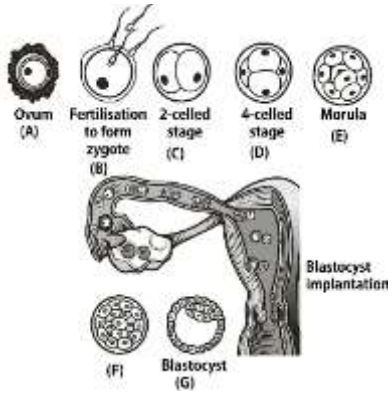
1. **(a)**In a fertilized ovule of an angiosperm, the cells in which n, 2n and 3 n conditions respectively occur are antipodal, zygote and endosperm.

Explanation:

It is true that most antipodal cells are haploid (n). The union of haploid egg and sperm cells produces a diploid (2 n) zygote. A haploid sperm cell fuses with two haploid polar nuclei in the centre cell to generate the triploid ($3n$) endosperm.

2. **(c)**



• The ovum, also called the egg cell, is round, and the nucleus is in the middle. The ovary has a layer of cells around it called the follicle. Figure (A) in the picture shows the ovum.

• It is called a morula when it has 8 to 16 blastomeres. The morula is shown in Figure (E). It keeps dividing and becomes a blastocyst as it goes deeper into the uterus.

• The blastomeres are organised in the blastocyst into two layers: the trophoblast, which is on the outside, and the inner cell mass, which comprises cells connected to the trophoblast. Figure (G) in the picture shows the morula.

3. **(c)** Explanation:

	Contraceptive/ Contraceptive Method		Mode of Action
(A)	The pill	(III)	Inhibits ovulation
(B)	Condom	(I)	Prevent sperm reaching cervix
(C)	Vasectomy	(IV)	Semen contains no sperm
(D)	Copper-T	(II)	Prevent implantation

4. **(c)Autosomal recessive**

Explanation:

• Gene mutations on non-sex chromosomes are the primary cause of disorders in autosomal recessive inheritance. In this pattern, both parents of an affected person who are unaffected carriers typically carry the gene.

• Therefore, the presence of multiple siblings in a family affected and their parents who are unaffected carriers indicates autosomal recessive inheritance.

5. **(a)** Explanation:

The last human chromosome to be fully sequenced was chromosome 1, which was finished in May 2006. With this milestone, the sequencing of all 24 human chromosomes-including the sex chromosomes X and Y and the 22 autosomes-came to an end.

6. **(a)**• It is called connective tissue. It is the main parenchymatous tissue that holds the two anther lobes together. This means that part (A) is the connective.

• The top layer is called the epidermis, and the layer below it is called the endothecium. This means that part B is the endothecium.

• The microspore mother cells are inside the tapetum. They divide meiotically to make pollen grains. In this case, the part marked (C) is the pollen grain.

7. **(a)** Explanation:

• An example of aneuploidy is Turner's syndrome. A genetic condition manifests when a female possesses only one X chromosome, unlike the standard two (45 with X0).

• This genetic abnormality is referred to as monosomy, a variety of aneuploidy characterised by an abnormally high number of chromosomes in a cell.

8. **(d)** Explanation:

DNA (deoxyribonucleic acid) is found in the nucleus of cells and holds an organism's genetic information. The information held in DNA is converted into messenger RNA (mRNA) through a process known as transcription. The genetic code is transported from the nucleus to the ribosomes in the cell's cytoplasm via mRNA. At the ribosomes, the genetic code is translated into a specific sequence of amino acids, which then make a protein. This procedure is known as translation. Thus, (P) denotes transcription, (Q) mRNA, and (R) protein.

9. **(a)** Explanation:

(1) Removal of oil stains: Lipase is an enzyme that helps get rid of oil stains.

(2) Removal of clots from blood vessels: Streptokinase is an enzyme that is used to take out clots from blood vessels.

(3) Lowering blood cholesterol: The drug statin is used to lower blood cholesterol levels.

(4) Immunosuppressive agent: Cyclosporin A is a drug that weakens the immune system.

10. **(b)** Explanation:

Bioactive Substance			Role
(A)	Statin	(III)	Lowering of blood cholesterol
(B)	Cyclosporin A	(IV)	Immuno-suppressive agent
(C)	Streptokinase	(II)	Removal of clots from blood vessels
(D)	Lipase	(I)	Removal of oil stains

11. **(d)** The 'molecular scissors' fall in the category of restriction enzymes.

Explanation:

'Molecular scissors' usually refers to enzymes called restriction enzymes or restriction endonucleases. These enzymes are proteins that can find certain parts of DNA and cut it at or near those parts.

12. **(b)**• ELISA technique is based on the principle of antigen-antibody interaction.

Explanation:

• Antigen-antibody interactions are what make ELISA work. The steps include putting an antigen in a gel, adding an enzyme-linked antibody, and seeing a color change to show that the reaction has happened.

• This makes it possible to find and measure individual antigens or antibodies in a sample.

13. **(a)**• Both (A) and (R) are true and (R) is the correct explanation of (A).

Explanation:

• Aspects of the mutualistic interaction between figs and fig wasps are described by both the Reason (R) and the Assertion (A). In general, the assertion's statement is accurate. The main pollinator for each species of fig is typically a particular type of wasp.
• Since the wasp pollinates the fig inflorescence while looking for appropriate egglaying locations, the process of this mutualistic interaction is explained by the explanation given in (R). Consequently, reason (R) supports claim (A), and both are true.

14. **(c)** (A) is true, but (R) is false.

Explanation:
Assertion (A) is the correct answer. Plasmids are made up of DNA units that copy themselves and are not connected to chromosomal DNA. They can copy themselves on their own inside a host cell. However, the reason (*R*) is wrong. It is not common for mammalian cells to have plasmids. Most of the time, they are found in prokaryotic cells, like bacteria.

15. **(a)** Both (A) and (R) are true and (R) is the correct explanation of (A).

Explanation:

• Assertion (A) is correct. Government entities do give patents to inventors or assignees who generate novel and beneficial inventions.
• Reasoning (R) is also correct. One of the primary functions of patents is to grant the patent holder the exclusive right to prevent others from commercially using, manufacturing, selling, or distributing the patented innovation without their permission for a set period of time.
• As a result, both statement (A) and reason (R) are right, and reason (R) provides an adequate explanation for claim (A).

16. **(c)** (A) is true, but (R) is false.

Explanation:
• Some aquatic ecosystems can have inverted biomass pyramids because of things like high primary producer growth rates, effective energy transfer between trophic levels, and a high number of small animals supporting a low number of large predators.
• However, inverted biomass pyramids are not primarily caused by the reason (R) because creatures at higher trophic levels require more energy.

17. (1) If the egg doesn't get fertilized after ovulation, which usually happens around the 14th day of the monthly cycle, the lining of the uterus is shed during menstruation, which happens every 28 days But if fertilisation happens, the lining of the uterus gets thicker to support the growing baby.

(2) The image shows that after 14 days, woman *Y* 's uterine wall starts to get thinner, which means the egg has not been fertilised. On the other hand, woman X's uterus wall starts to get thicker, which means the egg has been fertilised and she is now pregnant.

18. **(A)** Intensely lactating mothers generally do not conceive because high levels of prolactin hormone during lactation suppress ovulation and the menstrual cycle. This natural method of contraception is called lactational amenorrhea.

(B) The government has imposed strict conditions for MTP (Medical Termination of Pregnancy) to prevent its misuse, especially for female foeticide, and to ensure the safety and health of women. It also helps maintain ethical and legal control over abortions.

19. **(A)** • Insulin was extracted from the pancreases of animals, particularly pigs and cows, in earlier times.
• This insulin is no longer in use because it can cause allergic reactions and other complications.
• Modern recombinant human insulin, produced using biotechnology, is now used as it is more effective and safer for diabetic patients.

(B) The insulin synthesised in the human body initially exists as an inactive precursor called proinsulin. Proinsulin undergoes processing in the pancreas, where it is converted into active insulin by removing a portion called the C -peptide. This processing is necessary to activate the insulin so that it can effectively regulate blood glucose levels.
• Eli Lilly uses biotechnology to produce recombinant human insulin. Biotechnology involves genetically modifying bacteria or yeast to produce insulin.
• This insulin is already in its active form, meaning it is identical to human insulin and does not require the processing steps (like removing the C -peptide) that naturally occur in the human body. This makes it ready for use without further modification.

20. **(A)**

Aspect	Grazing Food Chain	Detritus Food Chain
Primary Producers:	Green plants and algae	Decomposers and detritivores
Primary Consumers:	Herbivores (e.g., animals feeding directly on plants)	Detritivores (e.g., organisms feeding on dead organic matter)
Energy Source:	Freshly synthesised organic matter (e.g., plants)	Dead organic matter (e.g., leaf litter, decaying organisms)
Energy Transfer:	Through consumption and digestion	Through decomposition and microbial breakdown
Trophic Levels:	Typically involves multiple trophic levels (e.g., plants, herbivores, carnivores)	It may involve fewer trophic levels (e.g., detritivores and decomposers)
Examples:	Grassland ecosystem, forest ecosystem	Decomposer-dominated ecosystems (e.g., soil ecosystems)

OR

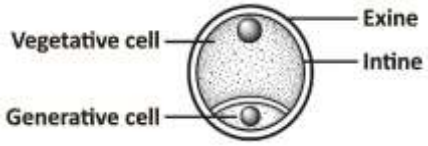
(B)• Brood parasitism is a reproductive technique used by some bird species in which one bird, known as the brood parasite, lays eggs in the nest of another bird species, known as the host. The host bird then incubates and nurtures the eggs as if they were its own, frequently to the detriment of its own young.

• The conduct of the common cuckoo is an excellent example of brood parasitism. Female cuckoos lay their eggs in the nests of other bird species, including crows. Cuckoo eggs closely resemble the host's eggs, making it less likely that the host will discover the incursion. The parasite bird's eggs have developed to mimic the host's egg in size and colour over time, reducing the likelihood of the host bird recognising and ejecting the foreign eggs from the nest.

21. (A)• Despite representing less than 2% of the Earth's land area, biodiversity hotspots are home to a disproportionate number of species. Strict preservation of these regions aids in conserving rare and threatened species, limiting biodiversity loss, and lowering extinction rates by preserving essential habitats and ecosystems.

(B)• Western Ghats and Eastern Himalayas are two important hotspots situated in India.

22. Sectional view of male gametophyte



Functions:
(1) Exine: A tough outer covering of pollen grains that can withstand harsh circumstances such as high temperatures, strong acids, and alkalines. It shelters the pollen and protects it during pollination.
(2) Intine: A fragile inner layer of cellulose and pectin that forms a thin, continuous covering. The intine promotes the formation of a pollen tube necessary for fertilisation.
(3) Vegetative cell: A vegetative cell is a more giant pollen grain component that contains enough food reserves for pollen germination and tube production during fertilisation.
(4) Generative cell: The pollen grain component that divides mitotically to produce two male gametes required for fertilisation.

23. **(A)** The father has blood group A(I^AI^A or I^Ai) and the mother has AB(I^AI^B). Since the child has blood group B(I^BI^B or I^Bi), the father must be heterozygous, carrying the recessive i allele. Therefore, the father's genotype is I^Ai.

Cross (Punnett Square): Father (I^At) × Mother (I^AI^B) „

	I^A (Mother)	I^B (Mother)
I^A (Father)	I^AI^A (Type A)	I^AI^B (Type AB)
i (Father)	I^Ai (Type A)	I^Bi (Type B)

Possible Blood Groups and Genotypes of Children:
• Type A: I^AI^A or I^Ai
• Type AB: I^AI^B
• Type B: I^Bi

(B) The ABO blood grouping is based on the presence or absence of specific antigens (isoagglutinogens) on the surface of red blood cells (RBCs), which are determined by three alleles (I^A, I^B, and i) of a single gene. I^A and I^B are codominant and produce A and B antigens respectively, while the i allele is recessive and produces no antigen.

24. **(A)** Because of its insufficient development, the skull of a young chimpanzee (B) resembles the skull of an adult human (A) more than the skull of an adult chimpanzee (C). Because both species share some anatomical traits in their early stages of development, several features observed in the skulls of infant chimpanzees and adult humans are similar. This likeness, which reflects the evolutionary ties between humans and chimpanzees, is ascribed to the young chimpanzee's cranium retaining certain rudimentary features.

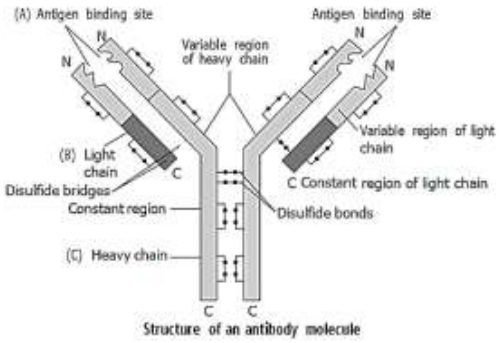
(B) (i) The ape-like mammal that lived 1.5 million years ago was probably Australopithecus, more specifically Australopithecus afarensis, the species from which the famous fossil 'Lucy' comes.
(ii) The more human-like primate that existed 1.5 million years ago could have been Homo erectus, an early human species notable for its upright posture and advanced tool-making abilities.

25. **(A) (i)** Cannabinoids

(ii) Cannabinoids can be ingested in a variety of ways, such as smoking, vaporising, consuming edibles, administering them sublingually, or applying them topically.

(iii) The brain is the human body organ most impacted by cannabis drug usage, owing to cannabinoids' interaction with cannabinoid receptors in the central nervous system, which causes changes in cognitive function, mood, memory, and perception.

(B)



26. **(A)** Clusters of suspended particles known as floes are created during the sewage treatment process when coagulants are introduced to wastewater. These coagulants enable colloidal particles to clump together by neutralising their negative charge. Through a process known as flocculation, floes aid in the removal of organic debris, suspended particles, and other pollutants from wastewater. Larger floes are easier to settle during sedimentation, which helps separate the solids from the liquid phase.

(B) Anaerobic sludge digestion is a biological process used in sewage treatment to degrade organic particles in sludge, creating biogas and stabilising the sludge for future disposal. In the anaerobic digester, bacteria that develop anaerobically consume the bacteria and fungi in the sludge. During this digestion, bacteria emit a combination of gases, including methane, hydrogen sulphide, and carbon dioxide. These gases combine to generate biogas, which can then be used as an energy source.

27. **(A)** A: Denaturation

D: Extension

(B). B represents primer

(C) C is Taq polymerase. Taq polymerase was called after the thermophilic eubacterial bacterium Thermus aquaticus. It is a thermostable DNA polymerase.

(D) **(i)** First, PCR is used to detect pathogens in clinical samples, allowing for the rapid and sensitive identification of viruses, bacteria, fungi, and parasites. This facilitates the rapid identification of infectious disorders such as COVID-19, HIV, and tuberculosis.

(ii) Second, PCR is used in genetic testing to help detect genetic variants associated with hereditary problems or vulnerability to diseases such as cancer. This enables early intervention and tailored treatment options.

(iii) Third, PCR is used in forensic analysis by amplifying trace amounts of DNA from crime scenes to establish identities or familial relationships critical for legal investigations.

28. **(A)** Transgenic animals play an important part in the generation of biological products by acting as bioreactors. When genetically edited to express specific proteins or enzymes, they can produce useful medications like insulin or growth hormones in their milk, blood, or tissues. This approach provides a cost-effective and scalable way to produce complex proteins for medicinal applications.

(B) Many transgenic animals are meant to help us understand how genes influence disease development. These are specifically designed to act as models for human diseases, allowing researchers to investigate new treatments.

(C) Transgenic animals are used in chemical safety testing to determine the toxicity of chemicals. This is referred to as toxicity and safety testing. Transgenic animals are created with genes that make them more susceptible to hazardous substances than non-transgenic animals. They are then exposed to harmful compounds, and the effects are investigated. Toxicity testing in such animals will allow us to gather results more quickly.

29. **(A)** A: Exponential growth

B: Logistic growth

(B) The dotted line symbolises carrying capacity. The concept of carrying capacity refers to an ecosystem's ability to sustainably support a given population level. Understanding it contributes to the maintenance of ecological balance, the prevention of resource depletion, and the appropriate management of natural settings.

OR

(B) The availability of resources is what distinguishes the logistic (B) growth curve from the exponential (A) growth curve. When resources are plentiful and unfettered, a population can expand steadily and at an accelerating rate, a phenomenon known as exponential expansion. The population size doubles over predetermined intervals in a J-shaped curve.

On the other hand, when a population faces resource constraints, logistic expansion takes place. The population grows exponentially at first, but as resources become limited, growth slows and eventually reaches the

environment's carrying capacity. An S-shaped curve is the result of this. As a result, logistic growth depicts the more realistic situation where population dynamics are influenced by resource restrictions, whereas exponential growth reflects ideal conditions with limitless resources.

(C) (i) In conditions with limitless resources, populations grow exponentially or geometrically. However, no population can maintain exponential expansion indefinitely; resource constraints inevitably restrict growth. Logistic growth, represented by a sigmoid curve, is a more realistic model that reflects this inherent restriction.

(ii) The logistic growth graph is more useful for the number of people living in our country right now. People's numbers have grown at an exponential rate in the past, but now resources like land, water, and energy are becoming more and more limited. As a result, population growth is more likely to follow a logistic trend because of these restrictions. This makes the growth trajectory more stable.

30. (A) Messenger RNA (mRNA) is the RNA product generated from the DNA that later transforms into a 400 amino acid polypeptide. RNA polymerase is the enzyme in charge of transcription of mRNA from DNA.

(B) Translation is the process by which an mRNA molecule can translate a polypeptide containing 400 amino acids. Translation takes place in the cytoplasm of eukaryotic cells. During translation, ribosomes read the mRNA molecule and assemble amino acids into a polypeptide chain based on the codons (three-nucleotide sequences) on it. Transfer RNA (tRNA) molecules transport the amino acids to the ribosome, where they are incorporated into the developing polypeptide chain.

(C) In prokaryotes, such as bacteria, DNA transcription is normally performed by a single kind of RNA polymerase. In contrast, eukaryotes contain many RNA polymers. In humans, for example, there are three varieties of RNA polymerases: RNA polymerase I, II, and III, each of which transcribes a different form of RNA molecule.

OR

(C) In prokaryotic cells, transcription occurs in the cytoplasm since there is no distinct nucleus. The DNA is present in the cytoplasm and RNA polymerase binds directly to the DNA to initiate transcription. In contrast, in eukaryotic cells, transcription primarily occurs within the nucleus.

31. (i) Spermatogenesis refers to the process indicated in the figure that results in the formation of spermatozoa. Spermatogenesis is the process by which spermatogonia in the testes' seminiferous tubules undergo mitosis followed by meiosis, resulting in haploid sperm cells or spermatozoa. These spermatozoa finally develop and are discharged into the seminiferous tubules to go through the male reproductive system.

(ii) In the diagram, the cell with a cluster of spermatozoa is most likely a Sertoli cell. Sertoli cells are supporting cells found in the seminiferous tubules of the testes. They give physical and nutritional support for the development of sperm cells during spermatogenesis. Sertoli cells also help regulate spermatogenesis by producing a variety of growth factors and hormones.

OR

(i) A. Chasmogamous
B. Cleistogamous

(ii) Comparing the two varieties of flowers with respect to:

(1) Characteristic Features: Chasmogamous flowers (type A) are often large and beautiful, with open petals that provide pollinators easy access to the reproductive organs. Cleistogamous flowers (type B) are often tiny, inconspicuous, and closed, with petals closely concealing the reproductive organs.

(2) Pollination modes: chasmogamous flowers (type A) rely on crosspollination, which is helped by pollinators such as insects, birds, and wind. These blooms attract pollinators by producing an abundance of nectar and pollen. Cleistogamous flowers (type B) pollinate themselves or reproduce autonomously. Because they remain closed, pollinators are less likely to visit them. Instead, they self-pollinate inside the closed bloom, ensuring reproductive success even in the absence of pollinators.

(iii) Two outbreeding devices in flowering plants:

(1) Dichogamy: The temporary separation of male and female reproductive organs within a flower or between flowers of the same plant.

(2) Herkogamy: structural adaptations that physically prohibit self-pollination, such as the spatial separation of stigma and anthers or specialised floral structures that direct pollinators to reproductive organs. Plants create outbreeding devices to increase genetic variety and reproductive success. Plants promote crosspollination or restrict self-pollination, increasing the chances of successful fertilisation and producing genetically diverse offspring, which helps species survival and adaptation.

32. (A) (i) Polarity is from 5′ to 3′. The UAA stop codon prevents the addition of any additional amino acids.

(ii) The initial codon for translation is AUG. The transfer RNA (tRNA) molecule's complementary anticodon is UAC. AUG codes for the amino acid methionine (Met).

(iii) Charging an adaptor molecule, which is a tRNA molecule, entails attaching the relevant amino acid to its corresponding tRNA molecule. This process is facilitated by an enzyme known as aminoacyl-tRNA synthetase. The charging of tRNA molecules is required for correct and efficient protein synthesis during translation. Without charge, tRNA molecules are unable to transfer the necessary amino acids to the ribosome, resulting in mistakes in polypeptide chain production. Charging ensures that each tRNA molecule is accurately paired to its corresponding amino acid, ensuring protein synthesis accuracy.

OR

(B) (i) Sickle-cell anaemia is named after the unusual sickle or crescent shape of red blood cells in affected patients. This aberrant form results from the presence of faulty haemoglobin molecules within red blood cells.

(ii) A single pair of alleles, Hb^A and Hb^S, govern the condition. Only homozygous for Hb^S (Hb^SHb^S) exhibit the sick phenotype out of the three potential genotypes. Heterozygous people (Hb^AHb^S) seem unaffected, but they are carriers of the disease since there is a 50% chance that the mutant gene will be passed on to their offspring, resulting in sickle cell trait. At position six of the beta-globin chain, valine is substituted for glutamic acid, resulting in the deficiency. Due to this mutation, red blood cells take on the distinctive sickle shape, which causes the hemoglobin molecule to polymerise in low-oxygen environments. While people who inherit one copy of the mutant allele and one normal allele (heterozygous carriers) may show some symptoms of the disorder but are generally less affected, those who inherit two copies of the mutant allele (homozygous for the sickle-cell gene) usually exhibit the severe form of the disease.

(iii) Sickle-cell anemia is an autosomal recessive genetic illness, which means that individuals must inherit two copies of the mutant allele (one from each parent) in order to develop the disorder. To have a kid with sickle-cell anemia, both parents must be carriers of the sickle-cell trait (heterozygous). Let's refer to the normal allele as H and the sickle-cell allele as S . Normal parents with the sickle-cell trait (heterozygous: HbA/S) have the following genetic makeup:

Father: Hb^AHb^S Mother: Hb^AHb^S

When these parents produce offspring, there are four possible combinations of alleles in their offspring:

(1) Hb^AHb^A (normal)

(2) Hb^AHb^S (carrier, asymptomatic)

(3) Hb^SHb^A (carrier, asymptomatic)

(4) Hb^SHb^S (affected with sickle-cell anemia)

In this case, there is a 25% chance, or 1 in 4 , that the child will get sickle-cell anemia because they will receive two copies of the sicklecell allele (Hb^SHb^S).

33. (A) Concise life cycle of HIV leading to AIDS:

(1) After entering the body, the virus enters macrophages, where the virus's RNA genome replicates to create viral DNA transcriptase with the help of the reverse enzyme.

(2) This viral DNA is incorporated into the host cell's DNA, causing the infected cells to create virus particles. The macrophages continue to create viruses, acting like an HIV factory.

(3) Simultaneously, HIV penetrates helper T cells (TH), multiplies, and produces offspring viruses. The offspring viruses that emerge in the blood assault other helper T lymphocytes. This is done multiple times, resulting in a gradual decline in the number of helper T lymphocytes in the infected person's body.

(4) During this time, the person experiences fevers, diarrhoea, and weight loss. As the number of helper *T* cells decreases, the person becomes susceptible to diseases that could have been avoided, such as those caused by bacteria, particularly Mycobacterium, viruses, fungi, and even parasites such as Toxoplasma. The patient's immune system deteriorates to the point that he or she is unable to protect themselves from these illnesses.

OR

(B) (i) Malaria can cause fevers, chills, headaches, tiredness, pain in the muscles and joints, nausea, vomiting, and, in the worst cases, anemia, breathing problems, and jaundice. These symptoms occur due to the lifecycle of Plasmodium parasites within the human body.

(1) These signs happen because of how Plasmodium parasites live and reproduce in humans.

(2) When a sick female Anopheles mosquito bites a person, it injects sporozoites, which infect hepatocytes in the liver.

(3) After copying themselves, they come out as merozoites, which infect red blood cells and start new copies of themselves.
(4) When red blood cells break, merozoites are released, which causes fever and chills. Anemia, tiredness, and weakness are all caused by the death of red blood cells.
(5) In addition, the release of harmful byproducts causes headaches, muscle pain, and feeling sick.
(6) Malaria can cause serious problems, like breathing problems and fever, because it damages many organs and makes the immune system fight the infection.
(ii) In the sexual mode of reproduction in the malaria parasite's life cycle, several steps occur:
(1) Gametocyte Development: Infected red blood cells give rise to male and female gametocytes.
(2) Mosquito Ingestion: When a mosquito feeds on a person, it eats both the blood and the gametocytes.
(3) Fusion and Zygote Formation: Male and female gametocytes join together to make zygotes inside the gut of a mosquito.
(4) Sporozoite Formation: Zygotes turn into sporozoites, which are made by dividing many times.
(5) Migration to Salivary Glands: Sporozoites move to the mosquito's salivary glands so they are ready to infect another person when they bite again. This completes the sexual cycle and starts a new infection.

34. (c) The protective seed coats develop from integuments.

35. (c) Total nucleotides $= 2000$
$A = 140 \Rightarrow T = 140$
So, $A + T = 280$
Remaining nucleotides $= 2000 - 280 = 1720$
These are G and C, which form triple hydrogen bonds.

36. (b) In pre-industrial England, white moths were better camouflaged, so dark-winged moths were fewer.
• less in number

37. (d) Formation of many embryos without fertilisation is called polyembryony, common in Citrus.

38. (c) Pink Snapdragon × White Snapdragon
Genotype: Rr × rr
Offspring: 50% Pink, 50% White

39. (a) Klinefelter's syndrome $(47, XXY)$ is characterized by a tall stature, feminized characters (such as gynaecomastia, or breast development in males), and sterility.

40. (b) In 1953, S.L. Miller created a simulated primitive atmosphere in a closed flask using methane (CH_4), hydrogen (H_2), ammonia (NH_3), and water vapour at $800°C$ to support the theory of chemical evolution.

41. (c) After growing $E.$ coli in ^{14}N (light) and then for six generations in ^{15}N (heavy), the DNA separates into hybrid $(^{14}N/^{15}N)$ and heavy $(^{15}N/^{15}N)$ bands. The ratio of hybrid to heavy DNA after six generations is 1:31.

42. (c) The symptoms of sustained high fever $(39°C$ to $40°C)$, stomach pain, constipation, headache, loss of appetite, and weakness are classic indicators of typhoid fever, caused by Salmonella typhi.

43. (c) Stanley Cohen and Herbert Boyer used the native plasmid of Escherichia coli for constructing the first recombinant DNA.

44. (b) In PCR, primers must anneal in opposite directions at the $3'$ ends of the strands so that DNA polymerase can extend them in $5' \rightarrow 3'$ direction.

45. (c) When resources are unlimited, population grows exponentially forming a J-shaped curve.

46. (a) • Primary transcript has both exons and introns.
• Introns are non-coding, so they are removed by splicing.
So, Both A and R are true and R is the correct explanation of A.

47. (b) • Alcohol causes liver damage leading to cirrhosis.
• Mental and financial distress is only an effect of addiction, not the reason for cirrhosis.
So, Both A and R are true but R is not the correct explanation of A.

48. (d) Correct sequence: zygote → proembryo → heart-shaped embryo.
Assertion is false but Reason is true.

49. (c) • Stirrer ensures proper oxygen mixing.
• Stirred-tank bioreactors usually have curved bases, not flat bases.
Assertion is true but Reason is false.

50. Oral Contraceptives and 'Saheli'

• Two Components: Oral contraceptives typically contain a combination of progestogen and estrogen, or sometimes progestogen alone.
• 'Saheli' Preference: Saheli is preferred because it is a non-steroidal and nonhormonal pill (contains Centchroman) with very few side effects. It is also a "once-a-week" pill rather than daily, which improves compliance. (c) World Health Organization (WHO) 14

51. Vaccine and Mechanism

• What is a Vaccine: A vaccine is a biological preparation containing weakened, dead, or components of microorganisms (pathogens).
• Basis of Action: It acts by stimulating the immune system to produce antibodies and memory cells against a specific pathogen without causing the disease. If the body is later exposed to the real pathogen, these memory cells enable a rapid and stronger immune response.

52. mRNA Analysis

• mRNA sequence: 5′-UCA UUA CCA CGA UUC UUU AAA AGA -3'
• Codons: 1. UCA, 2. UUA, 3. CCA, 4. CGA, 5. UUC, 6. UUU, 7. AAA, 8. AGA. (8 codons).
(A) Substitution at 5th codon:
If the 5^{th} codon ('UUC') has 'U' substituted by 'C', it becomes 'CUC'. However, the substitution does not create a stop codon. Thus, the chain length remains the same.
• Result: 8 amino acids will be formed (assuming the sequence ends with a stop codon outside the given snippet or at the end).
(B) Change in 4th codon:
If the 4th codon 'CGA' is changed to 'UGA' (U instead of C), 'UGA' acts as a stop codon.
World Health Organization (WHO)
• Result: 3 amino acids will be formed.
• Justification: The four th codon changes from a coding codon to a stop codon (UGA), halting translation prematurely after the first three codons (UCA, UUA, CCA).

53. **(A)** Separation in Set-up A vs. Set-up B

You would see the DNA fragments separated in Set-up A.
• Reasoning: DNA fragments are negatively charged molecules. In an electric field, they migrate toward the positive electrode (anode).
• Justification: In Set-up A, the anode is at the bottom, so DNA will move through the gel and separate by size. In Set-up B, the cathode (negative) is at the bottom, meaning the DNA will remain at the top or move out of the well in the wrong direction, resulting in no separation.
(B) Band Sizes in Set-up C
In Set-up C, the bands of longer fragments of DNA are located at I.
• Justification: The gel acts as a sieve. Smaller fragments move faster and travel further toward the anode (Position II), while longer (larger) fragments move more slowly and remain closer to the wells (Position 1).

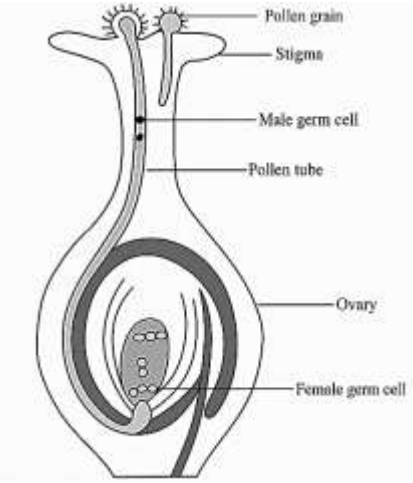
54. **(A)** Features of Humus

Humus is a dark-colored, amorphous substance formed during decomposition. Its key features include:
• Resistance to Microbial Action: It decomposes at an extremely slow rate.
• Colloidal Nature: It serves as a reservoir of nutrients.
• Soil Texture: It improves soil structure and its water-holding capacity.

OR

(B) Species-Area Relationship
(i) Graphical Representation: On a log-log scale, the relationship is a straight line.
(ii) Equation: The relationship is expressed by the following linear equation:
$\log S = \log C + Z \log A$
• S: Species richness
• A: Area
• Z : Slope of the line (regression coefficient)
• C: Y-intercept

55.



Labelled Diagram Components:
(A) Style/Tissue: The slender stalk through which the pollen tube grows downwards.
(B) Synergid/Embryo Sac: The cells within the ovule where the pollen tube releases male gametes.
Components of L.S. of Pistil:
• Stigma (landing platform)
• Pollen Grain/Tube (growing)
• A: Style (pathway)
• Ovary/Ovule
• B: Synergid (release site)

56. IUI and IUT Methods of ART
(i) IUI - Intra Uterine Insemination
In this technique, semen collected either from the husband or a healthy donor is artificially introduced directly into the uterus of the female to increase the chances of fertilisation.
(ii) IUT - Intra Uterine Transfer
In this method, embryos with more than 8 blastomeres formed outside the body are transferred into th uterus for further development and implantation.

57. Genotypes of Parents
(A) Phenotypic ratio:
6/16 violet axial : 2/16 violet terminal : 6/16 white axial : 2/16 white terminal
This corresponds to:
• Flower colour → $1:1 (Vv \times vv)$
• Flower position $-3:1 (Aa \times Aa)$
So parental genotypes are:
$VvAa \times vvAa$
(B) Phenotypic ratio:
$1:1:1:1$
This is a test cross:
VvAa × vvaa
(C) Phenotypic ratio:
3/4 violet axial : 1/4 white axial
Colour shows 3: 1 ratio $-Vv \times Vv$
All axial → one parent must be homozygous dominant for position.
$VvAA \times VvAA$
(or any combination giving all axial, e.g. $VvAA \times VvAa$)

58. **(A)** Frequency of recessive trait (aa) $= 9\%$
$q^2 = \frac{9}{100} = 0.09$
$q = \sqrt{0.09} = 0.3$
$p = 1 - q = 1 - 0.3 = 0.7$
Frequency of homozygous dominant snakes:
$p^2 = (0.7)^2 = 0.49 = 49\%$

Frequency of heterozygous dominant snakes:
$2pq = 2(0.7)(0.3) = 0.42 = 42\%$
Answer:
• Homozygous dominant $= 49\%$
• Heterozygous dominant $= 42\%$
(B) The mechanism of evolution operating here is Natural Selection.
Birds preyed more on easily visible snakes, causing change in population over time.

59. **(A) (i)** Two reasons for using cow-dung in a biogas plant instead of domestic sewage are:
(1) Cow dung contains large numbers of methanogenic bacteria.
(2) It produces more efficient and higher quantity of biogas.
(ii) The unslurred slurry is used as manure/fertiliser in fields.

OR

(B)

Disease/Condition	Bioactive molecule	Microbial source
(i) Myocardial infarction	Streptokinase	Streptococcus
(ii) High blood cholesterol	Statins	Monascus purpureus
(iii) Organ transplantation	Cyclosporin A	Trichoderma polysporum

60. **(A)** Scientific Name of the Bacteria
The bacteria widely used in biotechnology to create GM cotton resistant to bollworms is Bacillus thuringiensis (commonly known as Bt).
(B) Mechanism of Resistance in GM (Bt) Cotton
GM cotton (Bt cotton) resists insect attacks through the following mechanism: e
• Gene Incorporation: Specific genes called cry genes (e.g., cry1Ac and cry2Ab) are isolated from B. thuringiensis and inserted into the cotton plant's genome.
• Production of Toxin: The genetically modified plant produces inactive protoxin crystals in its tissues.
• Activation in Insect Gut: When a bollworm feeds on the cotton plant, it ingests these crystals. The alkaline pH of the insect's gut activates the protoxin into a toxin.
• Death of the Insect: The activated toxin binds to the surface of the midgut epithelial cells, creating pores, causing cell swelling, lysis, and ultimately, the death of the insect.

61. Fig Tree and Wasp Mutualism
The relationship between the fig tree and the wasp is a spectacular example of obligate mutualism (a one-to-one relationship where both species are dependent on each other for survival).
• Wasp Benefits (Shelter and Food): The female wasp uses the enclosed inflorescence (syconium) of the fig as a safe site for laying her eggs (oviposition). The developing seeds inside the fig provide nourishment and a secure home for the wasp larvae.
• Fig Tree Benefits (Pollination): While searching for a spot to lay eggs, the female wasp pollinates the fig flowers. The wasp carries pollen from its birth fig to another, ensuring the fertilization of the fig flowers.
• Specificity: A given fig species can be pollinated only by its specific partner wasp species and no other species, making it a highly specialized, mutualistic partnership.

62. **(A)** Alu I Digestion
The enzyme Alu I recognizes the sequence $5'AGCT3'$ and cuts between G and C ($5'AG \mid CT3'$).
Looking at the provided DNA strand:
5′ C-C-G-T-A-G-C-T-A-T-C-A-G-C-T-G-G 3′
3′ G-G-C-A-T-C-G-A-T-A-G-T-C-G-A-C-C 5′
There are two recognition sites for Alu 1 in this sequence. Therefore, three DNA fragments will be formed.
The fragments are:
(1) 5′ C-C-G-T-A-G 3′ and 3′ G-G-C-A-T-C 5′
(2) 5′ C-T-A-T-C-A-G 3′ and 3′ G-A-T-A-G-T-C 5′

(3) 5′ C-T-G-G 3′ and 3′ G-A-C-C 5′

(B) Choice of Enzyme

BamH I would be preferred for making a recombinant DNA molecule.

• Reason: BamH I produces "sticky ends" (staggered cuts), which facilitate easier ligation (joining) with a vector DNA cut by the same enzyme through complementary base pairing. Alu I produces "blunt ends", which are less efficient for recombinant DNA technology.

(C) Mechanism and Terminology

• Action: After binding, the restriction enzyme cuts the sugar-phosphate backbone of both strands of the double helix.

• Specific Term: The specific sequences recognized are called Palindromic Nucleotide Sequences.

OR

(C) The specific sequence recognized by EcoRI is:

5′ GAATTC 3′

3′ CTTAAG 5′

63. (A) Inference from Rwanda's Broad Base

The very broad base of Rwanda's age pyramid indicates a rapidly growing population with a very high birth rate. It shows that a large percentage of the population consists of young individuals.

• Supporting Data: In the $0-4$ age group, males account for 8.2% and females account for 8.2% of the total population. This combined total of 16.4% is significantly higher than any other age bracket in the pyramid, showing a heavy concentration of the population at the youngest level.

(B) Sweden's Age Distribution

Sweden's pyramid, which has a similar width at the base and middle sections before narrowing, indicates a stable population. This means the birth and death rates are nearly equal, leading to zero or very low population growth. It also suggests higher life expectancy compared to Rwanda.

(C) Type of Age Pyramids

• For Sweden: This is a Stable (or Bell-shaped) age pyramid.

OR

(C) For Rwanda: This is an Expanding (or Triangular) age pyramid.

64. (A) (i) Devices Encouraging Cross-Pollination (Outbreeding Devices)

Flowering plants have developed several mechanisms, known as outbreeding devices, to prevent self-pollination and promote cross-pollination to increase genetic diversity.

(1) Dichogamy (Unsynchronized Receptivity): The stamens (pollen release) and stigma (receptivity) mature at different times in a bisexual flower. In protandry (e.g., Sunflower), pollen is released before the stigma is receptive. In protogyny (e.g., Magnolia), the stigma matures before the pollen is released.

(2) Herkogamy (Structural Separation): The stamens and stigma are arranged in a way that physical contact between them is difficult within the same flower, reducing the chance of self-pollination.

(3) Self-Incompatibility: This is a genetic mechanism where the stigma/pistil recognizes and rejects its own pollen, inhibiting pollen germination or pollen tube growth. This ensures only pollen from different plants can fertilize the ovule (e.g., Tobacco).

(4) Unisexual Flowers/Dioecy: The plant produces only male or female flowers, not both, making self-pollination impossible (e.g., Papaya, Papaya).

(ii) Why Plants Discourage Self-Pollination

• Reason: Continuous self-pollination leads to inbreeding depression, which reduces the genetic vigor, adaptability, and survival of the offspring.

OR

(B) Events During the Human Menstrual Cycle

The menstrual cycle is characterized by hormonal changes that control ovarian and uterine events.

(i) Follicular/Proliferative Phase (approx. days 5-14)

• Hormonal Control: Pituitary FSH (Follicle-Stimulating Hormone) stimulates the growth of primary follicles into mature Graafian follicles. Growing follicles secrete estrogen.

• Ovarian Event: Follicles mature; the dominant follicle prepares for release.

• Uterine Event: Rising estrogen causes the endometrium to regenerate, thicken, and become vascularized (proliferative phase).

• Ovulation: High estrogen triggers a surge of LH (Luteinizing Hormone) from the pituitary, causing the release of the ovum around day 14 .

(ii) Luteal/Secretory Phase (approx. days 15-28)

• Hormonal Control: LH stimulates the ruptured Graafian follicle to turn into the corpus luteum, which secretes high levels of progesterone.
• Ovarian Event: The corpus luteum is active, producing progesterone and some estrogen.
• Uterine Event: Progesterone maintains the endometrium for implantation (thickening and secreting nutrients), making it ready for a fertilized egg.
(iii) Menstrual Phase (Days 1-5)
• Hormonal Control: In the absence of fertilization, the corpus luteum degenerates, leading to a sharp decline in progesterone and estrogen.
• Uterine Event: The reduction in progesterone causes the breakdown and shedding of the endometrial lining (endometrial tissue, blood, and unfertilized ovum), resulting in menstruation.

65. **(A)** Codominance and ABO Blood Group Inheritance

Codominance is a phenomenon where in a heterozygous condition, both alleles for a trait are fully expressed, resulting in a phenotype that is not a blend but a combination of both characteristics.
Explanation using ABO Blood Group:
• Multiple Alleles: The human ABO blood group is controlled by gene I, which has three alleles: I^A, I^B, and i.
• Heterozygous Expression: Alleles I^A and I^B are dominant over i, but when I^A and I^B are present together (I^AI^B genotype), neither dominates the other.
• Codominant Expression: Both alleles are expressed equally, leading to the production of both A and B antigens on the surface of red blood cells.
• Result: A person with the I^AII^B genotype has AB blood type, demonstrating that both alleles have influenced the phenotype.

OR

(B) Lac Operon Regulation &
(i) Mechanism of 'Switching On'
The structural genes ($\text{lac}Z, \text{lac}Y, \text{lac}A$) are switched on when lactose acts as an inducer. e
(1) Lactose Presence: Lactose is transported into the cell by small amounts of permease.
(2) Inducer Binding: Lactose (converted into allolactose) binds to the repressor protein, altering its conformation.
(3) Operator Clearance: The inactive repressor-inducer complex fails to bind to the operator region.
(4) Transcription: The operator is now free, allowing RNA polymerase to bind to the promoter and transcribe the structural genes into polycistronic mRNA.
(ii) Negative Regulation Justification
The lac operon is termed negatively regulated because the default state is controlled by a repressor protein that inhibits transcription.
• Reason: In the absence of an inducer (lactose), the regulator gene product (repressor) binds to the operator region. This binding physically blocks RNA polymerase from initiating transcription, thus keeping the operon switched "off".

66. **(A)** Life Cycle of Plasmodium in Humans and Mosquito
(i) Life Cycle Phases
(1) Infection: A female Anopheles mosquito bites a human and injects sporozoites (infectious stage) via its saliva.
(2) Liver Stage: The sporozoites reach the liver, infect hepatocytes, and multiply asexually, maturing into schizonts.
(3) Blood Stage: Liver cells rupture, releasing merozoites into the blood, which infect RBCs.
(4) Asexual Multiplication: Merozoites reproduce in RBCs, leading to rupture (causing fever) and the release of more merozoites to infect new RBCs.
(5) Gametocyte Formation: Some parasites differentiate into sexual stages, called gametocytes (male and female) within the RBCs.
(6) Transmission: When another female Anopheles mosquito bites the infected person, it ingests these gametocytes.
(ii) Events in Female Anopheles Mosquito
• Fertilization: Gametocytes fertilize within the mosquito's gut to form a zygote.
• Sporogony: The zygote develops into an ookinete, then an oocyst, which ruptures to release sporozoites that migrate to the mosquito's salivary glands.

OR

(B) Cancer Diagnostics and Tumors
(i) Differences Between Tumors

• Benign Tumor: Remains confined to its original location, does not spread to other parts of the body (no metastasis), and generally causes little damage.
• Malignant Tumor: Composed of proliferating cells (neoplastic) that invade surrounding tissues, travel to distant sites via blood or lymph, and cause severe damage (metastasis).
(ii) Diagnostic Techniques for Cancer
• Biopsy: A piece of suspected tissue is cut into thin sections, stained, and examined under a microscope by a pathologist to check for cancer cells.
• Imaging Techniques: Radiography (X-rays), Computed Tomography (CT scan), or Magnetic Resonance Imaging (MRI) are used to detect cancers of internal organs.
• Molecular Biology/Immunological Techniques: Techniques to detect specific antigens or genetic mutations associated with cancers, including monoclonal antibodies for cancer detection.

67. (c) The angiosperm embryo sac is located within the:

68. (b) Correct matching is:
• Mendelian monohybrid → 3: 1
• Incomplete dominance → 1: 2: 1
• Mendelian dihybrid → 9:3:3:1
• Test cross (monohybrid) → 1: 1
1-(iii), 2-(i), 3-(iv), 4-(ii)

69. (c) In humans, the secondary oocyte completes meiotic division when:

70. (d) The statement which is not true is :
• Homologous structures are a result of convergent evolution
(Homologous organs arise due to divergent evolution.)

71. (c) Calculation: If $p(A) = 0.6$, then $q(a) = 0.4$. The frequency of the heterozygote genotype ' Aa ' is $2pq$, so $2 \times 0.6 \times 0.4 = 0.48$.

72. (c) The two strands of DNA run in opposite directions ($5' \rightarrow 3'$ and $3' \rightarrow 5'$) and the nitrogenous bases pair specifically (A with T, G with C).

73. (d) In a transcription unit, regulatory sequences like the promoter and terminator are defined by their position on the coding strand. The terminator is located downstream at the $3''$ end.

74. (a) The woman is a carrier (X^cX^c) because her father was colorblind. When she marries a normal man (X^CY), their offspring possibilities are: normal daughter, carrier daughter, normal son, and colorblind son (X^cY). Only 1 out of $4(25\%)$ of the total progeny will be colorblind.

75. (a) Dengue fever is primarily transmitted by the bite of an infected female Aedes aegypti mosquito.

76. (c) This pair is incorrectly matched. Monascus purpureus is used to produce statins (bloodcholesterol lowering agents). Citric acid is typically produced by the fungus Aspergillus niger.

77. (c) Plasmids are generally:
• Circular DNA molecules
• Self-replicating
• Extra-chromosomal
• Double-stranded, not single-stranded.

78. (a) In sea ecosystems, the pyramid of biomass is inverted because phytoplanktons have very low biomass at any moment, while the biomass of consumers like fishes can be higher.

79. (a) Assertion is true, Reason is true and Reason correctly explains Assertion. RNA is less stable because of the presence of $2' - OH$ group, making it easily degradable and more prone to mutations.

80. (c) Assertion is true, Reason is false. Virus-infected cells produce interferons, which protect nearby cells from viral infection. Interferons do not cause inflammation of infected cells.

81. (c) Assertion is true, Reason is false. Specific enzymes are used to break cell walls for DNA isolation. Fungal cell wall is degraded by chitinase, not cellulase.

82. (b)• Assertion (A): Loss of biodiversity can occur due to overexploitation of resources. → True
• Reason (R): Introduction of Clarias gariepinus in Indian rivers has led to a decline in native Indian fishes. → True
But the reason explains biodiversity loss due to alien species invasion, not due to overexploitation.
So, Assertion is true, Reason is true, but Reason is not the correct explanation of Assertion.

83. Two reasons they are effective contraceptives:

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

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

84. Two differences between Haemophilia and Sickle Cell Anemia are:

Haemophilia	Sickle Cell Anemia
It is a sex-linked recessive disorder.	It is an autosomal recessive disorder.
Mostly affects males.	Affects both males and females equally.

85.

Scientific name of the plant	Drug	Effect on human body/system
Papaver somniferum	A = Opioids	Depressant/slows down body function
Cannabis sativa	Cannabinoids	B = Affect cardiovascular system of the body
Enythroxylum coca	C = Cocaine	D = Stimulates central nervous system

86. Role in cloning vector pBR322 :

• ori (origin of replication): Site from where replication starts; helps the plasmid multiply inside the host cell.

• Restriction site: Specific site recognized by restriction enzymes where foreign DNA is inserted.

87. Rate of decomposition:

• Nature of detritus: Decomposition is faster in detritus rich in nitrogen and water-soluble substances, and slower in detritus rich in lignin and chitin.

• Temperature: Decomposition increases at higher temperature and slows down at low temperature.

88. **(A)** IVF is called in vitro fertilization because fertilization occurs outside the body under laboratory conditions ("in vitro" means in glass).

Importance:

It helps infertile couples to have children.

(B) Difference between GIFT and ZIFT

GIFT	ZIFT
Gametes are transferred into fallopian tube.	Zygote/early embryo is transferred into fallopian tube
Fertilization occurs inside the body.	Fertilization occurs outside the body.

89. **(A) (i)**

• Karyotype: 47, XXY
• Genetic disorder: Klinefelter syndrome
(ii) Any two symptoms:
• Sterile male
• Enlarged breasts (gynaecomastia)
(iii) Possible reason:
• Nondisjunction of X chromosomes during meiosis leading to formation of an XX egg.

OR

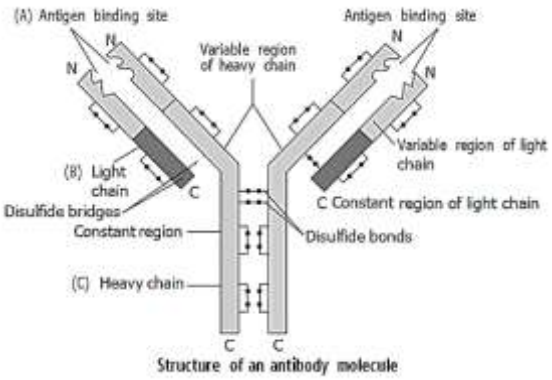
(B) Paternity can be determined using DNA fingerprinting because every individual has a unique DNA pattern inherited from parents. The child's DNA pattern is compared with that of the mother and suspected father. Matching DNA bands confirm paternity.

90. **(A)** Attachment of amino acid to tRNA is called charging of tRNA or aminoacylation of tRNA.
• The enzyme aminoacyl-tRNA synthetase catalyses the reaction.
• It is a two-step process requiring ATP.
• The correct amino acid gets linked to its specific tRNA at the 3′ end, forming aminoacyl-tRNA.
(B) Translation terminates when a stop codon (UAA, UAG or UGA) reaches the A-site of ribosome. No tRNA is available for stop codons, so release factors bind to the ribosome and release the completed polypeptide chain.
(C) UTR = Untranslated Regions
They are located at both ends of mRNA:
• 5' UTR before the start codon
• 3' UTR after the stop codon

91. **(A)** Difference between humoral and cell-mediated immune response

Humoral immune response	Cell-mediated immune response
Mediated by B-lymphocytes	Mediated by T-lymphocytes
Antibodies are produced	No antibodies are produced directly
Effective against extracellular pathogens	Effective against intracellular pathogens

(B)



Structure of an antibody molecule

92. The transformation in tobacco plant was achieved through RNA interference (RNAi).
• A nematode, Meloidogyne incognita, infects the roots of tobacco plants.
• Scientists introduced DNA into the tobacco plant using Agrobacterium tumefaciens.
• This DNA produced both sense and antisense RNA in the host cells.
• These complementary RNAs formed double-stranded RNA (dsRNA), which activated RNA interference.
• RNAi silenced the specific mRNA of the nematode, preventing synthesis of essential proteins.
• As a result, the nematode could not survive in the transgenic tobacco plant, and the roots remained healthy.

93. **(A)** Identification of groups in the pie chart:

• A → Amphibians
• B → Birds
• C → Mammals
• D → Reptiles
(Fishes represent the largest share of vertebrate diversity.)
(B) Two examples of recently extinct animals:
• Dodo
• Quagga

94. **(1)**Acting as "Conduits" for Energy Transfer
Predators serve as vital pipelines for transferring energy across different trophic levels in an ecosystem. Without them, the energy trapped in the biomass of primary consumers (herbivores) would not efficiently reach higher levels of the food web.
• Example: In a terrestrial ecosystem, a tiger (predator) eats a deer (herbivore/prey). By doing so, the energy the deer obtained from consuming plants is transferred further up the food chain to the carnivore level.
(2) Maintaining Prey Population Control
Predators keep the populations of herbivores and other prey species in check. In the absence of predators, prey populations would grow exponentially, leading to overgrazing, severe resource depletion, and the eventual collapse of the ecosystem.
• Example: The historic removal and subsequent reintroduction of wolves (predator) in Yellowstone National Park. When wolves were gone, the elk population exploded, overgrazing the local vegetation and destroying habitats. Once wolves were reintroduced, they controlled the elk population, allowing the flora and fauna to recover.
(3) Preserving Species Diversity and Reducing Competition
Predators often target the most dominant or competitive prey species. By keeping the population of these dominant species under control, predators prevent them from monopolizing resources, which allows weaker, competing species to survive. This heavily reduces interspecific competition and maintains high species diversity.
• Example: The predatory starfish Pisaster ochraceus in rocky intertidal communities.
When this starfish was experimentally removed from its habitat, the population of its primary prey, mussels, grew unchecked. The mussels crowded out almost all other invertebrates and algae, causing the species diversity in the area to drop significantly.

95. **(A)** FSH acts on the Sertoli cells present in seminiferous tubules of testes.
It stimulates Sertoli cells to nourish the developing sperms and helps in spermatogenesis.

OR

(A) LH acts on the Leydig cells (interstitial cells) of testes and stimulates them to secrete testosterone, which promotes spermatogenesis.
(B)
(i) Mitosis and differentiation:
• Cell: Spermatogonia
• Product: Primary spermatocytes
(ii) Meiosis I and Meiosis II:
• Primary spermatocytes undergo Meiosis I to form secondary spermatocytes.
• Secondary spermatocytes undergo Meiosis II to form spermatids.
(C) Accessory ducts through which sperms pass from seminiferous tubules to epididymis:
• Rete testis
• Vasa efferentia

96. **(A)** After entering the body. HIV attacks helper T-lymphocytes (CD4 cells).
Events occurring inside the cell:
(1) Viral RNA enters the host cell.
(2) Viral RNA forms viral DNA with the help of reverse transcriptase.
(3) Viral DNA gets incorporated into host DNA.
(4) Infected cells produce new virus particles.
(5) Newly formed viruses attack more helper T-cells, reducing immunity.
(B) Expanded form of ELISA:
• Enzyme Linked Immunosorbent Assay
Possible treatment:

• Antiretroviral therapy (ART) helps in controlling the virus and prolonging life, though complete cure is not available.

(C) Any two preventive measures suggested by WHO:

(1) Avoid sharing infected needles/syringes.

(2) Practice safe sexual contact/use condoms.

OR

(C) AIDS patients usually die from secondary infections because HIV weakens the immune system by destroying helper T-cells. Due to reduced immunity, the body cannot fight common infections like pneumonia, tuberculosis, etc., which ultimately may cause death.

97. (A) (i) Process of Double Fertilization:

Double fertilization is a hallmark characteristic of angiosperms.

• Pollen Germination: A compatible pollen grain lands on the stigma, absorbs moisture, and germinates to form a pollen tube.

• Pollen Tube Growth: The pollen tube grows through the style, carrying two male gametes, and enters the ovule (embryo sac) through the micropyle.

• Syngamy: One male gamete fuses with the egg cell to form a diploid (2n) zygote.

• Triple Fusion: The second male gamete fuses with the two polar nuclei to form a triploid (3n) Primary Endosperm Nucleus (PEN).

• Ploidy of End Products: The zygote is diploid (2n) and the primary endosperm cell/nucleus (PEN) is triploid (3n).

• Role of Synergids: The synergids contain the filiform apparatus at their micropylar tip. This apparatus guides the entry of the pollen tube into the synergid and facilitates the release of the male gametes into the embryo sac.

(ii) Precedence of Endosperm Development:

The development of the endosperm precedes that of the embryo because it provides a continuous source of essential nutrition and reserve food materials required to nourish the rapidly developing embryo.

OR

(B) (i) Site of Fertilization and Prevention of Polyspermy:

• Site of Fertilization: The fertilization of the ovum takes place in the ampulla (the wide part of the fallopian tube/oviduct).

• Process of Fertilization: A sperm comes in contact with the zona pellucida layer of the ovum and induces changes in the membrane that block the entry of other sperms (preventing polyspermy). The acrosome of the sperm releases enzymes to dissolve the zona pellucida and plasma membrane, allowing the sperm head to enter the ooplasm.

• Preventing Polyspermy: Upon sperm entry, the zona pellucida undergoes structural changes to prevent additional sperms from binding and entering.

(ii) Implantation:

• Embryonic Stage: The blastocyst (blastula stage) gets implanted in the uterus.

• Process of Implantation: The blastocyst moves down the fallopian tube and reaches the uterus. The trophoblast cells on the outer surface of the blastocyst attach to the highly vascularized uterine endometrium. The uterine cells divide rapidly and cover the blastocyst. Consequently, the blastocyst becomes embedded in the uterine wall, which marks the completion of implantation.

98. (A) (i) Inheritance of Flower Colour:

(1) **F_1** Phenotypic Expression: In garden peas**, F_1** plants show a dominant trait (all violet flowers). In snapdragons, F_1 plants show an intermediate trait (all pink flowers) due to incomplete dominance.

(2) **F_2** Phenotypic/Genotypic Expression:

• Peas: Phenotypic ratio is 3 (violet) : 1 (white). Genotypic ratio is 1 (homozygous violet) : 2(heterozygous violet) : 1 (homozygous white).

• Snapdragons: Phenotypic and genotypic ratios are identical: 1 (red) :2 (pink) :1 (white).

(3) Conclusion: Garden peas follow Mendel's law of dominance, where one allele completely masks the other. Snapdragon inheritance demonstrates incomplete dominance, where neither allele is completely dominant, resulting in a blended phenotype.

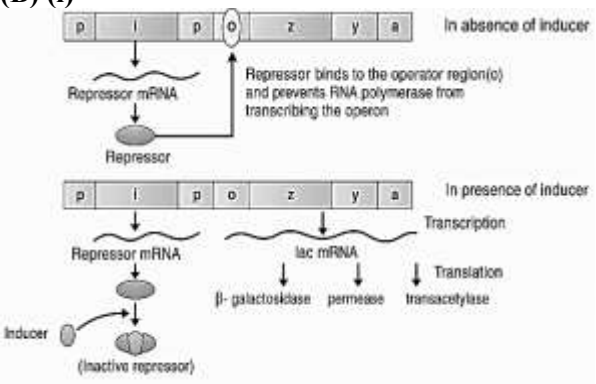
(ii) Characteristics of ABO Blood Group:

• It shows multiple allelism, where a single gene (I gene) is controlled by three alleles (I^A, I^B, i).

• It demonstrates co-dominance, as both alleles I^A and I^B express themselves simultaneously when present together (producing blood type AB).

OR

(B) (i)



(ii) The regulation of the lac operon is considered negative regulation because its default state is "off" due to a repressor protein. This repressor, synthesized by the regulatory gene, binds to the operator region. It acts as a physical block, preventing RNA polymerase from transcribing the structural genes.

99. (A) (i) A cell is made competent so that it can take up foreign (alien) DNA.

Making bacterial cells competent using calcium ions:

• Bacterial cells are treated with divalent calcium ions (Ca^{2+}).
• Calcium ions increase permeability of bacterial cell wall to DNA.
• The cells are then exposed to heat shock, which allows foreign DNA to enter the bacterial cell.

(ii)(1) Importance of gel electrophoresis:
It is used to separate and isolate DNA fragments.
(2) Principle:
DNA fragments are negatively charged and move towards the positive electrode through agarose gel. Smaller fragments move faster than larger fragments.
(3)
Ethidium bromide is used because it stains DNA and fluoresces under UV light, making DNA bands visible.

OR

(B) (i) Bt cotton was made resistant to bollworms by introducing cry genes from Bacillus thuringiensis into cotton plants.
These genes produce Bt toxin protein that protects the plant from insect attack.

(ii)• Bollworm larvae feed on Bt cotton plants.
• In the alkaline medium of insect gut, inactive Bt toxin becomes active.
• The activated toxin binds to epithelial cells of the insect midgut and forms pores.
• This causes cell swelling and lysis, leading to death of the bollworm.

100. **(c)** Explanation: Maize is a monoecious plant, meaning it bears both male (tassel) and female (ear) flowers on the same individual plant. Because both sexes live on the same plant, pollen can transfer between different flowers of the same plant (geitonogamy) or between different plants (xenogamy). Papaya, date palm, and spinach are dioecious (separate male and female plants), which completely rules out geitonogamy.

101. **(b)** Explanation: Human Chorionic Gonadotropin (hCG) is secreted by the human placenta shortly after implantation. It is critical for the maintenance of pregnancy because it signals the corpus luteum to continue producing progesterone, which prevents the uterine lining from shedding. While Human Placental Lactogen (hPL) and Relaxin are also placental hormones, hCG is specifically tasked with this primary maintenance role.

102. **(c)** Explanation: Periodic abstinence relies on avoiding sexual intercourse during the female's fertile window. In a standard 28-day human menstrual cycle, ovulation typically occurs around day 14 . Because a human egg is viable for about 24 hours and sperm can survive in the female reproductive tract for up to 3 to 5 days, days 10 to 17 present the absolute highest risk of fertilization.

103. **(b)** Explanation: A karyotype of $44 + XXY$ causes Klinefelter's syndrome. Individuals with this condition are genetically male due to the presence of the Y chromosome, but they develop overall masculine development with some secondary feminine features (such as gynecomastia) and are typically sterile. Therefore, labeling it as "overall feminine development" is scientifically incorrect.

104. **(c)** • Explanation: To find the minimum number of bases required per codon, we use the formula $B^n \geq A$, where B is the number of available bases, n is the codon length, and A is the number of amino acids to code for.

• Given $B = 12$ bases and $A = 96$ amino acids:
• If $n = 1: 12^1 = 12$ combinations (not enough to cover 96).
• If $n = 2: 12^2 = 144$ combinations (more than enough to cover 96).
• Therefore, a minimum of 2 bases per codon is required

105. **(c)**• Explanation: In a nucleotide chain, S represents the pentose sugar and B represents the nitrogenous base. The bond connecting a nitrogenous base to the $1'$ carbon of a pentose sugar is always an N -glycosidic linkage.
• Note: Phosphodiester bonds connect the sugar and phosphate group (P-S), while hydrogen bonds connect bases between two opposite strands (B---B).

106. **(b)** Explanation: Mast cells play a central role in allergic reactions. When an allergen enters the body, it binds to IgE antibodies on the surface of mast cells. This triggers them to degranulate and release inflammatory chemicals like histamine and serotonin, leading to classic allergy symptoms.

107. **(d)** Lactobacillus used in curd formation is a heterotrophic bacterium.

108. **(d)** Transgenic Mice are used to test the safety of the polio vaccine.

109. **(a)** Restriction endonuclease Hind II Restriction Endonuclease recognises a specific sequence of six base pairs.

110. **(d)** Golden Rice has been genetically modified for high Vitamin-A content.

111. **(c)** The rate of formation of new organic matter by consumers is called secondary productivity, while biomass available for herbivores and decomposers is net primary productivity.

112. **(c)** Assertion (A) is true. Legal adoption is one of the best methods for childless couples seeking parenthood. Reason (R) is false because emotional, religious, and social factors can act as deterrents in adoption in India.

113. **(a)**• Assertion (A) is true. Linked genes do not show the typical dihybrid F_2 ratio of 9:3:3:1.
• Reason (R) is true because linked genes do not assort independently.
• Reason correctly explains the Assertion.
So, Both A and R are true, and R is the correct explanation of A .

114. **(d)**• Assertion (A) is false because Agrobacterium tumefaciens mainly infects dicot plants, not monocots.
• Reason (R) is true. It transfers T-DNA into plant cells causing tumour formation.

115. **(c)**• Assertion (A) is true. The Indian Government established Genetic Engineering Approval Committee (GEAC) to evaluate the validity and safety of GM research.
• Reason (R) is false because genetically modified organisms can affect ecosystems when introduced.

116. Identification of A, B, C, and D
• 'A' (Pericarp): Fruit wall (developed from the wall of the ovary).
• 'B': Scutellum (the single, large shield-shaped cotyledon in the grass family).
• 'C' (Embryonal axis): Tigellum (the main central structural axis of the embryo containing the plumule and radicle).
• 'D': Perisperm (persistent, residual nucellus found in seeds like black pepper and beet).

117. Analysis of the Evolutionary Example
• Naturalist: Jean-Baptiste Lamarck
• Explanation:
• He proposed the theory of Inheritance of Acquired Characters (also known as the theory of Use and Disuse of Organs).
• Mechanism: He argued that an organ used extensively by an organism becomes more developed and larger over time, while disuse leads to deterioration.
• Application to Giraffes: Ancestors of modern giraffes had short necks and fed on ground vegetation. As forage on the ground became scarce, they had to continuously stretch their necks to reach leaves on taller trees.
• This continuous elongation was an acquired trait during their lifetime, which they passed on to their offspring. Over many generations, this cumulative stretching resulted in the modern long-necked giraffe.

118. Basic steps followed in Assisted Reproductive Technologies (ART)
ART programmes help childless couples to conceive through special medical techniques. The main steps are:
1.Collection of gametes
•Healthy sperm are collected from the male partner.
•Mature eggs (ova) are collected from the female partner.
2.Fertilisation outside the body
•The sperm and egg are combined in a laboratory under controlled conditions.

3.Formation of embryo
•Fertilisation produces a zygote which develops into an early embryo.
4.Embryo transfer
•The embryo is transferred into the uterus (or fallopian tube) of the woman for further development and pregnancy.
Why is it called a "test tube baby" programme?
It is called a test tube baby programme because fertilisation occurs outside the human body in laboratory glassware (such as test tubes or culture dishes) before the embryo is implanted into the uterus.

119. **(A)** Snake Bite and Immunity

(i) What the doctor injected and why?

The doctor injected Antivenom (specifically, pre-formed antibodies against the snake venom).
This is done because snake venom is highly toxic and fast-acting; the body's natural immune system would take too long to produce its own antibodies. Injecting pre-formed antibodies provides an immediate neutralized response to the toxin.

(ii) Name the kind of immunity provided by this injection.

This provides Passive Immunity (specifically Artificial Passive Immunity).

(OR)

(B) Organic Farming and Pests

Organic farmers do not recommend the complete eradication of insect pests because they believe in maintaining a balance within the ecosystem.
• Reason: Eradicating "pests" completely is often undesirable because many beneficial predatory and parasitic insects depend on these pests as a food source or host.
• Sustainability: Instead of using chemicals to wipe out species, organic farmers use Biocontrol methods. By keeping pest populations at manageable levels rather than eliminating them, the farmer ensures that the natural food web remains intact, allowing the ecosystem to regulate itself naturally.

120. Pyramid of Biomass

Based on the provided diagram (where level 'A' is larger than level 'B', but it is depicted as an inverted or spindle-like relationship in aquatic contexts):
• Standing Crop at Level 'A' (Primary Consumers): Zooplankton
• Standing Crop at Level 'B' (Producers): Phytoplankton
Type of Pyramid: This is an Inverted Pyramid of Biomass.
Ecosystem: This type of pyramid is found in an Aquatic Ecosystem (such as a sea or ocean).
Explanation: In these ecosystems, the biomass of the producers (phytoplankton) at any given time is much smaller than the biomass of the consumers (zooplankton/fish) because phytoplankton have a very high turnover rate-they reproduce and are consumed so quickly that their "standing crop" remains low despite supporting a larger mass of consumers.

121. Mode of Action and Schedule of Contraceptive Pills

Mode of Action:
• Inhibits Ovulation: They alter hormone levels to prevent the release of an egg from the ovary.
• Inhibits Implantation: They alter the quality of the uterine endometrium lining, making it unsuitable for a fertilized egg to attach.
• Alters Cervical Mucus: They thicken the mucus at the cervix, blocking or retarding the entry of sperm into the uterus.
Prescription Schedule:
• Taken daily for a period of 21 days.
• Must be started preferably within the first five days of the menstrual cycle.
• Following a 7 -day gap (during which menstruation occurs), the entire 21 -day cycle is repeated in the same pattern.

122. DNA Fingerprinting

(A) Type of DNA and Characteristics:
• Name: Satellite DNA (specifically VNTRs - Variable Number of Tandem Repeats / Minisatellites).
• Characteristics:
• High Polymorphism: They show a very high degree of sequence variation among individuals, which serves as a unique genetic signature.
• Non-coding Sequences: These repetitive sequences do not code for any specific structural or functional proteins.

(B) Applications:

• Forensic Science: Used as a definitive identification tool to solve crimes by matching suspect DNA with evidence collected from a crime scene (e.g., blood, hair, semen).
• Paternity Testing: Used to resolve familial or inheritance disputes by establishing biological relationships between parents and children.

123. S.L. Miller's Experiment

(A) Significance and Influencing Scientists:

• Significance: It provided the first empirical, experimental proof for the chemical evolution of life. It demonstrated that complex organic molecules (like amino acids) could be synthesized spontaneously from simpler inorganic compounds under primitive Earth conditions.
• Prompting Scientists: Oparin and Haldane, whose hypothesis on the "primordial soup" and abiotic synthesis inspired Miller's experimental simulation.

(B) Contribution of Meteorite Analysis:

• Analysis of fallen meteorites revealed the presence of similar organic compounds, including various amino acids.
• This proves that similar chemical synthesis processes occur elsewhere in outer space, directly backing the theory that organic building blocks can form naturally from inorganic precursors without pre-existing life.

124. Identification of A, B, C, D, E and F

Name of Human Disease	Causative Organism	Symptoms
Pneumonia	Streptococcus	A - Fever, chills, cough and headache
Typhoid	B - Salmonella typhi	High fever, weakness, headache, stomach pain
Common Cold	Rhino virus	C - Nasal congestion and discharge, sore throat, cough and headache
Ringworm	DMicrosporum/ Trichophyton /Epidermo phyton	Dry scaly lesions on body parts, redness, itching
Ascariasis	Ascaris	E - Internal bleeding, muscular pain, fever, anaemia and blockage of intestinal passage
F - Amoebiasis (Amoebic dysentery)	Entamoeba histolytica	Constipation, cramps, stools with mucous and blood clots

125. No, the colour blind son and daughter have not inherited the disease only from their father. Colour blindness is an X-linked recessive trait.

Let:

• X^C = normal vision allele

• X^c = colour blindness allele

Father is colour blind:

X^cY

Mother has normal vision but must be a carrier:

X^CX^c

Cross:

$X^cY \times X^CX^c$

Possible children:

• X^CX^c → normal carrier daughter

• X^cX^c → colour blind daughter

• X^CY → normal son

• X^cY → colour blind son

Thus:

• The son gets the defective X chromosome from the mother.

• The daughter gets one defective X chromosome from the father and another from the mother.

Hence, both parents contribute to the inheritance of colour blindness in the daughter, while the son inherits it from the mother only.

126. **(A) (i)** Transgenic animals are animals whose genetic material has been artificially altered by introducing foreign genes using genetic engineering techniques.

(ii) The first transgenic cow was Rosie.

Importance:

• It produced human protein-enriched milk containing human alpha-lactalbumin.

• The milk was nutritionally more balanced for human babies.

OR

(B) (i) Convention for naming EcoRI Restriction Endonuclease :

• E - Genus Escherichia

• co → Species coli

• R - Strain RY13

• I → First restriction enzyme isolated from this strain

(ii) Action of EcoRI on DNA polynucleotide:

EcoRI recognises the sequence:

$5' - GAATTC - 3'$

It cuts between G and A on both strands:

$5' - G \downarrow AATTC - 3'$

$3' - CTTAA \uparrow G - 5'$

This produces sticky ends.

127. **(A)** In Ophrys, pollination is ensured by sexual deceit. The flower resembles the female bee in size, colour and markings. It also produces a scent similar to the female bee pheromone. Male bees are attracted and attempt pseudocopulation with the flower, during which pollen grains attach to their body and are transferred to another flower.

(B) Co-evolution refers to the process in which two interacting species evolve together by exerting selective pressure on each other.

In the case of Ophrys and the bee species:

• The flower evolved features resembling the female bee.

• The bee evolved behavioural responses towards such signals.

Thus, both species influenced each other's evolution, demonstrating co-evolution.

128. Passage & Bar Graph Analysis

(A) Why species richness is maximum in Region III:

• Tropical Region Environment: Region III represents the tropical latitudinal zone (closer to the equator), which favors maximum biodiversity due to three core factors:
• Evolutionary Stability: Unlike temperate areas that faced frequent historic glaciations, the tropics remained undisturbed for millions of years, leaving ample continuous time for species to diversify.
• Predictable, Constant Climate: Lesser seasonal variation promotes highly specialized niche adaptation and allows more species to coexist stably.
• Higher Solar Productivity: Abundant solar energy input fuels high primary productivity, directly supporting a much broader food web.

OR

(A) Why species richness is minimum in Region I:
• Polar/High-Latitude Environment: Region I represents the polar or high-latitude temperate zone, which experiences low taxonomic diversity because:
• Glaciation Disturbances: These areas faced frequent catastrophic glaciations in their evolutionary past, wiping out species and resetting long-term diversification processes.
• Harsh, Dynamic Seasons: Extreme seasonal changes and harsh, unpredictable climates limit resources and narrow the survival niches available to mammals.
(B) Name of this kind of diversity pattern:
• Latitudinal Gradient (or Latitudinal Gradient in Biodiversity).
(C) Why prokaryotes are excluded from these global estimates:
• Incompatibility of Traditional Methods: Conventional taxonomic approaches and structural criteria are insufficient for properly classifying and distinguishing microscopic bacterial species.
• Culturing Constraints: The vast majority of prokaryotic organisms cannot be cultured or grown under laboratory conditions, making them impossible to identify via standard analytical tools.
• Underestimation Risk: If biochemical or molecular criteria (like RNA gene sequencing) were fully used to classify them, their species count would easily skyrocket into millions, rendering current estimation frameworks obsolete.

129. **(A)** Identification and Justification
• Transformed Recombinant Colony: Colony 4
• Justification: Colony 4 grows successfully on the master plate (Plate M) but fails to grow on Plate **N** which contains both ampicillin and tetracycline. This happens because the foreign DNA was inserted directly into the tetracycline resistance gene, causing insertional inactivation. As a result, the cell remains resistant to ampicillin but becomes sensitive to tetracycline.
(B) Name and Role of the Sites
• Name: Selectable Markers (specifically containing specific recognition/cloning sites for restriction enzymes).
• Role in Genetic Engineering: They act as selection checkpoints that allow scientists to selectively grow transformed host cells while completely screening out and eliminating non-transformed bacteria.
(C) Two Key Enzymes in Genetic Engineering
(1) Restriction Endonucleases: Function as "molecular scissors" to cut DNA strands at highly specific palindromic recognition sequences.
(2) DNA Ligase: Functions as "molecular glue" to link and seal the sugar-phosphate backbones of DNA fragments together via phosphodiester bonds.

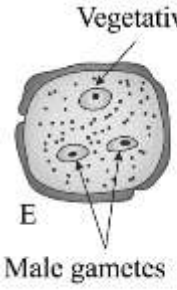
OR

(C) Role of β-galactosidase in Insertional Inactivation
• Reporter Enzyme Mechanism: The gene coding for β-galactosidase (lacZ) serves as a visual reporter marker sequence.
• Selection Process: When foreign DNA is successfully integrated inside this gene sequence, the production of functional β-galactosidase is completely disrupted. Recombinant colonies are easily identified because they fail to break down the chromogenic substrate (X-gal) and remain colorless/white, whereas nonrecombinants turn blue.

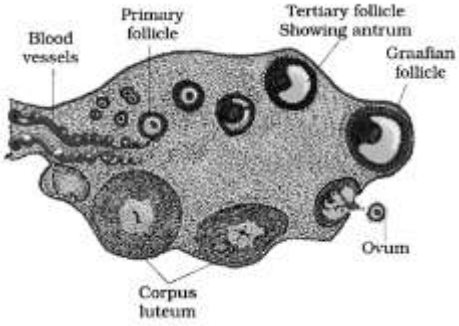
130. **(A) (i)** Development of Male Gametophyte in an Angiosperm
• Microspore Stage: The microspore represents the first cell of the male gametophyte. It expands in size and develops a distinct large central vacuole, pushing the nucleus to one side.
• Asymmetric Division: The microspore nucleus undergoes an unequal mitotic division. This forms two structurally distinct cells:
• Vegetative Cell: Large, contains abundant food reserves, and has a large, irregularly shaped nucleus.
• Generative Cell: Small, spindle-shaped cell with dense cytoplasm and a nucleus that floats freely in the vegetative cell's cytoplasm.

• Formation of 3 -Celled Stage: In about 40% of angiosperms, the generative cell divides mitotically once more to form two non-motile male gametes before pollen dispersal, resulting in a three-celled male gametophyte.

(ii) Labelled Diagram of a Three-Celled Male Gametophyte



(B) (i)



(ii) Stage of Formation

• Primary follicles are formed exclusively during the embryonic development (fetal life) stage of a female. No additional primary follicles are created after birth.

(iii) Post-Ovulatory Phase Events (Luteal Phase)

• Hormonal Events: Following ovulation, the spike in Luteinizing Hormone (LH) induces the ruptured Graafian follicle to transform into the corpus luteum. The corpus luteum secretes massive quantities of progesterone and moderate levels of estrogen.

• Structural Events: Progesterone maintains and thickens the highly vascularized endometrial lining of the uterus for potential implantation. If fertilization fails to take place, the corpus luteum degenerates into a scar tissue called the corpus albicans. This drop in progesterone and estrogen triggers the breakdown of the endometrium, leading to menstruation and initiating the next cycle.

131. **(A)** (1) The stability of genetic material was unequivocally shown in Frederick Griffith's 1928 experiment. Griffith conducted experiments using two strains of Streptococcus pneumoniae bacteria: a virulent smooth strain (S) characterised by a polysaccharide capsule and a non-virulent rough strain (R) lacking the capsule. He administered four distinct combinations to mice: live S strain, live R strain, heat-killed S strain, and a blend of heat-killed S strain with live R strain.

(2) Mice injected with the live S strain perished, whereas those injected with the live R strain or heat-killed S strain survived. Mice died after being injected with a mixture of heat-killed S strain and live R strain. Live S strain bacteria were found in their bodies during post-mortem examination.

(3) Griffith's experiment established DNA as the genetic material, demonstrating its ability to preserve genetic information over generations. Avery, MacLeod, and McCarty established DNA as the transformative principle and confirmed its significance in inheritance.

OR

(B) Identifying Unknown Genotype via Selfing

Let T = Tall, t = Dwarf, V = Violet, and v = White. Since the parent plant expresses both dominant traits (Tall, Violet), its unknown genotype could be one of four combinations: TTVV, TTVV, TTVv, or TtVv.

By selfing the unknown plant, we can definitively determine its true genotype based on the resulting F_2 phenotypic and genotypic distributions:

Case 1: If the Parent Genotype is TTVV (Homozygous Dominant for both)

• Cross: TTVV $\times$ $TTVV$

• Phenotypic Ratio: 100% Tall Violet plants.

• Genotypic Ratio: 100% TTVV .

Case 2: If the Parent Genotype is TtVV (Heterozygous Tall, Homozygous Violet)
• Cross: TYVV × $TYVV$
• Phenotypic Ratio: 3 Tall Violet: I Dwarf Violet.
• Genotypic Ratio: 1 TTVV: 2 TtVV: 1 ttVV .
Case 3: If the Parent Genotype is TTVv (Homozygous Tall, Heterozygous Violet)
• Cross: TTVv × $TTVv$
• Phenotypic Ratio: 3 Tall Violet: I Tall White.
• Genotypic Ratio: 1 TTVV: 2 TTVv: 1 TTvv.
Case 4: If the Parent Genotype is TtVv (Heterozygous for both traits)
• Cross: TiVv × $TYVv$
• Phenotypic Ratio: 9 Tall Violet: 3 Tall White : 3 Dwarf Violet: 1 Dwarf White.
• Genotypic Ratio: 1 TTVV: 2TTVv: 1 TTvp: 2 TtVV: 4 TIVv: 2 Ttvv: 1 ttVV: 2 ttVv : 1 ttvv.

132. **Part (A):** Cancer Biology

(i) Contact Inhibition: This is the property where normal cells stop dividing when they come into contact with other cells. Cancer cells lose this property, leading to uncontrolled growth and tumor formation.
(ii) Proto-oncogenes (or Cellular Oncogenes, c-onc): These are normal genes that regulate cell growth. When activated by certain conditions or mutations, they transform into oncogenes, which can cause normal cells to become cancerous.
(iii) Role of Techniques:
• Biopsy and Histopathology: A piece of suspected tissue is cut into thin sections, stained, and examined under a microscope by a pathologist to identify cancerous changes.
• Magnetic Resonance Imaging (MRI): Uses strong magnetic fields and nonionizing radiation to accurately detect pathological and physiological changes in living tissue, helping to locate internal tumors.

OR

Part (B): Sewage Treatment and Biofertilisers
(i) STP Flow Diagram Questions:
• Aeration Tanks: Primary effluent is passed into large aeration tanks and constantly agitated to allow the vigorous growth of aerobic microbes into flocs (masses of bacteria associated with fungal filaments). These microbes consume a major part of the organic matter in the effluent, significantly reducing the BOD (Biochemical Oxygen Demand).
• Activated Sludge: The 'sediment' is called activated sludge. A small part of it is pumped back into the aeration tank to serve as the inoculum, while the rest is pumped into anaerobic sludge digesters.
• Final Step: Once the BOD is significantly reduced, the bacterial flocs are allowed to sediment. The remaining treated effluent is then generally released into natural water bodies like rivers and streams.
(ii) Biofertilisers:
• Rhizobium (Kingdom Monera): These bacteria live symbiotically in the root nodules of leguminous plants and fix atmospheric nitrogen into organic forms, which the plant uses as a nutrient.
• Glomus (Kingdom Fungi): This genus of fungi forms mycorrhiza with plants. They absorb phosphorus from the soil and pass it to the plant, while also providing resistance to root-borne pathogens.

133. **(a)**Pollen tube contents → The pollen tube carries the cytoplasm, vegetative cell, and generative cell.
• cytoplasm, vegetative cell and generative cell
Generative cell divides later to form two male gametes

134. **(b)** • Scutellum in maize grain → It is the single cotyledon of the monocot embryo.
• Scutellum absorbs nutrients from the endosperm.

135. **(a)** • Tightly linked genes → Genes close together on the same chromosome show very low recombination.
• This is the principle of linkage.

136. **(c)** • Sex determination in honeybee → It follows haplodiploidy: fertilized eggs → females (diploid), unfertilized eggs → males (haploid).
• Learn more about haplodiploidy.

137. **(d)** • Plants with dinosaurs → Dominant plant forms were conifers (gymnosperms).
• Explore conifers.

138. **(b)** • Antibiotic resistance in bacteria → Resistance spread rapidly due to selection of resistant varieties after chance mutations.
• This is an example of adaptive evolution.

139. **(a)•** Polygenic inheritance is controlled by many genes and shows continuous variation influenced by environment. It does not have distinct alternate forms.
• Have distinct alternate forms

140. **(d)** • A 1:1 phenotypic ratio is obtained in a test cross:
• Heterozygous dominant × homozygous recessive
• Example: Aa × aa → 1Aa: 1aa

141. **(a)** Dengue fever is caused by Dengue virus, which belongs to the Flavivirus group.

142. **(d)•** In lac operon, structural genes are z, y, a.
• p gene is the promoter, not a structural gene.

143. **(d)** About 95% of transgenic animals are mice because they reproduce quickly and are easy to study genetically.

144. **(c)** Amensalism is an interaction where one species is harmed while the other remains unaffected. Example: Penicillium inhibits bacteria.

145. **(c)•** Seed dormancy
• Assertion (A): True → Embryo can enter dormancy.
• Reason (R): False → Dormancy occurs when conditions are unfavourable, not favourable.
• Assertion is true, Reason is false See seed dormancy.

146. **(a)**DNA polymer structure
• Assertion (A): True → DNA is a long polymer of deoxyribonucleotides.
• Reason (R): True → Correct description of 5′ and 3′ ends.
• Reason explains Assertion.
So,Both Assertion and Reason are true, and Reason is the correct explanation of Assertion
Learn more about DNA structure.

147. **(d)** Malaria causation
• Assertion (A): False → Malaria is caused by Plasmodium parasite, not mosquito itself.
• Reason (R): True → Female Anopheles requires blood for egg production.
• Assertion is false, Reason is true
Explore malaria causative agent.

148. **(c)•** ADA deficiency treatment
• Assertion (A): True → ADA deficiency causes severe immune disorders.
• Reason (R): Partially true but misleading → Bone marrow transplantation can help, but gene therapy is considered a permanent treatment, especially in children.
• Assertion is true, Reason is false

149. Male sex accessory ducts in humans (correct sequence):
• Rete testis → Vasa efferentia → Epididymis → Vas deferens → Ejaculatory duct → Urethra

150. Dual functions of codon AUG:
• Acts as the start codon for translation initiation.
• Codes for the amino acid methionine.

151. Justification: "Antibiotics should be taken as prescribed by doctors."
• Misuse or incomplete dosage can lead to antibiotic resistance.
• Doctors prescribe correct dosage and duration to ensure bacteria are completely eliminated.
• Prevents recurrence of infection and avoids resistant strains.

152. Characteristics of stem cells:
• Self-renewal → ability to divide and produce identical cells.
• Potency → ability to differentiate into specialized cell types.
• Can be embryonic (pluripotent) or adult (multipotent).
• Crucial for regeneration and repair of tissues.

153. **(A)** Food chain with birds and insects on a tree:
(i) Trophic levels:
• Tree → Producer
• Insects → Primary consumers
• Small birds → Secondary consumers

• Large birds → Tertiary consumers
(ii) Pyramids:
• Biomass pyramid → Upright (tree has maximum biomass).
• Number pyramid → Inverted (one tree supports many insects).

OR

(B) Decomposition of detritus:
(i) Composition of detritus → Rich in lignin/chitin slows decomposition; nitrogen-rich detritus decomposes faster.
(ii) Climatic factors → Warm, moist conditions accelerate decomposition; low temperature or dry conditions slow it down.

154. Corpus luteum in human female

(A) Develops in the ovary after ovulation, from the ruptured Graafian follicle. It forms during the luteal phase of the menstrual cycle.
• Hormone: Luteinizing hormone (LH)
• Source gland: Anterior pituitary
(B) Role:
(i) Menstrual cycle → Secretes progesterone, which maintains endometrium for possible implantation. If no fertilisation, corpus luteum degenerates → menstruation.
(ii) Pregnancy → Corpus luteum persists, secreting progesterone to maintain endometrium until placenta takes over.
Learn more about corpus luteum.

155. Fertilisation in human female

• Occurs in the ampullary-isthmic junction of the fallopian tube.
• Process:
(1) Capacitation of sperm in female tract.
(2) Acrosome reaction → sperm releases enzymes to penetrate zona pellucida.
(3) Fusion of sperm and egg membranes.
(4) Completion of meiosis II in ovum → formation of female pronucleus.
(5) Fusion of male and female pronuclei → zygote.
Explore fertilisation process.

156. Colour blindness inheritance

• Colour blindness is X-linked recessive.
• Parents both have normal vision → father has normal X , mother is a carrier (heterozygous).
• Son inherits mother's defective X → colour blind.
• Daughter inherits father's normal X + mother's defective X → carrier but normal vision.
This shows X-linked recessive inheritance.
See colour blindness inheritance.

157. Fossils and evolution

• Fossils: Preserved remains or traces of ancient organisms in rocks.
• Help in evolution:
• Show structural similarities between extinct and living species.
• Provide chronological evidence of changes over time.
• Indicate transitional forms (e.g, Archaeopteryx between reptiles and birds).
Learn about fossils in evolution.

158. Three enzymes obtained from microbes and their uses:

• Pectinase - used in clarification of fruit juices.
• Lipase - used in detergent industry for removing oily stains.
• Protease - used in detergent and leather industries.

159. **(A)** Steps to develop bollworm-resistant cotton plant:

• Identify and isolate Bt toxin gene (cry gene) from Bacillus thuringiensis.
• Introduce the gene into cotton plant using genetic engineering.
• Transfer transformed cells into culture medium.
• Regenerate whole plants from transformed cells.
• Select resistant plants producing Bt toxin against bollworm.

OR

(B)• Genes from Meloidogyne incognita were introduced into tobacco plant through Agrobacterium vectors.

• These genes produced both sense and antisense RNA.
• The RNAs formed double-stranded RNA (dsRNA).
• dsRNA triggered RNA interference (RNAi) and silenced mRNA of the nematode.
• As a result, essential proteins were not formed and the parasite could not survive in tobacco plants.

160. Three important levels of biodiversity:

(i) Genetic diversity
• Diversity in genes within a species.
• Example: Different varieties of rice in India.
(ii) Species diversity
• Variety of species present in an area.
• Example: Western Ghats having many amphibian species.
(iii) Ecological diversity
• Diversity at ecosystem level.
• Example: Deserts, forests, grasslands and wetlands.

161. Biotechnology and genetic engineering

(A) EcoRI recognition sequence
• EcoRI recognises the palindromic sequence 5′-GAATTC-3' / 3'-CTTAAG-5'.
• It makes a cut between G and A on both strands, producing sticky ends.
Learn more about EcoRI recognition.
(B) Transformant vs non-transformant colonies
• Transformants (bacteria that received recombinant DNA) can be distinguished by antibiotic resistance marker genes or colour change (e.g., blue-white screening).
• Non-transformants will either die (if antibiotic is present) or show different colony colour. See transformant screening.

OR

(B) Five tools of genetic engineering:
(1) Restriction enzymes (molecular scissors)
(2) DNA ligase (joins DNA fragments)
(3) Vectors (plasmids, phages)
(4) Host organism (usually bacteria)
(5) Selectable markers (antibiotic resistance genes)
(C) Synthetic/engineered vector
• Example: pBR322 or pUC18.
• Multiple restriction sites allow insertion of foreign DNA at different locations, increasing flexibility in cloning.

162. Ecological interactions

(A) Cuckoo and crow interaction
• This is brood parasitism.
• Cuckoo lays eggs in crow's nest → crow incubates and raises cuckoo chick.
• Crow is exploited, cuckoo benefits. Learn more about brood parasitism.

OR

(A) Adaptive features of parasites:
(1) High reproductive capacity
(2) Loss of unnecessary organs (e.g., digestive system in tapeworm)
(3) Specialised attachment structures (hooks, suckers)
(4) Immune evasion mechanisms
(B) Commensalism
• One species benefits, the other is unaffected.
• Example: Barnacles on whales → barnacles get transport, whale unaffected.
(C) Mutualism examples
• Plant: Leguminous plants and Rhizobium → nitrogen fixation.
• Animal: Oxpecker birds and buffalo → birds eat ticks, buffalo benefits.

163. Reproductive processes

(A) Double fertilisation in angiosperms

(i) Process:
• Pollen tube releases two male gametes into the embryo sac.

• One gamete fuses with the egg cell → syngamy → diploid zygote.
• Other gamete fuses with two polar nuclei → triple fusion → triploid primary endosperm nucleus.
This is called double fertilisation, unique to angiosperms.
See double fertilisation.
(ii) Endosperm development in coconut:
• Endosperm develops from the primary endosperm nucleus.
• In coconut, it is free-nuclear type: nuclei divide without cell wall formation.
• Later, cell walls form at the periphery → solid endosperm (copra).
• Central cavity remains liquid → coconut water.
Learn about coconut endosperm.

OR

(B) Spermatogenesis in humans
(i) Process:
• Occurs in seminiferous tubules of testes.
• Spermatogonia (diploid) → mitosis → primary spermatocytes.
• Primary spermatocytes → meiosis I → secondary spermatocytes.
• Secondary spermatocytes → meiosis II → spermatids.
• Spermatids → differentiation → spermatozoa.
Explore spermatogenesis.
(ii) Hormones:
•FSH → stimulates spermatogenesis via Sertoli cells.
• LH → stimulates Leydig cells to produce testosterone.
• Testosterone → promotes sperm maturation.
• Inhibin → regulates FSH secretion.
See hormonal regulation.

164. Mutations

(A) (i) Mutation: Sudden heritable change in DNA sequence.
(ii) Point mutation: Change in a single base pair. Example: Sickle cell anaemia → substitution of adenine for thymine in β-globin gene → valine replaces glutamic acid. Symptoms: anaemia, fatigue, distorted RBCs.
(iii) Another type: Frame-shift mutation (insertion/deletion of bases).
Learn about point mutation.

OR

(B) Meselson-Stahl experiment
• Used E. coli grown in heavy isotope (^15 N) medium, then shifted to light (^14 N).
• DNA samples analysed by density gradient centrifugation.
• Results showed intermediate density after one generation, and both light + intermediate after two generations.
• Conclusion: DNA replication is semi-conservative.
See Meselson-Stahl experiment.

165. Immunity and malaria

(A) Innate immunity
• Non-specific defence present at birth.
• Accomplished by:
(1) Physical barriers (skin, mucous membranes).
(2) Physiological barriers (saliva, tears, HCl in stomach).
(3) Cellular barriers (phagocytes, NK cells).
(4) Cytokine barriers (interferons).
Explore innate immunity.

OR

(B) Malaria
(i) Parasite: Plasmodium vivax / Plasmodium falciparum.
• Entry: Bite of infected female Anopheles mosquito → sporozoites injected into blood.
• Cycle: Sporozoites → liver (schizonts) → merozoites → infect RBCs → trophozoites → schizonts → gametocytes.
See Plasmodium life cycle.
(ii) Symptoms: Fever, chills, anaemia.

• Caused by rupture of infected RBCs → release of haemozoin toxin → triggers fever cycles.

166. **(d)** A single gene controlling more than one trait is called pleiotropism.

167. **(d)** Trisomy 21 = Down syndrome

Characteristics include:

• Furrowed tongue

• Characteristic palm crease

Rudimentary ovaries and gynaecomastia are related to Klinefelter syndrome.

168. **(c)**Reasoning: The text in the diagram explicitly states "Sperm being injected into the cytoplasm of the egg using a fine needle". This procedure is the definition of ICSI (Intracytoplasmic Sperm Injection), where a single sperm is directly microinjected into a mature egg.

169. **(d)** Reasoning: Interferons are cytokine barriers of the innate immune system. They are specialized antiviral proteins secreted by cells that have been infected with a virus. These proteins signal and protect adjacent, uninfected cells from further viral replication.

170. **(b)** In secondary sewage treatment, bacteria and fungi form mesh-like aggregates called flocs. These microbes help in decomposition of organic matter.

171. **(d)** DNA fragments are stained with Ethidium bromide (EtBr).

EtBr fluoresces under UV light, making DNA bands visible.

172. **(a)** Some orchids mimic female insects in appearance and smell. Male insects attempt mating (false copulation) and transfer pollen. This phenomenon is called pseudocopulation.

173. **(b)**• A: Degenerating synergids at top.

• B: Zygote formed near top.

• C: Central Primary Endosperm Nucleus.

• D: Degenerating antipodals at bottom.

174. **(d)**• Recessive: Unaffected parents have affected children.

• Autosomal: Affected daughter has unaffected father.

• Rule: X-linked daughters need affected fathers.

175. **(c)**• 'i' gene: Produces the repressor protein.

• 'z' gene: Codes for **β**-galactosidase.

• 'a' gene: Codes for transacetylase.

• 'y' gene: Codes for lac permease.

176. **(a)** • Explanation: Thalassemia is an autosomal recessive disorder. If both parents are carriers (Tt), a cross (Tt × Tt) yields:

25% Normal (TT)

50% Carriers (Tt)

25% Affected/Afflicted (tt)

177. **(a)** • Explanation: The sequence of the RNA transcript is identical to the coding strand of DNA, with the only difference being that Thymine (T) is replaced by Uracil (U).

• DNA coding strand: 5′ - ATGAATG - 3′

• RNA transcript: 5′ - AUGAAUG - 3′

178. **(c)**• Assertion (A): True

AIDS is caused by Acquired Immunodeficiency Syndrome due to infection by Human Immunodeficiency Virus.

• Reason (R): False

HIV is a retrovirus and contains RNA as genetic material, not DNA. It attacks and weakens the immune system.

So, A is true but R is false.

179. **(a)**• Assertion (A): True

In molecular diagnosis, a probe is a single-stranded DNA or RNA molecule tagged with a radioactive or fluorescent marker used to detect complementary sequences.

• Reason (R): True

The probe binds (hybridises) with its complementary DNA sequence in the sample or clone of cells.

•But R does not explain why the tagged strand is called a probe; it only describes its function.

So, both A and R are true, but R is not the correct explanation of A .

180. **(d)**• Assertion is False: In birds, the sex of the offspring is determined by the female parent, not the male.

• Reason is True: Birds show a ZW sex-determination system. Males have two identical sex chromosomes (ZZ / homogametic), so all sperm carry a Z chromosome. Females have two different sex chromosomes (ZW / heterogametic), producing two types of eggs (Z or W). The egg determines the final sex.

181. **(a)**• Assertion is True: Ecological studies (like David Tilman's long-term outdoor plots) show that ecosystems with higher species richness enjoy greater environmental stability.

• Reason is True: A key indicator of a stable community is that its productivity (total biomass) remains consistent and shows very little variation from year to year, which is achieved when a diverse mix of species buffers the community against disturbances.

So, Both (A) and (R) are true, and (R) is the correct explanation of (A).

182. **(A)** Farmers prefer apomictic seeds over hybrid seeds for two key reasons:

• No Segregation of Characters: Hybrid seeds undergo genetic segregation in subsequent generations, causing offspring to lose their desirable hybrid traits. Apomictic seeds develop through asexual reproduction (without fertilization), so they preserve identical parental traits indefinitely.

• Cost-Effectiveness: Hybrid seeds must be bought fresh every single year because saved seeds do not breed true. Apomictic seeds allow farmers to harvest and replant seeds year after year, saving money.

OR

(B)• Advantage: Amniocentesis detects chromosomal aberrations and genetic disorders (such as Down syndrome, Edwards syndrome, or hemophilia) early in a pregnancy to allow for guided medical intervention.

• Disadvantage: It is widely misused for pre-natal sex determination, driving illegal female foeticide. It also carries a small, baseline risk of inducing an accidental miscarriage.

183. **(A)**• Restriction Enzyme: EcoRI

•Type of Sequence: Palindromic sequence (or restriction recognition site) because it reads the exact same forward and backward when comparing the $5'-> 3'$ directions on both strands.

(B)•Indication of Arrows: The arrows show the specific cleavage sites where the enzyme breaks the phosphodiester bonds on each DNA strand. EcoRl always cuts away from the center, specifically between the Guanine (G) and Adenine (A) bases.

• Result Obtained: The staggered cuts produce single-stranded protruding ends called sticky ends:

5 - GATTC - 3 '

$3'$ - CTTAA G-5'

184. **(A)** Conditions for growth curves

• Growth curve A (J-shaped / Exponential growth):

Occurs when resources such as food, space and nutrients are unlimited and environmental conditions are favourable.

• Growth curve B (S-shaped / Logistic growth):

Occurs when resources are limited and competition occurs among organisms.

(B) Meaning of K

' K ' represents the carrying capacity of the environment, i.e., the maximum population size that the environment can support sustainably.

185. Glomus species form mycorrhizal association with plant roots.

Plants are benefitted in the following ways:

(1) Increased absorption of water and minerals, especially phosphorus.

(2) Greater resistance to drought and salinity.

(3) Protection against root pathogens.

(4) Overall better plant growth and development.

186. Given:

Adenine (A) $= 31\%$

According to Chargaff's rule in DNA:

$A = T$ and $G = C$

So,$T = 31\%$

Therefore,

$A + T = 31 + 31 = 62\%$

Remaining percentage:

$100 - 62 = 38\%$

Since $G = C$,

$C = \frac{38}{2} = 19\%$

187. The missing values in the table are:

- a: Statin
- b: Blood cholesterol-lowering agent
- c: Penicillium notatum (or Penicillium chrysogenum)
- d: Penicillin
- e: Trichoderma polysporum|
- f: Immunosuppressive agent

188. **(A)** Biologists use three primary hypotheses to explain why tropical regions have higher species richness than temperate regions: e

- Speciation is a Function of Time: Unlike temperate regions which have faced frequent glaciations in the past, tropical latitudes have remained relatively undisturbed for millions of years. This long period of stability allowed species a continuous, uninterrupted opportunity to diversify.
- Less Seasonal Environments: Tropical climates are more predictable, constant, and less seasonal compared to temperate areas. This niche specialization promotes a reduction in competition and allows a much wider variety of species to coexist.
- Higher Solar Energy: The tropics receive more direct solar energy. This increased availability of sunlight drives higher primary productivity, which indirectly supports a more complex food web and higher resource availability for diverse species.

OR

(B) (i) Representation: An ecological pyramid visually represents the trophic structure and function of an ecosystem. It graphs parameters like total biomass, energy content, or the total number of individual organisms across succeeding trophic levels, starting with producers at the base.

(ii) Shape Justifications:

- Upright Pyramid Example (Pyramid of Numbers in a Grassland): Autotrophic plants (producers) are massive in number at the base. The number of herbivores (primary consumers) feeding on them is lower, and the number of carnivores (secondary/tertiary consumers) at the top is the smallest.
- Inverted Pyramid Example (Pyramid of Biomass in a Sea): The standing crop biomass of phytoplankton (producers) is remarkably small at any given moment. However, it supports a much larger standing biomass of zooplankton and predatory fish (consumers) because the phytoplankton reproduce and turn over at an exceptionally rapid rate.

189. **(A)** Transgenic Animals: These are animals whose genome has been deliberately altered through genetic engineering techniques to introduce, express, and carry a foreign (exogenous) segment of DNA from another organism.

(B) Largest Population: Mice are the most common transgenic animal, accounting for over 95% of all existing transgenic research models.

(C) Three Reasons for Production:

(1) Normal Physiology and Development: They allow scientists to study how specific genes are regulated and how they affect the normal structural, metabolic, and physiological development of the body.

(2) Study of Human Disease: Transgenic models are purposefully engineered to mimic human illnesses (such as cystic fibrosis, Alzheimer's disease, cancer, and rheumatoid arthritis) to investigate targeted therapeutic treatments.

(3) Biological Products: They are used as living factories to manufacture costly biological medicines. For example, transgenic sheep or cows are modified to produce human proteins like α-1-antitrypsin (used to treat emphysema) or nutrientenriched milk.

190. Chromosome Numbers and Process in Maize

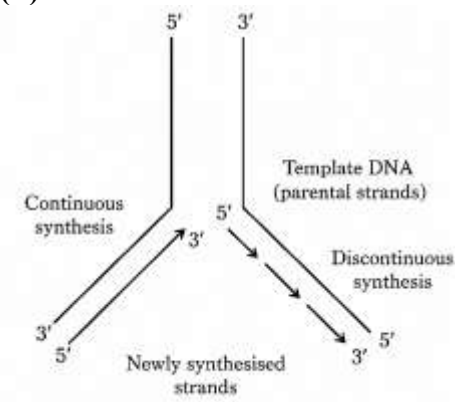
If leaf cells (2n) have 10 chromosomes, the haploid number (n) is 5. d

- Zygote (2n): 10 chromosomes (Fusion of $n = 5$ sperm $+n = 5$ egg).
- Endosperm (3n): 15 chromosomes (Fusion of $n = 5$ sperm $+2n = 10$ polar nuclei).
- Process - Double Fertilization: A unique angiosperm process where one sperm fertilizes the egg to form the diploid zygote (embryo), and the second sperm fuses with two polar nuclei to form the triploid (3n) endosperm.

191. DNA Replication

(A) Replication Fork Reason: DNA is extremely long and energetic. Replicating the entire length simultaneously requires immense energy and time, and risks DNA damage or entangling. A fork allows localized, high-speed, and accurate copying, managing energy consumption by copying only a small section at a time.

(B)



Explanation:

(1) In order to create a replication fork, DNA replication begins at a location known as the origin of replication (ori).

(2) The separated strands act as templates for the synthesis of new strands.

(3) DNA replicates in the $5' \rightarrow 3'$ direction.

(4) Deoxyribonucleotide triphosphate, or dNTPs, serve as a substrate and source of energy for nucleotide polymerisation.

(5) An enzyme called DNA polymerase creates a new DNA strand complementary to the template strand.

(6) As the complete genome is duplicated, DNA polymerase keeps moving along the template strand and appending new nucleotides to the complementary or expanding strand.

(7) The DNA polymerase synthesises one new strand (leading strand) continuously in the $5' \rightarrow 3'$ direction.

(8) The other new strand is synthesised in short segments (Okazaki fragments) in the $5' \rightarrow 3'$ direction (discontinuous synthesis).

(9) An enzyme called DNA ligase joins the Okazaki fragments to generate a new strand. This new strand is known as the lagging strand.

192. Processing of hnRNA

• Location: Nucleus.

• Processes:

• Splicing: Introns (non-coding) are removed, and exons (coding) are joined together.

• Capping: A methylated guanosine triphosphate (cap) is added to the $5'$ end.

• Tailing (Polyadenylation): Poly-A tail is added to the $3'$ end. O Allenin +1

193. Human Activities Driving Species Extinction

(1) Habitat Loss and Fragmentation: Deforestation, urbanization, and agricultural expansion destroy natural habitats, forcing species into small, unsustainable areas.

(2) Over-exploitation: Overhunting, overfishing, and poaching (e.g., for food, trade, or medicine) reduce population sizes below viable levels.

(3) Introduction of Invasive Species: Non-native species introduced intentionally or accidentally outcompete, pray on, or bring diseases to native species, destroying local ecosystems.

194. **(A)** Hormones and Source Organs

At puberty, the menstrual cycle is primarily regulated by hormones from the pituitary gland and the ovaries:

• FSH (Follicle Stimulating Hormone) & LH (Luteinizing Hormone): Secreted by the Anterior Pituitary.

• Estrogen & Progesterone: Secreted by the Ovaries.

(B) Implantation in ART

For successful pregnancy using Assisted Reproductive Technology (ART), an early embryo (up to 8 blastomeres) should be implanted during the Luteal phase (Secretory phase), typically between days 15-24.

• Reason: During this phase, the hormone progesterone is at its peak, making the uterine endometrium thick, highly vascularized, and glandular. This creates the optimal "receptive window" for the embryo to attach and receive nourishment.

(C) Proliferative Phase Events

• Hormone: Estrogen.

• Source Organ: Growing ovarian follicles.
• Explanation: During the proliferative phase (days 5-14), rising estrogen levels stimulate the regeneration and thickening of the uterine endometrium that was shed during menstruation. It also stimulates the maturation of the Graafian follicle in the ovary.

OR

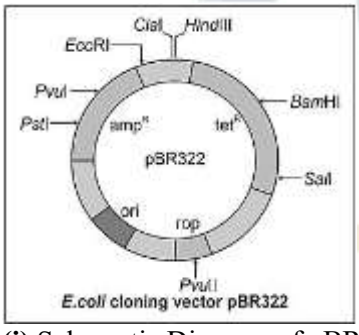
(C) Why Menstruation Occurs
Menstruation occurs only if the released ovum is not fertilized because:
(1) Without fertilization, the corpus luteum degenerates as there is no HCG hormone to maintain it.
(2) This causes a sharp decline in progesterone levels.
(3) Progesterone is essential for maintaining the uterine lining; its withdrawal causes the breakdown of the endometrium, leading to bleeding (menses).

195. **(A)** Plasmodium Entry Forms
(i) Human Body: Plasmodium enters as Sporozoites.
(ii) Female Anopheles Body: Plasmodium enters as Gametocytes (sexual stages) when the mosquito takes a blood meal from an infected person.
(B) Malarial Symptoms
Reason for Delay: Symptoms do not appear immediately because the parasites must first reach the liver and undergo several rounds of asexual multiplication (incubation period) before they can enter and rupture red blood cells (RBCs).
When and How Symptoms Appear: Symptoms appear when the parasites attack and rupture the host's RBCs. This rupture releases a toxic substance called haemozoin, which causes the characteristic recurring high fever and chills.

OR

(B) Events within Female Anopheles
After sucking blood containing gametocytes:
(1) Fertilization and Development: The gametocytes undergo fertilization and further development within the mosquito's intestine.
(2) Formation of Sporozoites: The parasites multiply to form infectious sporozoites.
(3) Migration: These sporozoites migrate from the intestine to the salivary glands of the mosquito, where they are stored until the next bite.
(C) Other Mosquito Species
• Species: Aedes aegypti.
• Disease: Dengue or Chikungunya.

196. **(A)**



E.coli cloning vector pBR322

(i) Schematic Diagram of pBR322
The pBR322 vector is a circular plasmid. Key components include: &
• 'ori': Origin of replication (top).
• 'rop": Gene for protein involved in replication regulation (near ori).
•Amp^R : Ampicillin resistance gene (bottom).
• Te^R : Tetracycline resistance gene (bottom-right).
• BamHI: Restriction site located within the $TerR^R$ gene.
(Refer to this structure: A circular map showing clockwise: ori -> rop -> Pvul -> Pstl -> Amp^R-> Sall -> BamHl (Tet^R) -> EcoRl)
(ii) Role of 'rop' gene

The 'rop' gene stands for "repressor of primer" and codes for proteins involved in the regulation of the plasmid's replication, specifically controlling and limiting the copy number of the plasmid in a host cell.

(iii) Impact of No Selectable Marker

If a cloning vector lacks a selectable marker, it becomes impossible to distinguish between transformants (cells that took up the plasmid) and non-transformants (cells that did not). This prevents the identification of clones containing the desired recombinant DNA, making the cloning process inefficient or impossible.

(iv) Insertional Inactivation vs. Selectable Markers

Insertional inactivation is preferred because it allows for a "two-step" selection process.

• Selection: Antibiotic resistance identifies cells that have taken up the plasmid (recombinant or non-recombinant).

(1) Screening: Insertional inactivation occurs when a gene (e.g., Te^R) is broken by the inserted DNA, allowing differentiation between recombinant and non-recombinant cells because the recombinant ones lose resistance to that specific antibiotic.

OR

(B) (i) Nematode Name

Meloidogyne incognita

(ii) Vector Used

Agrobacterium tumefaciens (or Ti plasmid)

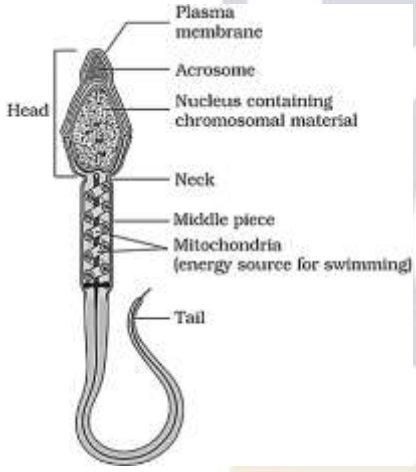
(iii) Function of Sense and Anti-sense RNAs

The introduced DNA produces both sense (mRNA) and anti-sense (complementary to mRNA) RNA. These two strands bind to each other to form double-stranded RNA (dsRNA). This dsRNA initiates a process called RNA interference (RNAi), which silences the specific mRNA of the nematode, preventing it from producing vital proteins.

(iv) Parasite Survival Failure

The parasite cannot survive because the transgenic tobacco plant produces dsRNA that initiates RNA interference (RNAi). The RNAi mechanism silences crucial genes within the nematode, thus inhibiting its ability to feed and survive within the plant.

197. (A) (i)



Functions of parts:

(1) Head: The nucleus, which houses the genetic material (DNA) required for fertilisation, is in the sperm's head. Enzymes that help penetrate and fertilise the egg are found in the acrosome, a cap-like structure that covers the head.

(2) Midpiece: Numerous mitochondria in the sperm's midpiece supply the energy (in the form of ATP) required for motility or body movement. The sperm's tail beats because of the electricity provided by mitochondria.

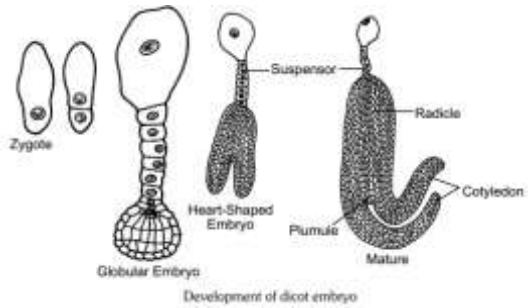
(3) Tail (Flagellum): The sperm moves around due to its tail, also called the flagellum. For the sperm to reach and pierce the egg for fertilisation, it must be propelled through the female reproductive canal.

(4) Neck: During sperm maturation and motility, the neck of the sperm facilitates the transfer of genetic material from the head to the tail and joins the head to the midpiece.

(ii) The sperm alters the zona pellucida during fertilisation and prevents other sperms from entering. This avoids polyspermy and guarantees monospermy, in which only one sperm fertilises the ovum.

OR

(B) (i)



Development of dicot embryo

(ii) In developing plants, endosperm development comes before embryo development in order to supply the developing embryo with vital nutrients and support. Male and female gametes fuse to produce endosperm, which guarantees the development of a nutritional tissue that provides the growing embryo with proteins, carbohydrates, and other vital elements. Employing the nutrients the endosperm provides for growth and differentiation, embryonic development begins as soon as the endosperm is developed and functioning. This methodical procedure guarantees the developing embryo the right nutrition and care, which eventually aids in the successful production of viable seeds.

198. **(A) (i)** Type of Natural Selection

The graph depicts disruptive (or diversifying) selection. This occurs when environmental conditions favor individuals at both extremes of a phenotypic range over those with intermediate phenotypes, potentially leading to two distinct groups.

(ii) Industrial Melanism in England

After industrialization, dark-winged moths (melanic forms) were favored due to directional selection caused by environmental changes:

• Pollution: Soot from factories covered tree trunks, killing light-colored lichens and darkening the bark.

• Predation: White-winged moths became easily visible to predators against the dark background, while dark moths were camouflaged.

• Survival: Consequently, dark moths had a higher survival and reproduction rate, increasing their frequency in the population.

(iii) Anthropogenic Action and Evolution

Anthropogenic (human-induced) actions can accelerate evolution through intense selective pressure.

• Example: The development of antibiotic resistance in bacteria. When humans overuse antibiotics, susceptible bacteria die, but those with random mutations for resistance survive and multiply rapidly, leading to a resistant population in a very short time.

OR

(B) (i) Use of ^{35}S and ^{32}P

Hershey and Chase used these specific radioactive isotopes to distinguish between protein and DNA:

• ^{35}S (Sulfur): Found in proteins (in amino acids like cysteine and methionine) but not in DNA.

• ^{32}P (Phosphorus): Found in DNA (phosphate backbone) but not in proteins. This allowed them to track which molecule entered the bacteria during viral infection.

(ii) Importance of Blending and Centrifugation

(1) Blending: This step physically agitated the bacteria to detach the viral coats (ghosts) from the outside of the bacterial cells.

(2) Centrifugation: This separated the heavier bacterial cells (which formed a pellet at the bottom) from the lighter viral particles and liquid medium (which remained in the supernatant).

(iii) Conclusion

They concluded that DNA is the genetic material. They observed that only ^{32}P (DNA) entered the bacterial cells and was passed on to progeny viruses, while ^{35}S (protein) remained outside in the supernatant.