Competition: Two species fight for the same limited resource (space on rocks).

• Competitive Exclusion: The larger barnacle (Balanus) physically outgrew and excluded the smaller barnacle (Chthamalus).

• Other Options: This interaction does not involve harming a host (parasitism), eating prey (predation), or mutual benefit (mutualism).

111. **(c)** • Bt Toxin Specificity: Different Cry genes from Bacillus thuringiensis target specific insect pests.

• Gene Function: The Cry-1 Ab gene specifically produces toxins that kill the corn borer larvae.

• Distinction: The genes Cry-IAc and Cry-IIAb are used to control cotton bollworms instead.

112. **(a)** • Assertion (A): Cleistogamous flowers have assured seed set. (True)

• Reason (R): Cleistogamous flowers are invariably autogamous and do not depend on any pollinating agents. (True)
• Explanation: Cleistogamous flowers never open. This ensures that pollen grains from the anthers automatically land on the stigma of the same flower (autogamy), leading to guaranteed seed formation without needing external pollinators. Therefore, the reason correctly explains the assertion.
So, Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

113. **(b)** • Assertion (A): The human blood group 'AB' exemplifies co-dominance. (True)
• Reason (R): The gene for human blood group trait exists in three allelic forms I^A, I^B and i. (True)
• Explanation: The assertion is true because alleles I^A and I^B express themselves completely and simultaneously in an individual with the AB blood group. The reason is also true because it describes multiple allelism (the presence of three alleles for a single gene in a population). However, the existence of three alleles does not explain why I^A and I^B show co-dominance when paired together.
So, Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

114. **(a)** • Assertion (A): Nucleopolyhedrovirus are useful as they are good biocontrol agents. (True)
• Reason (R): They are species-specific, narrow spectrum bioinsecticides. (True)
• Explanation: Viruses belonging to the genus Nucleopolyhedrovirus are excellent biological control agents because they selectively target specific pest insects without causing any harm to non-target organisms like birds, mammals, or beneficial insects.
So, Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

115. **(a)** • Assertion (A): The pyramid of biomass in a pond aquatic ecosystem is always inverted. (True)
• Reason (R): The biomass of consumers like fishes far exceeds that of the producers like phytoplanktons. (True)
• Explanation: In an aquatic ecosystem like a pond or sea, the standing crop of producers (phytoplankton) at any given time is small due to their rapid life cycles and high turnover rate. Consequently, their total biomass is less than that of the larger, longer-lived consumers (fishes), resulting in an inverted biomass pyramid shape.
So, Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

116. Mechanism of Action:
Contraceptive implants are placed under the skin and slowly release progestogen (or a progestogen-estrogen combination). They prevent pregnancy through three main actions:
• Inhibiting ovulation (preventing the release of an egg).
• Thickening the cervical mucus, which forms a barrier that prevents sperm from entering the uterus.
• Altering the lining of the uterus (endometrium) to make it unfavorable for the implantation of a fertilized egg.
• Advantage over Contraceptive Pills:
Implants offer long-lasting protection (typically 3 to 5 years) and eliminate the risk of user error, such as forgetting to take a daily pill.

117. **(A)** Development of Apomictic Seeds:
Apomictic seeds can develop when a diploid egg cell is formed without reduction division (meiosis) and develops directly into an embryo without fertilization.
Alternatively, surrounding nucellar cells can divide and protrude into the embryo sac to develop into embryos (as seen in Citrus species).
(B) Preference over Hybrid Seeds:
Hybrid seeds must be purchased by farmers every year because the desirable hybrid characters segregate and are lost in successive generations. If apomictic seeds are developed from hybrids, there is no segregation of characters, allowing farmers to reuse the seeds from their harvest year after year without losing crop quality or purchasing new seeds.

118. Biochemical Oxygen Demand (BOD) directly reflects the amount of organic pollution in a water sample; higher BOD values mean higher pollution levels.
(A) Most Polluted Sample:
Sample C is the most polluted because it has the highest BOD value (400mg/L).
(B) Identification of Labels:
• Sample B (8mg/L): River water (lowest BOD, as it is relatively clean).
• Sample A (30mg/L): Secondary effluent discharged from a sewage treatment plant (partially treated, reducing BOD significantly but still containing organic material).
• Sample C (400mg/L): Untreated sewage water (highest BOD due to massive organic waste contamination).

119. Role of 'ori' (Origin of Replication):

This is the specific DNA sequence where replication initiates. Any foreign DNA linked to this site is replicated alongside the vector inside the host cell. It is also responsible for controlling the copy number of the linked DNA.

• Role of 'restriction' site:

These are specific recognition sequences where particular restriction enzymes introduce cuts. They provide a precise location for cutting open the vector so that a foreign gene/DNA fragment can be ligated (inserted) to create a recombinant DNA molecule.

120. **(A)** Ecosystem Services (Any two):

(1) Oxygen Production: Photosynthetic organisms in diverse ecosystems (like the Amazon rainforest) generate a massive proportion of the oxygen required by living organisms on Earth.

(2) Pollination: Ecosystem pollinators like bees, butterflies, birds, and bats pollinate flowers, which is essential for plant reproduction and agricultural crop yields.

(3) Climate and Flood Control: Plant covers regulate regional climates by acting as carbon sinks and prevent soil erosion while moderating local water cycles to prevent flash floods.

OR

(B) (i) Standing Crop:

The standing crop represents the total mass of living material (biomass) present at a specific trophic level in an ecosystem at a given time.

(ii) Measurement Ways:

(1) Fresh weight: Measuring the total weight of organisms in their natural, hydrated state.

(2) Dry weight: Measuring the weight of organisms after all water has been removed. This method is highly preferred because dry weight remains stable and is not altered by temporary environmental moisture variations.

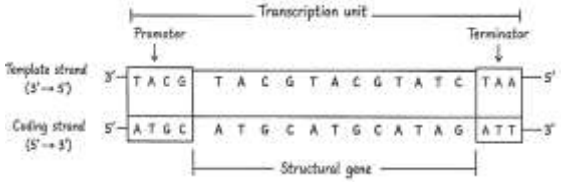
121.

Feature	Wind-Pollinated Flowers	Insect-Pollinated Flowers
Appearance	Small, inconspicuous, dull-colored.	Large, conspicuous, brightly colored.
Scent & Nectar	Lack odor and nectar.	Strongly scented and produce sweet nectar.
Pollen Grains	Light, dry, smooth, produced in massive numbers.	Sticky, heavy, covered in a sticky layer (pollenkitt).
Stigma	Large, feathery, and protruding outside.	Small, sticky, and remains inside the petals.
Stamens	Long filaments with versatile, wellexposed anthers.	Short filaments safely enclosed inside the flower.
Examples	Maize, Wheat, Grasses.	Rose, Sunflower, Jasmine.

122. Transcription Unit

(A) Construction of the Transcription Unit

By convention, the sequence of the coding strand is written in the $5' \rightarrow 3'$ direction. The complementary template strand runs in the $3' \rightarrow 5'$ direction. The Promoter is located at the $5'$ end of the coding strand, while the Terminator lies at the $3'$ end.



(B) Transcribed RNA Strand

The RNA strand is transcribed using the template strand. Its sequence matches the coding strand perfectly, except Thymine (T) is replaced by Uracil (U).

• RNA Sequence with Polarity:

mRNA transcript : 5' – A U G C A U G C A U A G – 3'

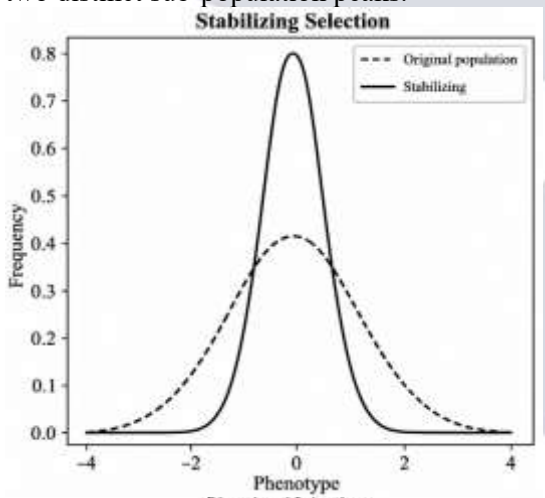
123. Modes of Natural Selection

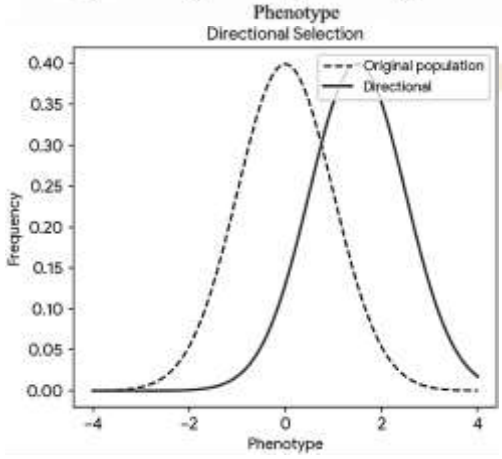
Natural selection alters phenotypic distributions in a population in three distinct ways:

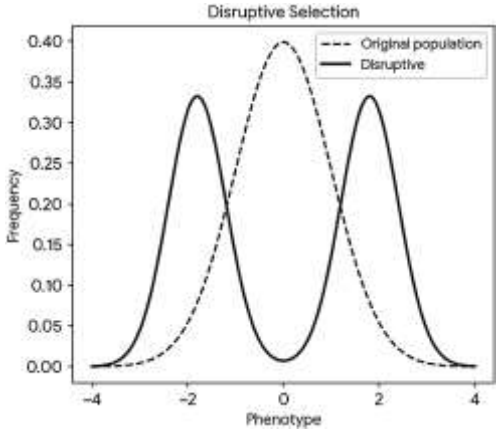
(1) Stabilizing Selection: Favors intermediate phenotypes. It eliminates extreme phenotypes, narrowing the peak around the mean value.

(2) Directional Selection: Favors individuals at one extreme of the phenotypic distribution. This shifts the entire curve and its mean in a particular direction.

(3) Disruptive Selection: Favors both extreme phenotypes over the intermediate values. It splits a single peak into two distinct sub-population peaks.







124. Cancer and Tumors

(A) • Oncogenic Viruses: Certain viruses carry specific genes called viral oncogenes (v-onc).

• Activation: When these viruses infect human cells, their genetic material integrates into the host genome.

• Transformation: They disrupt or abnormally activate cellular proto-oncogenes (c-onc), transforming healthy, controlled host cells into cancerous cells characterized by uninhibited cellular division.

(B) Tumor Progression and Damage

• Conversion to Malignancy: Benign tumors turn malignant when cells acquire mutations that allow them to escape local tissue boundaries, breach the basement membrane, and develop a blood supply (angiogenesis).

• Harm to the Body:

• Metastasis: Malignant cells slough off the primary tumor, travel through blood vessels or lymphatic channels, and colonize distant vital organs.

• Nutrient Starvation: These cancer cells grow rapidly and aggressively compete with normal tissue cells for essential nutrients, starving healthy cells.

• Organ Disruption: Expanding masses physically crowd, compress, and destroy surrounding healthy tissue structures, causing organ failure.

125. Insulin and rDNA Technology

(A) • Proinsulin: A completely inactive precursor hormone molecule that contains three distinct polypeptide chains linked together: Chain A, Chain B, and an extra processing segment called the C-peptide.

• Insulin: The biologically active configuration of the hormone. During maturation, the C-peptide is enzymatically excised, leaving Chain A and Chain B directly locked together via strong disulfide bonds.

(B) Production of Human Insulin via rDNA Technology

(1) Isolation & Synthesis: DNA sequences matching the exact genetic code for human insulin Chain A and Chain B are synthetically created in a laboratory.

(2) Vector Insertion: These distinct DNA fragments are inserted independently into plasmid vectors adjacent to a promoter gene (like the β-galactosidase gene).

(3) Transformation: The engineered recombinant plasmids are introduced into host Escherichia coli cells to transform them.

(4) Bioreactor Cultivation: Transformed E. coli cells are cultured inside specialized industrial bioreactors to produce massive quantities of fusion protein chains.

(5) Extraction & Purification: The expressed Chain A and Chain B proteins are isolated from individual bacterial cultures and purified.

(6) Disulfide Bond Joining: The purified individual polypeptide chains are mixed together and treated chemically to form functional disulfide bonds, yielding mature, active human insulin (Humulin).

126. **(A) (i)** Status of food and space in curves a and b :

• Curve a (Exponential Growth Curve): Food and space resources are unlimited (abundant).

• Curve b (Logistic Growth Curve): Food and space resources are limited (finite).

(ii) Curve depicting prey population in the absence of predators:

• Curve a would appropriately depict the prey population because, in the absence of predator checks, the population grows exponentially without biological resistance until environmental capacity constraints trigger.

(iii) Significance of the dotted line:

• The dotted line represents the Carrying Capacity (K) of the habitat. It indicates the maximum number of individuals of a population that a given environment can sustainably support with its available resources, beyond which no further population growth is possible.

OR

(B) (i) Predation is an interspecific biological interaction where one organism (the predator) kills and consumes another organism (the prey).

(ii) Two reasons why predation is required in a community:

(1) Energy Transfer: It acts as a conduit for transferring energy across higher trophic levels in an ecosystem.

(2) Prey Population Control: It keeps the prey population under check, preventing them from achieving unsustainably high densities that could lead to habitat degradation.

(3) Maintaining Species Diversity: It reduces intense competition among competing prey species, allowing weaker species to coexist.

(iii) Predators are described as prudent because they do not overexploit their prey. If a predator is too efficient and overexploits the prey population, the prey species could become extinct, which would subsequently lead to the starvation and extinction of the predator itself due to a lack of food.

127. **(A)** Type of bio-diversity conservation observed:

• Ex-situ Conservation (Off-site conservation).

(B) Two other ways that help in this type of conservation:

(1) Cryopreservation: Gametes of threatened species can be preserved in viable and fertile conditions at ultra-low temperatures (using liquid nitrogen) for long periods.

(2) Seed Banks: Seeds of different genetic strains of commercially important or endangered plants are stored under specific temperature and moisture conditions to maintain long-term viability.

(3) Tissue Culture: In vitro clonal propagation can be used to multiply endangered plant populations rapidly.

(C) One other place that serves this purpose besides zoological parks:

• Botanical Gardens (or Wildlife Safari Parks / Seed Banks).

128. **(A)** Justification for Basal-Level Operation

• Lactose entry: The bacterial cell requires a transport protein called permease to allow lactose to enter the cell.

• Gene expression: Permease is encoded by the structural gene (lac Y) inside the lac operon.

• Induction requirement: If the operon is completely turned off, no permease is made, lactose cannot enter, and it cannot act as an inducer to activate the system.

• Conclusion: Therefore, a very low (basal) level of operon expression must always exist.

(B) (i) Activation of Structural Genes

• Inducer presence: Lactose (or allolactose) acts as an inducer when added to the medium.

• Repressor inactivation: The inducer binds to the repressor protein, altering its shape and making it inactive.

• Unblocking transcription: The inactive repressor cannot bind to the operator region anymore.

• Transcription initiation: RNA polymerase freely binds to the promoter, transcribing the structural genes (IacZ, IacY, and IacA).

OR

(ii) Reason for "Negative Regulation"

• Repressor dominance: The system is naturally kept in an "off" state by a regulatory repressor protein.

• Inhibition mechanism: Since the active regulatory gene product (repressor) prevents transcription, the control mechanism is termed negative regulation.

(C) Transcriptionally Regulated System

• Primary control point: The regulation occurs predominantly at the initiation of transcription.

• Polymerase control: The cell regulates gene expression by controlling whether RNA polymerase can access the promoter to begin transcribing messenger RNA (mRNA).

129. **(A)** Two types of specialised cells

• B-lymphocytes (B cells): Produce antibodies into the blood to fight pathogens.

• T-lymphocytes (T cells): Help B cells produce antibodies and mediate cellmediated immunity.

(B) (i) Two barriers providing innate immunity

(Choose any two from below)

• Physical barrier: Skin (prevents entry of microorganisms) or mucus coating of respiratory tracts.

• Physiological barrier: Acid in the stomach or saliva in the mouth.

• Cellular barrier: White blood cells like macrophages or neutrophils.

OR

(ii) Characteristic responsible for graft rejection

• Ability to differentiate self from non-self: The immune system recognizes the foreign tissue as "non-self".

• Cell-Mediated Immunity (CMI): This specific branch of the immune system is primarily responsible for rejecting the transplanted organ.

(C)

Feature	Active Immunity	Passive Immunity
Production	Produced by the host's own body cells in response to antigens.	Received from outside; ready-made antibodies are directly injected.
Response Time	Slow and takes time to develop its full effective response.	Fast and provides immediate protection.
Duration	Long-lasting, sometimes lifelong.	Short-lived and temporary.
Memory	Creates immunological memory.	Does not create immunological memory.

130. **(A)** Hormones Involved at Each Stage

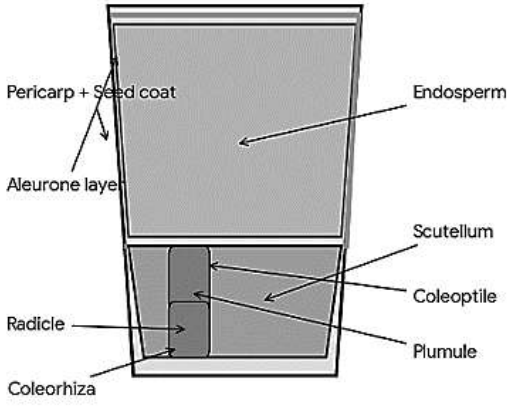
(1) Hypothalamus → Pituitary: GnRH (Gonadotropin-Releasing Hormone).
(2) Pituitary → Ovary: LH (Luteinizing Hormone) and FSH (Follicle-Stimulating Hormone).
(3) Ovary → Pregnancy: Estrogen and Progesterone.

Functions of Each Hormone

• GnRH: Stimulates the anterior pituitary gland to secrete LH and FSH.
• FSH: Stimulates the growth and development of ovarian follicles.
• LH: Triggers ovulation and stimulates the formation of the corpus luteum.
• Estrogen: Helps repair and proliferate the uterine endometrium wall.
• Progesterone: Maintained by the corpus luteum; prepares and maintains the endometrium for implantation and pregnancy.

(B) (i) Diagram of L.S. of Maize Grain :

L.S. of Maize Grain



(ii) Differentiation Table

Feature	Perisperm	Endosperm
Origin	Derived from the persistent, unused nucellus.	Formed by triple fusion (primary endosperm nucleus).
Ploidy	Diploid (2n).	Triploid (3n).
Example	Black pepper, Beetroot.	Maize, Castor, Wheat.

131. **(A)** Types and Locations of Genes causing Thalassemia

• α-Thalassemia: Controlled by two closely linked genes, HBA1 and HBA2, located on chromosome 16.
• β-Thalassemia: Controlled by a single gene, HBB, located on chromosome 11.
Cause and Symptoms
• Cause: Mutations or deletions in the genes governing globin chain synthesis, resulting in reduced or absent synthesis of α or β polypeptide chains.
• Symptoms: Severe anemia, jaundice, bone deformities (especially facial), dark urine, and delayed growth.
Difference from Sickle-Cell Anemia
• Thalassemia: A quantitative defect where too few globin molecules are synthesized.
• Sickle-Cell Anemia: A qualitative defect where an incorrect, mutated functional globin molecule is synthesized (glutamic acid replaced by valine).

OR

(B) (i) Four Prime Goals of the Human Genome Project (HGP)
• Identify all the approximately $20{,}000 - 25{,}000$ genes in human DNA.
• Determine the sequences of the 3 billion chemical base pairs making up human DNA.
• Store this genomic information in organized computer databases.
• Improve tools and computational methods for data analysis.
(ii) Two Methodologies of HGP
• Expressed Sequence Tags (ESTs): This method focused on identifying and sequencing only the regions of DNA that are expressed as RNA.
• Sequence Annotation: This approach involved sequencing the entire genome (both coding exons and non-coding introns) blindly, followed by assigning functional jobs to different segments later.
(iii) YAC Expansion and Purpose
• Expansion: Yeast Artificial Chromosome.
• Use: It was used as a specialized vector to clone and carry very large fragments of human DNA inside host yeast cells for sequencing.

132. **(A) (i) (I)** Naming Convention for EcoRI

The name of the restriction enzyme EcoRI is derived from the source bacterium Escherichia coli RY 13 using the following rules:
• E: Represents the first letter of the genus name (Escherichia).
• co: Represents the first two letters of the species name (coli).
• R : Represents the specific strain of the bacterium (strain RY 13).
• I: The Roman numeral indicates the order in which the enzyme was isolated from that strain of bacteria (first enzyme isolated).
(II) Recognition Site of EcoRI
EcoRI recognizes a specific palindromic nucleotide sequence and cuts between the bases G and A on both strands:
$5' - \mathrm{G} \downarrow \mathrm{AATTC} - 3'$
$3' - \mathrm{CTTAA} \uparrow \mathrm{G} - 5'$
(ii) Overhanging Stresses and Their Role
• Name: Single-stranded overhanging stretches are called sticky ends (or cohesive ends).
• Role in rDNA formation:
• They form hydrogen bonds with complementary sticky ends of the vector DNA.
• This base-pairing aligns the DNA fragments precisely.

• The enzyme DNA ligase then joins the sugar-phosphate backbones smoothly.
• This efficiency makes the creation of recombinant DNA (rDNA) much easier.

OR

(B) (i) Insertional Inactivation Method
Insertional inactivation is a screening procedure used to differentiate recombinant host cells from non-recombinant cells.
• A foreign gene is inserted directly inside the coding sequence of a selectable marker gene (e.g., the β-galactosidase gene).
• This insertion disrupts the sequence, making the marker gene non-functional (inactivated).
• When grown on a medium containing a chromogenic (color-producing) substrate:
• Non-recombinants have a functional gene, produce active enzyme, and turn blue.
• Recombinants have an inactivated gene, produce no enzyme, and remain white/colorless.
(ii) Vector for Transferring Genes in Plants
• The commonly used vector is the Ti plasmid (Tumor-inducing plasmid) delivered by the soil bacterium Agrobacterium tumefaciens.
(iii) Mechanism of Tumor Transformation
• The Ti plasmid contains a specific DNA segment called T-DNA (Transfer DNA).
• During infection, the bacterium delivers this T-DNA segment directly into the host plant cell's nuclear genome.
• Once integrated, the T-DNA genes force the plant cell to overproduce growth hormones (auxins and cytokinins).
• This hormone imbalance triggers rapid, uncontrolled cell division, transforming normal cells into a tumor known as a crown gall.

133. **(b)** • P - Thalamus: The fleshy outer edible part of the apple (since apple is a false fruit).
• Q - Seed: The ripened ovules enclosed inside the core.
• R - Endocarp: The tough, inner cartilaginous layer directly enclosing the seeds.
• S - Mesocarp: The tissue layer located between the endocarp and the outer thalamus.

134. **(b)** The foetal ejection reflex is a neuroendocrine mechanism where the fully developed fetus and placenta send signals inducing mild uterine contractions. This triggers the release of oxytocin from the maternal pituitary gland, which further stimulates stronger contractions during parturition (childbirth).

135. **(b)** DNA molecule = 160 base pairs, Guanine = 30%
Total bases $= 160 \times 2 = 320$
$G = 30\%, C = 30\%$
$A + T = 40\%$
$A = T = 20\%$
$A = 20\% \times 320 = 64$

136. **(b)** Cross Vv × vv
Punnett square:

v	v
v	w
Violet offspring $= 1/2$	w

50%

137. **(d)** Analysis of the Phases:
• Phase I (Days 1-7): Menstrual phase / Early follicular phase.
• Phase II (Days 8-14): Follicular/Proliferative phase leading up to ovulation on day 14. Primary follicles mature into Graafian follicles during this stage.
• Phase III (Days 15-28): Luteal/Secretory phase. The corpus luteum forms and secretes large amounts of progesterone, which is responsible for maintaining the endometrium required for pregnancy.
• Evaluating Statements:
• (a) is correct: Primary follicles mature into Graafian follicles during Phase II.
• (b) is correct: Progesterone is secreted in high amounts during Phase III and maintains pregnancy.

138. **(a)** Evolution sequence
Given:
• (I) Seaweed
• (II) Invertebrates

• (III) Jawless fish
Evolutionary order:
Seaweed → Invertebrates → Jawless fish
(I), (II), (III)

139. **(d)** Monascus purpureus is used for production of
Monascus purpureus produces statins (cholesterol-lowering agents).

140. **(d)** Restriction endonuclease Pst I
Recognition sequence:
$5'CTGCAG3'$
$3'G \mid ACGTC5'$
Cut occurs between A and G on the top strand and between G and A on the bottom strand.
Resulting fragments are:
$5'CTGCA$
$3'G$
And
$5'G$
$3'ACGTC$

141. **(b)** An interaction where one species benefits (+) and the other is unaffected (0) is known as commensalism.
(a) Mycorrhizae: Mutualism (+/+) where both species benefit.
(b) Sea anemone and clownfish: Commensalism ($+/0$). The clownfish gets protection from predators within the stinging tentacles, while the sea anemone is neither harmed nor benefited.
(c) Abingdon tortoises and goats: Competition ($-/-$) for food resources.
(d) Cuscuta on hedge plants: Parasitism ($+/-$) where the parasite benefits at the expense of the host.

142. **(c)** • Transgenic animals are created by introducing foreign DNA into a zygote or an early-stage embryo.
• Because this genetic modification happens before cellular differentiation and division, the integrated foreign DNA is replicated and passed on during mitosis to all cells of the growing organism.

143. **(d)** Options (a), (b), and (c) are examples of analogous organs/structures resulting from convergent evolution (different structures evolving for similar functions). On the other hand, thorns of Bougainvillea and tendrils of Cucurbita are homologous organs arising from the same modification (axillary bud), which represents divergent evolution.

144. **(c)** The introduction of the alien invasive species, Nile Perch, into Lake Victoria in East Africa led to the ecological disaster and extinction of over 200 native species of cichlid fish.

145. **(c)** • Assertion (A): The embryo with 8 to 16 blastomeres is called a morula.
• Reason (R): The morula continues to divide and transform into trophoblast.
• Explanation: The assertion is correct as the $8-16$ cell stage is called a morula. However, the reason is false because the morula continues to divide and transforms into a blastocyst (not just a trophoblast). The trophoblast is merely the outer layer of cells within that blastocyst.

146. **(b)** • Assertion (A): Repetitive sequences make up a very large portion of human genome.
• Reason (R): Repetitive sequences do not have direct coding functions in the genome.
• Explanation: According to the Human Genome Project, both statements are independently true: repetitive sequences constitute a vast major portion of our DNA, and they lack direct protein-coding roles. However, the lack of coding function does not explain why they occupy such a large part of the genome.

147. **(a)** • Assertion (A) is true: Trichoderma species are free-living fungi that are extremely common in the soil and root ecosystems (rhizosphere).
• Reason (R) is true: They act as highly effective biological control agents (biocontrol) against several plant pathogens (e.g., Fusarium, Pythium, and Phytophthora) by competing for nutrients and space, producing antibiotics, and directly parasitizing the pathogens.
• Connection: The reason explains why these fungi are studied and commonly found in root ecosystems-because of their natural ability to protect plants by warding off harmful pathogenic fungi.

148. **(a)** • Assertion (A) is true: When isolating and extracting DNA, the cell wall of the organism must be broken down to access the cellular contents. Yeast is a fungus and has a tough cell wall primarily made of chitin. Therefore, treating yeast cells with the enzyme chitinase is necessary to digest the cell wall. In contrast, Spirogyra is green algae, and its cell wall is primarily made of cellulose; thus, chitinase is not required for it.

• Reason (R) is true: Fungal cell walls are indeed made up of chitin, making the chitinase enzyme the perfect catalyst to break them down.
• Connection: The reason explicitly justifies the assertion by stating that chitinase is used because the yeast cell wall is made of chitin.

149. **(A)** Mention the functions of each of the following:

(i) Tassels of Corn Cob: They represent the male inflorescence that produces and releases pollen grains into the air. They wave in the wind to facilitate wind pollination (anemophily).

(ii) Scutellum: It is the single, large shield-shaped cotyledon found in monocot seeds. Its function is to absorb nutrients from the endosperm and transfer them to the developing embryo during germination.

OR

(B) Farmers prefer apomictic seeds over hybrid seeds. Give any two reasons.

(1) No Segregation of Characters: Apomictic seeds produce clones of the parent plant. Characters do not segregate in the progeny, maintaining the desired traits across generations.

(2) Cost-Effective: Farmers do not need to buy expensive hybrid seeds every year. They can reuse the seeds collected from their harvest.

150. Definition: Amniocentesis is a prenatal diagnostic technique where a small sample of amniotic fluid containing fetal cells is extracted from the uterus to test for chromosomal abnormalities, genetic disorders, or metabolic errors in the developing fetus.

• Reason for Statutory Ban: The technique was being widely misused for pre-natal sex determination, leading to a severe increase in female foeticide and skewed sex ratios.

151. Name: Spleen.

• Role as a Lymphoid Organ:
• It acts as a blood filter by trapping blood-borne microorganisms.
• It contains a large population of lymphocytes and phagocytes that destroy these trapped pathogens to trigger an immune response.

152. **(A)** Method: Meristem culture (Tissue culture).

• Explanation: The apical and axillary meristems of a virus-infected plant remain virus-free because the rate of cell division is faster than the rate of viral multiplication. Removing these meristems and growing them in vitro on a sterile nutrient medium allows the regeneration of healthy, virus-free plants.

OR

(B) (1) Chemical Treatment: Treat the bacterial cells with a specific concentration of a divalent cation, such as Calcium (Ca^{2+}). This alters the cell wall, increasing the efficiency with which DNA enters through the bacterial pores.

(2) Heat Shock: Incubate the treated cells with recombinant DNA on ice, briefly expose them to a high temperature of 42°C (heat shock), and immediately place them back on ice. This transiently opens pores to force DNA uptake.

153. **(A)**

Feature	Grazing Food Chain (GFC)	Detritus Food Chain (DFC)
Starting Point	Begins with living green plants (producers).	Begins with dead organic matter (detritus).
Primary Energy Source	Solar radiation.	Energy stored in dead organic remains.
Major Organisms	Herbivores and carnivores.	Decomposers (saprotrophs like fungi and bacteria).

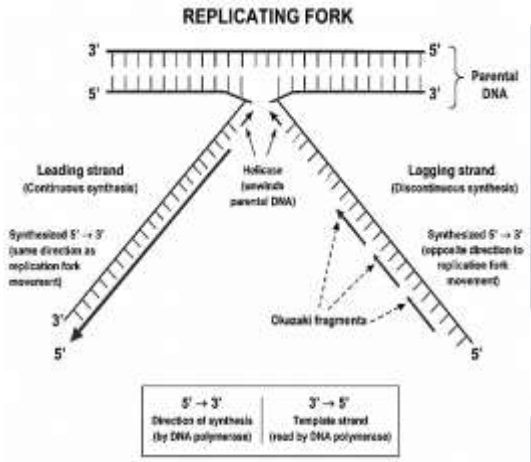
OR

(B) (1) Trophic Level Complexity: It does not account for species that belong to two or more trophic levels simultaneously (e.g., omnivores like humans or sparrows).
(2) Exclusion of Decomposers: Saprophytes and decomposers are not given a place in ecological pyramids, despite their critical role in recycling nutrients in the ecosystem.
(3) Food Web Omission: It assumes a simple, linear food chain, which rarely exists naturally.

154. Three Outbreeding Devices in Flowering Plants

Continuous self-pollination often leads to inbreeding depression, so plants have evolved mechanisms to prevent it and encourage cross-pollination:
(1) Dichogamy: The male (anther) and female (stigma) reproductive organs mature at different times in the same bisexual flower. This asynchronous development (either the pollen matures before the stigma, or vice versa) prevents selffertilization.
(2) Self-Incompatibility: A genetic mechanism that prevents self-pollen (from the same flower or other flowers on the same plant) from fertilizing the ovules. The stigma or style actively rejects or inhibits pollen germination and pollen tube growth.
(3) Dicliny (Unisexual Flowers): Plants produce separate male and female flowers instead of bisexual ones. If a plant bears only unisexual male or female flowers on separate plants (dioecy), self-pollination is physically impossible.

155.



• The entire DNA molecule does not open in a single stretch because of the very high energy required. The point of separation proceeds slowly towards both directions giving the appearance of a Y -shaped structure called the replication fork

156. **(A)** Psilophyton

(B) Seed ferns (pteridosperms)

(C) Mosses (bryophytes)

(D) Psilophyton provides common ancestry to ferns and to the seed-plant line (conifers/seed ferns → ultimately flowering plants).

(E) Immediate/common ancestor - Psilophyton (seed ferns are shown branching from Psilophyton). If the question means a deeper/shared ancestor, that would be the Tracheophyte ancestors.

(F) Chlorophyte ancestors

157. Microbes and Their Products

(A) Saccharomyces cerevisiae: Ethanol (alcohol) or Bread.
(B) Propionibacterium shermanii. Swiss cheese.
(C) Aspergillus niger. Citric acid.
(D) Trichoderma polysporum: Cyclosporin A (immunosuppressive agent).
(E) Acetobacter acetí. Acetic acid (vinegar).
(F) Streptococcus. Streptokinase (clot buster enzyme).

158. Benefits of Transgenic Animals

Transgenic animals are genetically modified to benefit humans in the following three ways:
• Study of Disease: They serve as models to analyze how genes contribute to human illnesses like cancer, cystic fibrosis, and Alzheimer's disease.

• Biological Products: They produce valuable human proteins in their milk, such as α -1-antitrypsin used to treat emphysema.
• Vaccine Safety Testing: They are used to test the safety of new vaccines, like the polio vaccine, before being cleared for human use.

159. Gause's 'Competitive Exclusion Principle'
• Principle: Two closely related species competing for the exact same limited resources cannot coexist indefinitely.
• Outcome: The competitively inferior species will eventually be eliminated by the superior one.
• Example: Introduction of goats to the Galapagos Islands.
• Detail: Goats had a greater browsing efficiency than the native Abingdon tortoises.
• Result: The Abingdon tortoises became extinct within a decade due to food scarcity.

160. Levels of Biodiversity
(1) Genetic Diversity
• Explanation: Variation in genetic information within a single species.
• Example: The medicinal plant Rauwolfia vomitoria shows genetic variation in the potency and concentration of the active chemical reserpine.
(2) Species Diversity
• Explanation: Variety and richness of different species within a specific region.
• Example: The Western Ghats have a much greater diversity of amphibian species than the Eastern Ghats.
(3) Ecological Diversity
• Explanation: Variety of ecosystems, habitats, and communities within a geographical area.
• Example: India possesses high ecosystem diversity with its deserts, rain forests, mangroves, and coral reefs compared to a Scandinavian country like Norway.

161. **(A)**Because RNA polymerase builds RNA in the $5' \rightarrow 3'$ direction, it must use the DNA strand that runs $3' \rightarrow 5'$ as the template so nucleotides can be added to the growing RNA's $3'$ end. Polymerisation therefore requires the template to be read $3' \rightarrow 5'$ (absence of a $3'OH$ blocks further chain extension).

(B) (i) hnRNA contains non-coding intervening sequences (introns) that must be removed and the coding sequences (exons) joined to form a continuous, translatable mRNA; splicing also enables alternative exon combinations (isoform diversity).

OR

(ii) Additional processes which hnRNA needs to undergo-
• Addition of a $5'$ methylated guanosine cap (for ribosome binding/translation initiation).
• Addition of a $3'$ poly-A tail (for mRNA stability/longevity).

(C) Only one strand of DNA is transcribed because RNA polymerase synthesizes RNA in the $5' \rightarrow 3'$ direction. The DNA template strand that runs $3' \rightarrow 5'$ provides the correct orientation for RNA polymerase to synthesize RNA in the $5' \rightarrow 3'$ direction. The two strands of DNA serve distinct purposes. One strand functions as the template strand, which is transcribed, and the other is the coding strand, which shares the same sequence as the RNA (except that the RNA substitutes uracil for thymine). Transcription only requires the template strand.

162. **(A)** Because plasmids and bacteriophages can carry foreign (alien) DNA into host cells and replicate independently in the host, producing many copies of the inserted DNA; they are easy to cut/ligate (have useful restriction sites) and contain selectable markers for identifying transformants.

(B) (i) (I) The rop gene.

(II) The restriction site labelled C is located in the rop gene (site C on the map).

OR

(ii) ampicillin resistance gene (AmpR) and tetracycline resistance gene (TetR).

(C) The two restriction sites in each selectable-marker gene:
• AmpR (ampicillin resistance) gene: sites A and B .
• TetR (tetracycline resistance) gene: sites D and E .

163. **(A)** During coitus, the semen is released into the vagina, passing through the cervix of the uterus and reaching the ampullary-isthmic junction of the fallopian tube.
• The ovum is also released into the junction for fertilisation.
• The fusion of the sperm and ovum is known as fertilisation.
• During fertilisation, the sperm induces changes in the zona pellucida and blocks the entry of other sperms. This ensures that only one sperm fertilises an ovum.

• The enzymatic secretions of the acrosomes help the sperm enter the cytoplasm of the ovum.
• This completes the meiotic division of the secondary oocyte, resulting in the formation of a haploid ovum (ootid) and a secondary polar body.
• Then, the haploid sperm nucleus fuses with the haploid nucleus of the ovum to form a diploid zygote.
• Mitosis starts as the zygote moves through the isthmus of the oviduct (cleavage), forming 2,4,8, and 16 daughter cells called blastomeres.
• The $8-16$ cell embryo is called a morula, which continues to divide to form the blastocyst. The morula moves further into the uterus.
• The cells in the blastocyst are arranged into an outer trophoblast and an inner cell mass.
• The trophoblast gets attached to the uterine endometrium and the process is called implantation. This leads to pregnancy.
• The inner cell mass gets differentiated to form the embryo.

OR

(B) (i) The sequence of secretion of the given hormones in a pregnant woman is as follows:
(1) FSH
(2) LH
(3) hCG
(4) Relaxin

(ii)(A) Source: Chorionic cells of the placenta
Function: Maintains the corpus luteum and stimulates it to secrete progesterone
(B) Source: Anterior pituitary lobe
Functions: Induces ovulation and maintains the corpus luteum
(C) Source: Ovary
Function: Helps during childbirth by relaxing the pelvic muscles as well as the muscles of the cervix.

164. **(A)** Let's consider the contrasting traits of flower colour in pea plants. The two parental plants are Purple (P) and White (p) flowers. The cross involves the genotype Pp (heterozygous purple) and Pp (heterozygous purple).

F_1 Generation:

Pp × Pp produces offspring with the following genotypes:
• PP (Purple): 25%
• Pp (Purple): 50%
• pp (White): 25%

F_2 Generation:

The F_2 generation has a phenotypic ratio of $3:1$, with 3 purple and 1 white. This follows the Mendelian inheritance pattern of dominant and recessive traits.

Monohybrid Cross in Antirrhinum Plants:

Antirrhinum plants (Snapdragon) exhibit a different inheritance pattern. The colour of the flowers follows incomplete dominance, where red (R) is incompletely dominant over white (r).

F_1 Generation:

Rr × Rr produces offspring with the following genotypes:
• RR (Red): 25%
• Rr (Pink): 50%
-rr (White): 25%

F_2 Generation:

The F_2 generation exhibits a phenotypic ratio of $1:2:1$
• 25% Red flowers (RR)
• 50% Pink flowers (Rr)
• 25% White flowers (rr)

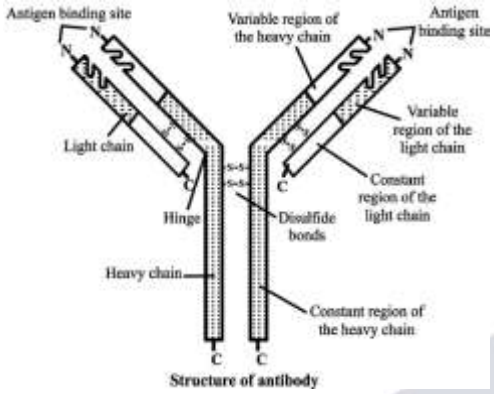
This shows incomplete dominance, where the heterozygous condition results in an intermediate phenotype.

OR

(B) (i) (1) Chromosomal Disorder: An anomaly in the quantity or arrangement of chromosomes results in a chromosomal disease. For example, Down syndrome is brought on by an extra copy of chromosome 21.
(2) Mendelian Disorder: Mutations in a single gene that follow Mendelian inheritance patterns result in a Mendelian disease. As an illustration, consider cystic fibrosis, which is an inherited autosomal disorder caused by a mutation in the CFTR gene.

(ii) (1)Phenomenon Leading to XO Abnormality: Turner Syndrome is the condition that results in an XO chromosomal aberration. This happens when one X chromosome instead of two is present due to a missing or incomplete second sex chromosome.
(2) Symptoms of XO Chromosomal Abnormality: Short stature, infertility, heart disorders, kidney issues, and learning disabilities are common in people with Turner syndrome. Additionally, they usually do not develop secondary sexual traits like breast growth.
(3) Karyotype: Turner syndrome patients have a karyotype of 45, X, meaning they have one X chromosome rather than two sex chromosomes and a total of 45 chromosomes rather than the standard 46 .

165. (A) (i)



(ii)

Active immunity	Passive immunity
1. It is a type of acquired immunity in which the body produces its own antibodies against disease-causing antigens.	1. It is a type of acquired immunity in which readymade antibodies are transferred from one individual to another.
2. It has a long lasting effect.	2. It does not have long lasting effect.
3. It is slow. It takes time in producing antibodies and giving responses.	3. It is fast. It provides immediate relief.
4. Injecting microbes through vaccination inside the body is an example of active immunity.	4. Transfer of antibodies present in the mother's milk to the infant is an example of passive immunity.

OR

(B) (i) (I) Wuchereria bancrofti and Brugia malayi.
(II) The parasites inhabit and damage the lymphatic vessels and nodes, causing lymphatic dysfunction that leads to lymphoedema, elephantiasis (chronic swelling and skin/tissue thickening) and hydrocele, with recurrent painful inflammatory attacks.
(III) Lymphatic filariasis is transmitted when an infected mosquito (e.g., Culex, Anopheles, or Aedes species)

bites a person and deposits infective larvae that develop into adult worms in the human lymphatics; infected humans then serve as the reservoir for further mosquito-borne transmission.

(ii) (I) Source: Histamine is produced and stored in mast cells and basophils.

Role: Histamine plays a key role in the inflammatory response. It is released during an allergic reaction or infection, causing blood vessels to dilate and become more permeable. This allows white blood cells and proteins to enter the affected tissues and fight the infection.

(II) Source: Interferons are produced by infected cells, primarily by virus-infected cells, as part of the immune response.

Role: Interferons inhibit viral replication by interfering with the ability of viruses to infect healthy cells. They also stimulate the activity of immune cells, such as macrophages and natural killer cells, to attack infected cells.

166. **(b)** • Ploidy of Primary Spermatocytes

• Spermatogonia undergo mitotic division to form primary spermatocytes. Since they are formed by mitosis, they retain the full double set of chromosomes (2n).

167. **(b)** • Pollen-Pistil Interaction

• The pistil has the ability to recognize whether the pollen is compatible (right type) or incompatible (wrong type). If it is incompatible, the pistil rejects the pollen by preventing pollen germination or pollen tube growth.

168. **(b)** • Avery, MacLeod, and McCarty Experiment

• Their experiment chemically purified components from heat-killed Sstrain bacteria to show that only DNA was capable of transforming live, harmless Rstrain bacteria into virulent S-strain bacteria.

169. **(c)**• Base Pair Combinations in RNA

• RNA contains the nitrogenous base Uracil (U) instead of Thymine (T). Therefore, the pairing of Uracil with Adenine is unique to RNA molecules.

170. **(c)**• Hemoglobin Mutation Disorder

• Sickle cell anemia is caused by a point mutation in the β-globin gene that substitutes glutamic acid with valine at the 6th position, leading to abnormally shaped red blood cells under low oxygen conditions.

171. **(c)** • i gene: Codes for the repressor protein.

• z gene: Codes for β-galactosidase.

• y gene: Codes for permease, which increases cell permeability to β-galactosides.

• a gene: Codes for transacetylase.

172. **(c)** • Symptoms: Short stature, small round head, furrowed tongue, and partially open mouth are classic clinical features of Down's syndrome.

• Cause: It is a chromosomal disorder caused by the presence of an additional copy of chromosome number 21 (Trisomy 21).

173. **(a)** • Chargaff's Rule: In double-stranded DNA, Cytosine (C) equals Guanine (G), and Adenine (A) equals Thymine (T).

• Calculation:

$C = 30\% \Longrightarrow G = 30\%$

$C + G = 60\%$

Remaining DNA $(A + T) = 100\% - 60\% = 40\%$

$A = 40\%/2 = 20\%$

174. **(b)** • Inoculum: The starter culture added to milk contains millions of Lactic Acid Bacteria (LAB), such as Lactobacillus.

• Function: These bacteria multiply at suitable temperatures to convert milk proteins into curd.

175. **(a)** • Divergent evolution is the process where groups from the same common ancestor evolve and accumulate differences, resulting in the formation of new species. This typically happens when populations adapt to different environmental conditions, niches, or functional needs.

176. **(c)** • Sticky ends are single-stranded overhanging sequences of DNA created by staggered cuts from restriction enzymes. They are called "sticky" because they readily form specific hydrogen bonds with their complementary base pairs on a counterpart DNA strand cut by the same enzyme.

177. **(d)** • Curd is produced by the fermentation of milk by Lactobacillus bacteria (Lactic Acid Bacteria).

• Wine, Penicillin, and Citric acid are all commercially produced using various species of fungi (yeast and molds).

178. **(d)** • Assertion (A): To isolate DNA from plant cell enzyme chitinase is used.

• Reason (R): Chitinase breaks down the plant cell wall.

• Explanation:
• Assertion is False: Cellulase and pectinase are used to break down plant cell walls, not chitinase. Chitinase is used to break down the cell walls of fungi.
• Reason is True: Structurally speaking as a general chemical definition, chitinase breaks down chitin (which forms fungal cell walls), but in the context of plant cells, this makes the assertion completely incorrect since plants have cellulosic walls. Note: In standard textbook keys where the specific biochemical target is evaluated, both statements are often deemed false because chitinase doesn't target plant walls, but since option (d) is the only standard fit when an assertion is flatly incorrect, (d) is chosen.

179. **(a)** • Assertion (A): Eukaryotic mRNA requires post-transcription processing for formation of functional mRNA.
• Reason (R): Eukaryotic transcripts possess extra non-functional segments called introns.
• Explanation:
• Assertion is True: Primary eukaryotic transcripts (hnRNA) undergo processing like splicing, capping, and tailing to become functional mRNA.
• Reason is True: They contain non-coding, non-functional intervening sequences called introns that must be removed.
• Explanation Check: The presence of these non-functional introns is precisely why splicing (processing) is required to form functional, continuous coding mRNA.

180. **(d)** • Assertion (A): An increase in BOD indicates that the water is fit for consumption.
• Reason (R): BOD is a measure of the organic matter present in water.
• Explanation:
• Assertion is False: A higher Biochemical Oxygen Demand (BOD) indicates a higher amount of organic pollution, making the water highly polluted and completely unfit for consumption.
• Reason is True: BOD directly measures the amount of oxygen required by microbes to decompose the organic matter present in a water sample.

181. **(a)** • Assertion (A): Organisations like GEAC are necessary to monitor GM researches and to test the safety of introducing Genetically Modified organisms for public services.
• Reason (R): GM researches can have unpredictable results which can even be disastrous, when Genetically Modified organisms are introduced into the ecosystem.
• Explanation:
• Assertion is True: The Genetic Engineering Appraisal Committee (GEAC) in India is responsible for regulating and safety-testing GMOs before public introduction.
• Reason is True: Genetic modification can lead to unpredictable ecological risks or unintended consequences when released into nature.
• Explanation Check: The statutory monitoring bodies are required because of these unpredictable and potentially dangerous ecological impacts.

182. **(A)** • GnRH Function: Gonadotropin-Releasing Hormone (GnRH) is a hypothalamic hormone that triggers the male reproductive system by acting on the anterior pituitary gland.
• Hormone Stimulation: It stimulates the pituitary gland to secrete two gonadotropins: Luteinizing Hormone (LH) and Follicle Stimulating Hormone (FSH).
• Leydig Cells Activation: LH acts on the Leydig cells of the testes to stimulate the synthesis and secretion of androgens (testosterone).
• Spermatogenesis Support: Testosterone and FSH act together on Sertoli cells to stimulate and regulate the process of spermatogenesis (sperm production).

OR

(B) Two Male Accessory Glands: Seminal vesicles and the Prostate gland (or Bulbourethral glands).
• Common Function: They secrete seminal plasma rich in fructose, calcium, and specific enzymes, which provides nutrition, motility, and a transport medium for sperm while lubricating the reproductive tract.

183. **(A)** • Drosophila Mechanism: Exhibits an XX-XY sex-determination system where females are homogametic (XX) and males are heterogametic (XY). Maleness is determined by the presence of the Y chromosome alongside the X -to-autosome (X : A) ratio.
• Grasshopper Mechanism: Exhibits an XX-XO sex-determination system where females have two X chromosomes (XX) and males have only one (XO). Males are heterogametic, producing 50% sperms with an X chromosome and 50% sperms without any sex chromosome.

OR

(B) Mendelian Disorders: Caused by alteration or mutation in a single gene and follow classic Mendelian laws of inheritance (e.g., Haemophilia).

• Chromosomal Disorders: Caused by the absence, excess, or abnormal arrangement of one or more entire chromosomes due to failure in cell division.

• Two Chromosomal Disorders: Down's syndrome and Klinefelter's syndrome (or Turner's syndrome).

184. **(A)** Malaria: Transmitted to humans by the bite of an infected female Anopheles mosquito.

• Dengue: Spread by the bite of an infected Aedes aegypti mosquito.

(B) Biological Control: Gambusia fish are predatory freshwater fish introduced into water bodies to feed on mosquito larvae.

• Vector Reduction: By consuming the larvae, they break the mosquito life cycle and significantly reduce the vector population without using chemical pesticides

185. Key Tools of Recombinant DNA Technology (Any Four)

(1) Restriction Enzymes: Function as molecular scissors to cut DNA molecules at specific palindromic recognition sequences.

(2) DNA Ligase: Acts as a molecular glue to join two distinct DNA fragments together by forming phosphodiester bonds.

(3) Cloning Vectors (e.g., Plasmids): Function as vehicles to deliver the foreign gene of interest into a host cell.

(4) Competent Host Organism: Acts as the biological factory to receive, replicate, and express the recombinant DNA to produce desired proteins.

186. **(A) (i)** Organisms: Producers or Autotrophs (such as green plants, algae, and photosynthetic bacteria).

• Source: Solar energy from the Sun.

(ii) Second Law of Thermodynamics: Ecosystems comply because energy transformations are not 100% efficient. At each trophic transfer, only about 10% of the energy is conserved, while 90% is dissipated as un-utilizable heat, increasing the entropy of the surroundings.

OR

(B) Nile Perch: Introduced into Lake Victoria in East Africa, it led to the catastrophic extinction of more than 200 unique native species of cichlid fish.

• Water Hyacinth (Eichhornia crassipes): Introduced into Indian waterways for its flowers, it turned into an invasive weed that choked water bodies, depleted dissolved oxygen, and killed native aquatic life.

187. **(A)** Coleoptile: Protective sheath covering the plumule (shoot tip).

• Coleorhiza: Protective sheath covering the radicle (root tip) and root cap.

(B) Definition: Endosperm development where the primary endosperm nucleus undergoes successive nuclear divisions without immediately forming cell walls. This creates a large number of free nuclei.

• Example: Tender coconut water.

(C) Definition: Fruits that develop without fertilization of the ovules. They are typically seedless.

• Example: Banana (or seedless grapes).

188. **(A)** Specific location of vasa efferentia and vas deferens

• Vasa efferentia: Located between the rete testis and the epididymis, conducting sperms out of the testis.

• Vas deferens: Extends from the epididymis, loops over the urinary bladder, and opens into the urethra via the ejaculatory duct.

(B) Definition: A small, haploid cell formed during oogenesis that contains very little cytoplasm and eventually degenerates.

• First production: It is first produced during Meiosis I (specifically at the completion of the first meiotic division of the primary oocyte).

(C) Fate of the Graafian follicle after ovulation

• Transformation: It transforms into a temporary endocrine structure called the corpus luteum.

• Function: It secretes large amounts of progesterone to maintain the endometrium for potential pregnancy.

• Regression: If fertilization does not occur, it degenerates into a scar-like structure called the corpus albicans.

189. **(A)** Dual role of deoxyribonucleoside triphosphates (dNTPs)

(1) Act as substrates: They provide the necessary nucleotides (dATP, dGTP, dCTP, dTTP) to build the new DNA strand.

(2) Provide energy: They provide energy for polymerization through the cleavage of high-energy terminal phosphate bonds.

(B) Phase of replication and consequences of failed cell division

• Phase: DNA replication occurs during the S phase (Synthesis phase) of interphase.

• Consequence: If DNA replication occurs but is not followed by cell division (cytokinesis), it leads to polyploidy (an increase in the whole set of chromosomes within the cell).

190. Process of Translation in Protein Synthesis

Translation is the process where genetic information in mRNA is decoded to synthesize a polypeptide chain (protein). It consists of the following key steps:

• Activation and Charging of tRNA: Amino acids are activated using ATP and linked to their specific tRNA molecules (aminoacylation).

• Initiation: The small ribosomal subunit binds to the mRNA at the start codon (AUG). The initiator tRNA carrying Methionine binds to this codon. The large ribosomal subunit then joins to complete the initiation complex.

• Elongation:

• The ribosome moves along the mRNA from codon to codon in the 5′ to 3′ direction.

• New aminoacyl-tRNA molecules enter the A (aminoacyl) site.

• Peptide bonds form between amino acids, catalyzed by the ribozyme peptidyl transferase.

• The tRNA shifts to the P (peptidyl) site as the ribosome moves forward (translocation).

• Termination: When a stop codon (UAA, UAG, or UGA) reaches the A site, a release factor binds to it. This terminates translation and releases the newly synthesized polypeptide chain.

191. Bacillus thuringiensis as a Biocontrol Agent

Bacillus thuringiensis (Bt) is a bacterium widely used to control insect pests naturally:

• Protoxin Production: The bacterium produces specific insecticidal crystalline proteins (Cry proteins) during its growth phase. These exist as inactive protoxins inside the bacterial cell.

• Ingestion: Pest insects (like caterpillars) ingest the bacterial spores while feeding on plant parts.

• Activation: The alkaline pH of the insect's midgut solubilizes and activates the inactive protoxin into an active toxin.

• Lysis and Death: The active toxin binds to the epithelial cells of the midgut, creating pores. This causes cell swelling, lysis, and ultimately leads to the death of the insect.

192. ELISA: Expansion, Principle, and Process

• Expansion: Enzyme-Linked Immunosorbent Assay.

• Principle: It is based on the principle of specific antigen-antibody interaction. Infection is detected by identifying pathogen antigens or antibodies produced against the pathogen.

• Process:

• Fixation: The target antigen or antibody from the sample is immobilized on the surface of a microtiter plate.

• Blocking: Unbound areas are blocked with non-reactive proteins to prevent false positives.

• Primary Reaction: The patient's serum is added. If present, specific antibodies or antigens bind to the fixed targets.

• Enzyme Conjugation: An enzyme-linked secondary antibody is introduced, which binds specifically to the initial antibody-antigen complex.

• Substrate Addition: A chromogenic substrate is added. The enzyme reacts with it to produce a distinct color change. The intensity of the color quantifies the concentration of the pathogen marker.

193. Plant-Animal Interactions

(A) Type of Interaction: Mutualism (specifically, obligate mutualism).

(B) Benefits to Female Wasps:

• The female wasp uses the fig fruit as a safe site for oviposition (laying eggs).

• The developing larvae feed on some of the developing seeds inside the fig fruit for nourishment.

(C) Example of Co-evolution: The obligate relationship between the Yucca plant and the Yucca moth (Tegeticula). The moth cannot complete its life cycle without the Yucca flower, and the Yucca plant depends entirely on this specific moth species for pollination.

194. **(A)** • Requirement: DNA techniques arise when bodies are deformed, decomposed, or burnt beyond recognition, making physical identification impossible.

• Suggested Technique: DNA Fingerprinting (DNA Profiling).

(B) Matching: Specific repetitive DNA sequences (VNTRs/STRs) are matched between the victim and their biological relatives.

• Other Uses:

• Resolving paternity or maternity disputes.

• Identifying criminals in forensic investigations.

• Determining evolutionary relationships and population genetic diversity.

(C) (i) Definition: Satellite DNA consists of highly repetitive non-coding DNA sequences that form separate minor peaks during density gradient centrifugation.

• Role: They exhibit high degrees of polymorphism, forming the foundational basis for DNA fingerprinting.

OR

(ii) Paternity Disputes: Confirms biological parentage.

• Pedigree Analysis: Establishes lineage in plants and breeding animals.

• Evolutionary Biology: Traces human migration patterns and genetic history.

• Medical Diagnostics: Identifies genetic markers associated with hereditary disorders.

195. **(A)** It detects tumors before they metastasize (spread) to other vital organs.

• It enables timely medical intervention when treatments are most effective.

• It significantly reduces mortality rates and improves the patient's quality of life.

(B) Avoid tobacco use, smoking, and alcohol.

• Minimize exposure to hazardous industrial chemicals and asbestos.

• Use protection against harmful ultraviolet (UV) radiation.

• Maintain a balanced diet and healthy weight.

• Get vaccinated against oncogenic viruses like HPV and Hepatitis B.

(C) (i) Physical Factors: lonizing radiations (X-rays, gamma rays) and non-ionizing radiations (UV rays).

• Chemical Factors: Tobacco smoke, tar, soot, and specific industrial pollutants.

• Biological Factors: Cancer-causing oncogenic viruses.

• Name of Agents: Carcinogens.

OR

(ii)

Feature	Viral Oncogenes (v - onc)	Proto-oncogenes (c - onc)
Origin	Present in the genome of oncogenic viruses.	Present in normal, healthy host cellular DNA.
Normal Function	Serve viral replication and cellular transformation.	Regulate normal cell growth, division, and differentiation.
Cancer Induction	Induce cellular transformation directly upon infecting host cells.	Induce cancer only when activated or mutated by external carcinogens.

196. **(A) (i)** Definition: 'RCH' stands for Reproductive and Child Health Care programme.

• Motive: To create awareness about various reproduction-related aspects and provide facilities and support for building a reproductively healthy society.

(ii) Five steps to implement the programme and create awareness:

(1) Audio-visual and Print Media: Utilizing government and non-governmental agencies to broadcast information via television, radio, and newspapers.

(2) Sex Education in Schools: Introducing sex education to provide right information to youth and discourage myths or misconceptions.

(3) Education on Birth Control and Care: Educating fertile couples and marriageable youth about available birth control options, care of pregnant mothers, and postnatal care.

(4) Awareness of STDs and AIDS: Providing information about Reproductive Tract Infections (RTIs), STDs, and safe sexual practices.
(5) Infrastructure Development: Providing professional expertise, suitable infrastructural facilities, and material support in health centers.
(iii) Useful but misused test and its importance:
• Test Name: Amniocentesis (a fetal sex determination test based on the chromosomal pattern in the amniotic fluid).
• Misuse: It is illegally used for female foeticide by determining the sex of the unborn child.
• Importance: It is meant to detect genetic disorders, chromosomal abnormalities (such as Down's syndrome), and metabolic errors in the developing fetus.

OR

(B) (i) Average duration of human pregnancy:
• Duration: Approximately 9 months (or about 280 days / 40 weeks from the last menstrual period).
• Name of the period: Gestation period.
(ii) Explanation of Menarche and Menopause:
• Menarche: The first occurrence of menstruation in a human female, marking the onset of puberty (usually between 11-15 years of age).
• Menopause: The permanent cessation of menstruation and reproductive capacity in females, typically occurring around 50 years of age.
(iii) Sterilisation methods in males and females:
• In Males (Vasectomy): A small part of the vas deferens is removed or tied up through a small incision on the scrotum to prevent sperm transfer.
• In Females (Tubectomy): A small part of the fallopian tube is removed or tied up through a small incision in the abdomen or through the vagina to prevent the ova from reaching the uterus.

197. **(A)** Steps involved in Recombinant DNA (rDNA) technology in sequence:
(1) Isolation of Genetic Material (DNA): Breaking open the cell (using enzymes like lysozyme, cellulase, or chitinase) and purifying the DNA by removing proteins and RNA.
(2) Cutting of DNA at Specific Locations: Utilizing restriction endonucleases to cut the purified DNA into fragments.
(3) Amplification of Gene of Interest using PCR: Making multiple copies of the specific DNA sequence using Polymerase Chain Reaction.
(4) Ligation of DNA Fragment into a Vector: Joining the isolated gene of interest with a vector DNA using the enzyme DNA ligase to form recombinant DNA.
(5) Insertion of Recombinant DNA into Host Cell/Organism: Introducing the recombinant DNA into a recipient host cell (e.g., using competent cells, microinjection, or biolistics).
(6) Culturing the Host Cells on a Large Scale: Growing the transformed host cells in a nutrient medium at a large scale, often using bioreactors, to express the desired protein.
(7) Downstream Processing: Separation, purification, formulation, and quality control testing of the expressed product before marketing.

OR

(B) (i) Cells are treated with a specific concentration of a divalent cation, such as calcium (Ca^{2+}), which increases the efficiency with which DNA enters the bacterium through pores in its cell wall.
• Recombinant DNA is then incubated with these cells on ice, followed by placing them briefly at $42°C$ (heat shock), and then putting them back on ice. This enables the bacteria to take up the recombinant DNA.
(ii) Methods to introduce alien DNA into cells:
(I) Plant Cell - Biolistics or Gene Gun method: Gold or tungsten micro-particles coated with the alien DNA are bombarded into the plant cells at high velocity.
(II) Animal Cell - Micro-injection: The recombinant DNA is directly injected into the nucleus of an animal cell using a micro-needle.

198. **(A) (i)** Meaning of 'Stable Community'
A stable community is a biological community whose population size and total biomass remain relatively constant or show minimal variation over a long period.
(ii) Characteristics of a Stable Community
• Productivity: It does not show too much variation in total biomass productivity from year to year.
• Resilience: It is resistant or resilient to occasional natural or man-made disturbances.

• Invasion Resistance: It must be highly resistant to invasions by alien (exotic) species.
(iii) Ecologist and Findings
• Ecologist: David Tilman
• Findings:
• Plots with more species showed less year-to-year variation in total biomass.
• Increased diversity directly contributed to higher overall productivity.

OR

(B) (i) Role of Detritivores and Example
• Role: They feed on dead plant and animal remains (detritus) and break them down into smaller particles through a process called fragmentation.
• Example: Earthworm.
(ii) Catabolism and Humification
• Catabolism: The process in which bacterial and fungal enzymes degrade detritus into simpler inorganic nutrients.
• Humification: The process leading to the formation and accumulation of a darkcolored, amorphous substance called humus in the soil. Humus is highly resistant to microbial action and serves as a nutrient reservoir.
(iii) Comparison of Grazing Food Chain (GFC) and Detritus Food Chain (DFC)

Aspect	Grazing Food Chain (GFC)	Detritus Food Chain (DFC)
(I) Origin	Starts with living green plants (producers) at the first trophic level.	Starts with dead organic matter (detritus) at the first trophic level.
(II) Energy Status	Driven by solar energy and is the primary pathway for energy flow in aquatic ecosystems.	Driven by chemical energy locked in dead organic matter and is the primary pathway for energy flow in terrestrial ecosystems.