1. **(b)** Which process(es) result in the production of recombinants in future generations?
(i) Mutation → Creates new alleles, producing genetic variation.
(ii) Independent assortment during meiosis I - Produces new combinations of maternal and paternal chromosomes.
(iii) Independent assortment during meiosis II → Does not produce recombinants; assortment occurs in meiosis I.
(iv) Crossing over of bivalents - Exchanges genetic material between homologous chromosomes, producing recombinants.
(Among the given options, this is the best answer because independent assortment in meiosis I and crossing over are the recognized mechanisms of recombination.)

2. **(c)** Identify region ' X ', factor ' Y ' and enzyme ' Z '
The diagram represents transcription in prokaryotes.
• Region X = Promoter (site where RNA polymerase binds)
• Factor Y = Sigma (σ) factor (helps RNA polymerase recognize the promoter)
• Enzyme Z = RNA polymerase (synthesizes RNA)

Region 'X	Factor 'Y	Enzyme 'Z
Promoter	Sigma (σ)	RNA polymerase

3. **(a)** Age Pyramid
The pyramid shows:
• Pre-reproductive group is smaller than the reproductive group.
• Base is narrower than the middle.
This indicates a declining (negative growth) population.

4. **(a)** Entry of Untreated Sewage in River
Untreated sewage causes:
• Dissolved oxygen (DO) decreases
• Mineral ions increase
In the graph, the change begins at Point (i), where DO starts falling and mineral ions start rising.

5. **(d)** Match the Enzymes and Functions

Enzyme	**Function**
(P) DNA Ligase	(III) Joins DNA fragments
(Q) Restriction exonuclease	(I) Removes nucleotides from ends of DNA
(R) Taq polymerase	(II) Extends primer on a DNA template
(S) Restriction endonuclease	(IV) Cuts DNA at a specific position

Matching:
(P)- (III), (Q)-(I), (R)- (II), (S)- (IV)

6. **(a)** DNA Fingerprinting
Rule: Every band in the child must be present in either of the two parents.
Looking carefully at the DNA profiles:
• Several bands of Child X match Individual 1.
• The remaining bands match Individual 2 .
• Individual 3 does not account for all the unmatched bands of the child.
Therefore, the possible parents are:
• 1 and 2

7. **(c)•** Natural Selection in Giraffes
The question asks for the process of natural selection responsible for the evolution of longer necks in giraffes.

When one extreme phenotype (long neck) is favored over the others, it is called directional selection.

8. **(c)** During microsporogenesis, each microspore mother cell (MMC) undergoes meiosis to produce 4 pollen grains.
• Calculation: $325\text{MMCs} \times 4 = 1300$ pollen grains.

9. **(a)** Matching Table:

Device		**Mode of Action**	
(P)	Lippes loop	**(II)**	Phagocytosis of sperms in uterus
(Q)	Multiload 375	**(IV)**	Makes cervix hostile to sperms
(R)	Subcutaneous Norplant	**(III)**	Causes thickening of cervical mucus
(S)	Saheli	**(I)**	Inhibition of ovulation

10. **(c)** Analysis of Options:
(a) Incorrect: Sertoli cells provide nourishment to sperms; Leydig cells produce Testosterone.
(b) Incorrect: Prolactin (from the pituitary), not Estrogen, initiates the secretion of milk.
(c) Correct: Leydig cells secrete androgens (Testosterone) which stimulate spermatogenesis.
(d) Incorrect: FSH is secreted by the Anterior Pituitary, not the Ovary.

11. **(b)** • The organism used in construction of the first artificial recombinant DNA by Cohen and Boyer in 1972 was:
• Note: Stanley Cohen and Herbert Boyer linked an antibiotic resistance gene with a native plasmid of Salmonella typhimurium.

12. **(d)** The CSIR (Council of Scientific & Industrial Research), under the leadership of Dr. R.A. Mashelkar, successfully challenged this patent by providing evidence of turmeric's traditional use in India.

13. **(c)** • Assertion (A): A patient of ADA deficiency undergoing treatment for gene therapy requires periodic infusion of genetically engineered lymphocytes. Reason (R): Lymphocytes are immortal.
• Explanation: Because lymphocytes have a finite lifespan and are not immortal, patients require periodic infusions of corrected cells.

14. **(a)** • Assertion (A): A cattle egret and grazing cattle in close association is a classic example of commensalism.Reason (R): As grazing cattle move through the field, they stir up and flush out insects from the vegetation that otherwise might be difficult for egrets to find and catch.
• So, Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

15. **(c)** Seed Development
• Assertion (A): Endosperm is completely consumed during the development of embryc in ex-albuminous seeds.
• Reason (R): Castor, pea and beans are all examples of ex-albuminous seeds.
• Explanation: The assertion is correct because ex-albuminous (non-endospermic) seeds completely utilize their endosperm during embryonic development. However, the reason is false because while pea and beans are ex-albuminous, castor is an albuminous (endospermic) seed that retains its endosperm at maturity.

16. **(a)** • Sex Determination in Birds
• Assertion (A): Birds like pigeon have heterogametic females whereas the males are homogametic.
• Reason (R): In pigeons, females have Z and W sex chromosomes whereas males have ZZ sex chromosomes.
• Explanation: Birds exhibit a ZW-ZZ sex determination system where females possess two different sex chromosomes (ZW, heterogametic) and males possess identical sex chromosomes (ZZ, homogametic). The reason accurately defines the chromosome distribution that makes the female heterogametic.
• So, Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

17. **(A)** Stage Identification:
• Blastocyst (or Blastula stage).
(B) Exact Location:
• Implanted in the endometrium layer of the uterus.
(C) Functions of Labelled Parts:

• X (Trophoblast): Attaches to the endometrium during implantation and later helps form the placenta.
• Y (Inner Cell Mass): Differentiates and develops into the actual embryo (giving rise to all fetal tissues).

18. **(A)** Entry of Pollen Tube:
• End of Ovule: It enters through the micropylar end.
• How it enters: It is chemically guided into the embryo sac by the filiform apparatus located in the synergids.
(B) Fate of Male Nuclei:
• First Male Gamete: Fuses with the egg cell (syngamy) to form a diploid zygote (2n).
• Second Male Gamete: Fuses with the two polar nuclei (triple fusion) in the central cell to form the triploid primary endosperm nucleus (PEN) (3n).

19. **(A) (i)** Identification:
A: Plasmid (circular, double-stranded extrachromosomal DNA).
B: Bacteriophage (virus that infects bacteria).
(ii) Importance in Biotechnology:
• Both act as essential cloning vectors used to deliver and replicate foreign genes inside a host organism.

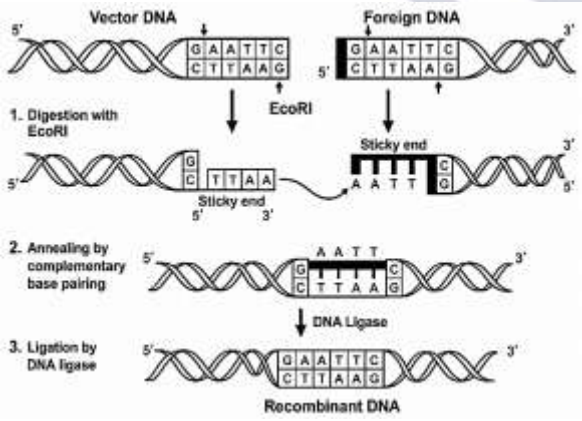
OR

(B) Bacterial Competence Process
(1) Divalent Cation Treatment: The bacterial cells are treated with a specific concentration of a divalent cation like Calcium (Ca^{2+}). This increases the permeability of the cell wall, allowing DNA to bind to the cell membrane.
(2) Chilling on Ice: The bacterial cells are incubated with the foreign recombinant DNA on ice.
(3) Heat Shock: The mixture is briefly subjected to a sudden temperature increase at 42°C for a short duration (heat shock).
(4) Recovery on Ice: The cells are immediately placed back on ice. This rapid shift in temperature creates transient thermal pores, forcing the bacterial cell to take up the foreign DNA.

20. Limitations of Ecological Pyramids
Two main limitations of ecological pyramids include:
• Exclusion of Saprophytes: Decomposers and saprophytes (e.g., bacteria and fungi) play a vital role in ecosystems, but they are not given any place in ecological pyramids.
• Assumption of Simple Food Chains: Ecological pyramids assume a simple, linear food chain. They do not accommodate the complex, interconnected food webs that actually exist in nature, nor do they account for species that occupy multiple trophic levels (like omnivores).

21. India's Land Area and Mega Diversity Status
• Percentage of Land Area: India accounts for approximately 2.4% of the world's total land area.
• Mega Diversity Status: India is considered one of the world's 12 mega-diversity countries because, despite its relatively small share of land, it harbors an immense variety of flora and fauna. India possesses a wide range of ecosystems (from deserts and mountains to forests and wetlands) and supports approximately 8.1% of the world's recorded species, making it exceptionally rich in global biodiversity.

22.



23. Pedigree Analysis
(A) Dominant or Recessive?
• Answer: Recessive.
• Reason: The trait skips generations. Unaffected parents in Generation I have an affected child (Individual 2 in Gen II), and unaffected parents in Generation II have an affected child (Individual 2 in Gen III).
(B) Autosomal or Sex-linked?

• Answer: Autosomal.
• Reason: An affected female in Generation II (partner of Individual 1) has an unaffected male child (Gen III, Individual 1). If it were an X-linked recessive trait, an affected mother (X^aX^a) would always pass the affected allele to her son, making him affected (X^aY). Since the son is normal, the trait must be autosomal.
(C) Genotypes of Children '1' and '3' of Generation II:
• Let A be the normal allele and a be the affected recessive allele.
• Genotype of Child 1 (Gen II): Aa (Heterozygous carrier, because he has an unaffected daughter with an affected female (aa), meaning he must pass a normal allele A).
• Genotype of Child 3 (Gen II): Aa (Heterozygous carrier, because she is unaffected but gives birth to an affected child, Gen III Individual 2 (aa)).

24. Stem Cells
(A) Characteristics of Stem Cells:
• Self-renewal: The ability to divide and replicate themselves indefinitely.
• Potency: The capacity to differentiate into various specialized cell types (e.g.muscle cells, nerve cells).
(B) Sources in Humans:
• Embryos (Inner cell mass of blastocyst stage).
• Adult Tissues (Bone marrow, adipose tissue).
• Umbilical Cord Blood (Collected at birth).
(C) Applications in Curing Human Diseases:
• Bone marrow transplantation to treat blood disorders and cancers like leukemia.
• Regenerative medicine to repair damaged tissues (e.g., treating Parkinson's disease or repairing cardiac tissue after a heart attack).

25. Cancer and Tumours
(A) Differentiation Table:

Feature	Benign Tumour	Malignant Tumour
Growth Rate	Grows slowly.	Grows rapidly and aggressively.
Localization	Remains confined to its original location.	Invades and destroys surrounding healthy tissues.
Metastasis	Does not spread to other parts of the body.	Spreads to distant organs via blood or lymph.

(B) Most Feared Property:
• Name: Metastasis.
• Explanation: Cells slough off from the primary malignant tumour and reach distant sites through blood circulation or the lymphatic system. Wherever these cells get lodged in the body, they start dividing rapidly to initiate a new secondary tumour, making the cancer difficult to treat and localize.

26. Sewage Treatment Process
(A) Primary sludge: The solid material that settles at the bottom during primary treatment. It consists of all solids like grit and organic matter that are removed through sedimentation.
(B) Activated sludge: The sediment formed during secondary treatment. When the "flocs" (masses of bacteria associated with fungal filaments) settle in the settling tank, this sediment is called activated sludge. A small part of it is pumped back into the aeration tank to serve as inoculum.
(C) Anaerobic sludge digesters: Large tanks where anaerobic bacteria digest the organic matter present in the sludge (both primary and activated). During this digestion, a mixture of gases such as methane, hydrogen sulfide, and carbon dioxide is produced, which forms biogas.

27. Primate Evolution

(A) Primate Ancestors (15 mya): Dryopithecus and Ramapithecus.

(B) Australopithecines: They lived about 2 million years ago in the East African grasslands.

(C) Homo habilis vs. Homo erectus:

• Brain Capacity: Homo habilis had a cranial capacity of 650-800cc, while Homo erectus had a larger brain around 900 cc .

• Diet/Habits: Homo habilis probably did not eat meat, whereas Homo erectus probably ate meat.

28. **(A)** Assisted Reproductive Technologies (ART)

(i) Abbreviations:

(1) ZIFT: Zygote Intra Fallopian Transfer

(2) ICSI: Intracytoplasmic Sperm Injection

(3) IUT: Intra Uterine Transfer

(4) GIFT: Gamete Intra Fallopian Transfer

(ii) Non-IVF Procedure:

GIFT (Gamete Intra Fallopian Transfer) is generally not considered an In-Vitro Fertilization (IVF) procedure.

• Reason: In IVF, fertilization occurs outside the body in a laboratory setting. In GIFT, the ovum and sperm are transferred into the fallopian tube, and fertilization occurs inside the female body (In-vivo).

OR

(B) Key Biological Differences

Feature	**Difference**
(i) Perisperm vs. Pericarp	Perisperm is the persistent residual nucellus in some seeds (e.g., black pepper). Pericarp is the wall of the fruit developed from the ovary wall.
(ii) Syncarpous vs. Apocarpous	In Syncarpous pistils, multiple carpels are fused together (e.g., Papaver). In Apocarpous pistils, the carpels are free (e.g., Michelia).
(iii) Plumule vs. Radicle	The Plumule is the part of the embryonic axis that develops into the shoot system. The Radicle is the part that develops into the root system.

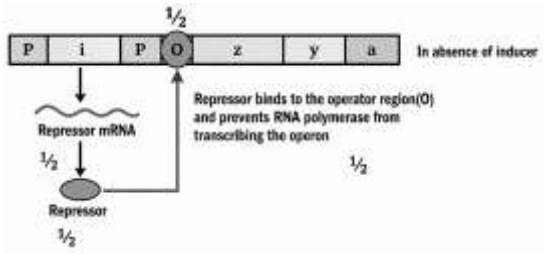
29. **(A)** In presence of lactose repressor protein dose not bind to the operator region (O) and allow RNA polymerase to transcribe the operon.

In absence of lactose repressor protein bind to the operator region (O) and prevent RNA polymerase from transcribing the operon.

(B) Presence of Permease enzyme coded by gene ' y ' is required that allows lactose to enter the cell for switching on the operon / so that lactose enter inside the cell.

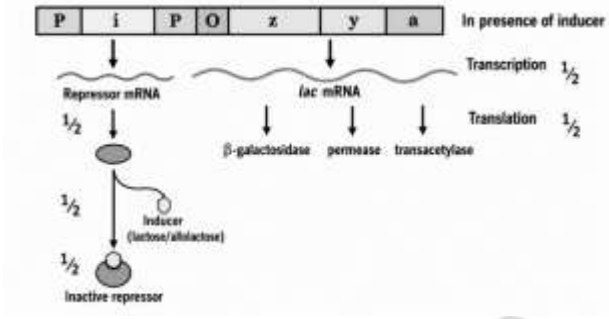
(C) 'i' stands for 'inhibitor/ this gene transcribes repressor protein which binds to the 'operator' site and switch off the operon.

(D)



OR

(D)



30. **(A)** Species Diversity from Region ' A ' to Region ' B '

Observation:

As you move from region 'A' (tropical) to region 'B' (temperate/polar), species diversity decreases. Biodiversity is highest near the equator and declines significantly as latitude increases toward the poles.

Reasons:

(1) Speciation and Time: Tropical regions (A) have remained relatively undisturbed for millions of years, allowing more time for species to evolve and diversify. In contrast, temperate regions (B) have faced frequent glaciations in the past.

(2) Solar Energy and Productivity: Region 'A' receives more intense and consistent solar energy throughout the year. This leads to higher primary productivity, which can support a wider range of species and complex food webs.

(B) Bird Species in India

• India has approximately 1,200 bird species.

Reason:

This high number is primarily because a significant portion of India's landmass lies in the tropical latitudes (like region ' A '). Tropical environments provide more favorable conditions, constant resources, and niche specialization compared to higher latitudes.

OR

(B) Region with Greatest Biodiversity

Region:

The Amazonian rain forest in South America records the greatest biodiversity on Earth.

• Tropical Location: It is located in the equatorial belt, benefiting from maximum solar energy and high rainfall.

• Environmental Stability: The climate is relatively stable and predictable without extreme seasonal changes, allowing species to specialize and thrive in specific ecological niches.

31. **(A)(i)** Nitrogen Types and Reasons:

• Types used: Heavy nitrogen (^{15}N) and light nitrogen (^{14}N).

• Reason: Nitrogen is an essential component of DNA. By growing E. coli in a medium containing the heavier isotope (^{15}N), they incorporated it into the bacterial DNA, making the DNA heavier. They could then track the incorporation of lighter nitrogen (^{14} N) over subsequent generations to understand how new DNA is synthesized.

(ii) Sampling at Definite Time Intervals:

• Reason: E. coli bacteria divide rapidly (every 20 minutes). Taking samples at definite time intervals (such as every 20 minutes/1 generation) allowed the scientists to extract and analyze the DNA of successive generations. This helped them observe the step-by-step transition of heavy DNA into hybrid and light DNA over time.

(iii) Role of Caesium Chloride Density Gradient:

• Role: The caesium chloride (CsCl) density gradient was used during ultracentrifugation. It allowed the separation and identification of different types of DNA molecules (heavy, hybrid, and light) based strictly on their

buoyant densities.
(iv) Conclusions Arrived At:
• Conclusion: They concluded that DNA replication is semi-conservative. This means that in each newly formed DNA molecule, one strand is derived from the parental (original) DNA, and the other strand is newly synthesized.

OR

(B) (i) Dihybrid Cross up to the F_2 Generation:
• Parents: Tall with round seeds (TTRR) × Dwarf with wrinkled seeds (ttrr)
• F_1 Generation: All Tall with round seeds (TtRr)
• Phenotypic Ratio of F_1: 100% Tall and Round (0.5.1)
If you self-pollinate the F_1 generation (TtRr × TtRr), the F_2 generation exhibits four combinations in a typical Punnett square:
• Tall & Round (T_R_): 9
• Tall & Wrinkled (T_rr): 3
• Dwarf & Round (ttR_): 3
• Dwarf & Wrinkled (ttrr): 1
Phenotypic Ratio of F_2: 9: 3: 3: 1
(ii) Mendelian Principle Derived:
• Principle of Independent Assortment: This cross demonstrates that when two pairs of traits are combined in a hybrid, segregation of one pair of traits is independent of the other pair of traits (e.g., plant height segregates independently from seed shape).

32. (A) (i) The vaccine contains the antigen, which stimulates or activates immune cells to produce antibodies (by B lymphocytes) / which generates primary response or humoral immune response.
(ii) Memory cells generate, amnestic response/secondary response
(iii)P=Yes
Q= Catching an infection/getting infected
R=No
S=Yes
T=No

OR

(B) (i) Diacetylmorphine
• as it is highly addictive, and being a depressant it slows down body functions.
(ii) (1) Cannabis sativa, affects the cardiovascular system of the body.
(2) Erythroxylum coca /coca plant, interferes with the transport of neurotransmitter dopamine / produces sense of euphoria / increased energy.
(3) Papaver somniferum, acts as depressant/slows down body function/ reduces pain/sedative

33. (A) (i) Pollen transfer methods:
• Method 1: Autogamy (self-pollination)
• Method 2: Geitonogamy (Pollination between flowers of the same plant)
• Method 3: xenogamy (Cross-pollination between different plants)
(ii)
(1) Water lily (Nymphaea) - Entomophily (Insect pollination):
• The insects transfer pollen when visiting flowers for nectar.
• It is pollinated by insects like beetles and bees.
(2) Vallisneria - Hydrophily (water pollination):
• Male pollen grains or blooms separate and float on the water's surface.
• Pollen is transported to the female flowers by water currents.
(iii) One hereditary and one physiological device to avoid inbreeding depression
Plants have evolved outbreeding devices to prevent self-pollination and inbreeding.
Hereditary Device: Self-incompatibility (Self-sterility)
• It is a genetically controlled mechanism.
• Pollen grains from the same plant are unable to fertilize the ovules of that plant.
Physiological Device: Dichogamy
• Pollen release and stigma receptivity occur at different times.
• Thus self-pollination is prevented.
(Protandry and protogyny are examples of dichogamy.)

OR

(B) (i) Technical Terms
(1) Days 1-7: Menstrual phase (Menstruation)
(2) Days 8-12: Follicular phase (Proliferative phase)
(3) Days 13-15: Ovulatory phase
(4) Days 16-28: Luteal phase (Secretory phase)
(ii) Role of Hormones
(1) Days 8-12 (Follicular Phase)
• Pituitary Hormones: Secretion of FSH (Follicle Stimulating Hormone) and LH (Luteinizing Hormone) increases gradually. FSH stimulates the growth of primary follicles into mature Graafian follicles.
• Ovarian Hormones: The growing follicles secrete Estrogen, which stimulates the regeneration and proliferation of the uterine endometrium.
(2) Days 13-15 (Ovulatory Phase)
• Pituitary Hormones: Both LH and FSH attain a peak level in the middle of the cycle. A rapid surge in LH (LH surge) induces the rupture of the Graafian follicle.
• Ovarian Hormones: High levels of Estrogen peak just before ovulation to trigger the LH surge, resulting in the release of the ovum (ovulation).
(3) Days 16-28 (Luteal Phase)
• Pituitary Hormones: LH and FSH levels decline. LH maintains the corpus luteum for a period.
• Ovarian Hormones: The ruptured follicle transforms into the corpus luteum, which secretes large amounts of Progesterone. Progesterone is essential for maintaining the endometrium for potential implantation of a fertilized ovum.

34. (b)• Sex Determination
• Explanation: In grasshoppers, the XO type of sex determination occurs where males have only one X chromosome (XO) and females have two (XX).
• Why others are wrong: (a) In birds, ZZ is male (homogametic). (c) XXY in humans is Klinefelter Syndrome, not Turner (which is XO). (d) In Drosophila, XX is female.

35. (c)• Meselson and Stahl Experiment
The sequence of the semi-conservative DNA replication experiment is:
(III) Bacteria grown in ^{15}N medium for many generations.
(IV) All bacteria contain ^{15}N DNA (Heavy).
(I) Bacteria transferred to a ^{14}N medium and sampled every 20 minutes.
(II) All bacteria contain hybrid DNA (^{14}N and ^{15}N) after the first generation.
(V) Bacteria contain either all ^{14}N DNA or hybrid DNA in subsequent generations.

36. (a) Evolutionary Patterns
• Explanation: The Mouse (placental mammal) and the Marsupial mouse are from different lineages but evolved similar physical features because they occupy similar ecological niches in different regions (or the same region like Australia). This is a classic example of Convergent Evolution.

37. (d) Surgical Contraception (Vasectomy)
• Explanation: The diagram shows the human male reproductive system. The surgical method of contraception in males is called a vasectomy. In this procedure, a small part of the vas deferens is removed or tied up.
Point P labels the vas deferens.
Point S labels the urinary bladder.
Point T labels the seminal vesicle.
Point Q labels the prostate gland.
Point R labels the epididymis.

38. (c) • Hormone Matching
• Explanation: Although the fourth row (S) of the table is cut off in the image, standard question archives like Testbook show that row S represents Progesterone and iv represents the Ovaries. The correct biochemical matches are:
(P) Oxytocin → (III) Pituitary Gland (produced by the hypothalamus, stored/released by the posterior pituitary).
(Q) Relaxin → (IV) Ovaries (secreted by the corpus luteum within the ovary).
(R) hCG → (I) Placenta (human chorionic gonadotropin secreted by trophoblastic cells).
(S) Progesterone → (II) Corpus Luteum (maintains the uterine endometrium).

39. (a) Seed Longevity

• Explanation: Viability records from archaeological excavations indicate that seeds of the date palm, Phoenix dactylifera, recovered from King Herod's palace near the Dead Sea, remained viable and germinated after nearly 2,000 years.

40. **(d)** Incorrect Statements about T-lymphocytes

• Explanation:
(I) They are a type of white blood cell. → Correct (They are agranular leukocytes).
(II) They are produced in bone marrow. → Correct (All blood cells originate in the bone marrow hematopoietic stem cells).
(III) They remain active at all times. → Incorrect (They stay inactive as naive cells until they encounter a specific matching antigen).
(IV) They mature in the bone marrow. → Incorrect (Immature T-cells migrate to the Thymus to mature and undergo selection, which is why they are called "T" cells).

41. **(a)** (II) Population of large animals decreases: Small patches often lack the resources and space required to support large animals.
(III) Biodiversity decreases: Fragmentation reduces the number of species a habitat can sustain.
(IV) Competition from surrounding habitats increases: This is due to the "edge effect," where external influences from adjacent areas impact the small patch.
Note: (I) is incorrect because small, disturbed patches are actually more vulnerable to invasive species.

42. **(c)** While the female Anopheles mosquito bites humans for a blood meal to provide nutrients for its eggs, it is considered a predator or a micropredator rather than a parasite. It does not live on or in the host for an extended period to complete its life cycle.

43. **(d)** • Penicillium roqueforti
Note: There is a slight error in the options provided in the image. While (d) mentions Penicillium notatum (the source of Penicillin), the specific fungus that ripens Roquefort cheese is actually Penicillium roqueforti. Given the choices, (d) is the intended category.
Saccharomyces cerevisiae: Brewer's yeast used in baking and brewing.
Propionibacterium sharmanii: Bacterium used to give Swiss cheese its large holes.
Monascus purpureus: Yeast used to produce statins (blood cholesterol-lowering agents).

44. **(b)** Step P → Shows double-stranded DNA intact. This is the starting material before denaturation. → So, statement (I) "denaturation at low temperature" is incorrect (denaturation requires high temperature).
Step Q → DNA strands are separated (denaturation at high temperature) and primers are annealed.
→ Statement (II) "denaturation at high temperature, followed by annealing" is correct.
→ Statement (IV) "extension with two sets of primers" is incorrect (extension happens later, not here).
Step R → DNA strands are extended by thermostable DNA polymerase (Taq polymerase). → Statement (III) "extension in presence of thermostable DNA polymerase" is correct.

45. **(b)** A child inherits half of their DNA bands from one parent and half from the other parent.
Therefore, every band in the child's profile must match with at least one band from each parent.
• Step-by-Step
Child X has a set of DNA bands.
Compare with Individual 1 → Some bands match.
Compare with Individual 2 → Some bands match.
Compare with Individual 3 → Some bands match too, but not all required.
When checking carefully, the child's bands are fully accounted for only when combining Individual 1 and Individual 2. This means they are the actual parents.

46. **(a)** Assertion (A): In humans, genotype AABBCC has the darkest skin colour. True
Reason (R) : In a polygenic trait, phenotype reflects the contribution of each allele. True
Since skin colour is a polygenic trait and dominant alleles contribute additively, AABBCC gives the darkest skin colour.

47. **(c)** Assertion (A): The number of white-winged moths decreased drastically after industrialisation in England. True
Reason (R): Effects of industrialisation were more marked in rural areas of England. False
Industrialisation was more marked in urban/industrial areas, not rural areas.

48. **(a)** Assertion (A): More and more children in metro cities of India suffer from allergies and asthma. True

Reason (R): Modern lifestyle and a protected environment in early life have resulted in lowered immunity. True
This is explained by the hygiene hypothesis.

49. **(c)** Assertion (A): The Mediterranean orchid Ophrys uses sexual deceit to get pollinated by a species of bee. True
Reason (R): The female bee changes its colour depending on the temperature of the area. False
The orchid mimics the appearance and pheromones of the female bee; the female bee does not change colour due to temperature.

50. **(A)** Process of Development of a Male Gametophyte
The pollen grain (microspore) is the first cell of the male gametophyte. Its development occurs in two distinct phases:
(1) Pre-pollination development (Inside Anther):
• The microspore expands in size and develops a large central vacuole, pushing the nucleus to one side.
• The nucleus undergoes an asymmetric mitotic division to form two unequal cells: a large vegetative cell (rich in food reserves) and a small generative cell (spindleshaped, floating in the cytoplasm of the vegetative cell).
• In over 60% of angiosperms, pollen grains are shed at this 2 -celled stage.
(2) Post-pollination development (On Stigma):
• Once landed on a compatible stigma, the pollen grain absorbs moisture and germinates, extending into a pollen tube through a germ pore.
• The generative cell divides mitotically inside the pollen tube to form two male gametes (forming the 3-celled stage).
(B) Why is it called a Male Gametophyte?
It is called a gametophyte because it is a haploid (n) multicellular structure that produces and carries the male gametes essential for sexual reproduction.

51. **(A)** First Step in Secondary Treatment Plant
• First Step: The primary effluent is pumped into large aeration tanks where it is continuously mechanically agitated and air is forcefully injected.
• Purpose: This promotes the rapid growth of useful aerobic microbes into flocs (masses of bacteria intertwined with fungal filaments to form mesh-like structures). These microbes decompose and consume the bulk of the dissolved organic matter in the wastewater.
(B) Level of B.O.D. and its Significance
• Indication: Biochemical Oxygen Demand (B.O.D.) indicates the amount of biodegradable organic matter present in the water sample. A higher B.O.D. value signifies highly polluted water with low dissolved oxygen.
• Significance: B.O.D. serves as a critical measure for treatment progress. The secondary biological treatment is sustained continuously until the B.O.D. of the sewage is drastically reduced, verifying that the water is safe enough to be discharged into natural water bodies.

52. **(A)** Identification of Organisms
• Two Producers: 1 and 2 (or 3) - Reason: All arrows originate from them, indicating they generate energy via photosynthesis.
• Two Carnivores: 6 and 8 (or 9) - Reason: They exclusively consume other consumers/animals in the network.
(B) Feasibility of an Ecological Pyramid
Answer: No, it is not possible to construct a standard ecological pyramid for a food web.
• Reason: Ecological pyramids are strictly built on the assumption of a simple, linear food chain where a species occupies exactly one fixed trophic level. In a food web, an organism can occupy multiple trophic levels simultaneously (e.g., organism 7 acts as both a secondary and tertiary consumer depending on the pathway), which cannot be geometrically represented in a rigid pyramid.

53. Alien Species Invasion and Indigenous Decline
When non-native (alien) species are introduced unintentionally or deliberately into a new geographical habitat for any purpose, some turn invasive due to a lack of natural predators and compete aggressively for resources, causing the decline or extinction of indigenous species.
• Classic Example: The introduction of the Nile Perch into Lake Victoria in East Africa.
• Impact: This predatory fish multiplied rapidly and aggressively hunted local fauna, eventually causing the catastrophic extinction of an ecologically unique assemblage of more than 200 species of native cichlid fish in the lake.

54. **(A)** Insertional Inactivation Method
Insertional inactivation is a highly efficient screening technique used to differentiate recombinant colonies from non-recombinant ones based on color selection:

• Mechanism: A foreign DNA fragment is cloned directly into the coding sequence of a reporter enzyme, typically β-galactosidase (encoded by the lacZ gene) on a plasmid vector.
• Non-Recombinants: If the plasmid does not take up the foreign DNA, the lacZ gene remains functional. The enzyme converts a chromogenic substrate added to the agar medium into blue-colored colonies.
• Recombinants: The introduction of foreign DNA breaks the coding sequence of the gene, inactivating the enzyme (insertional inactivation). Consequently, these colonies fail to produce any color and appear as white colonies, allowing direct visual identification.

OR

(B) Early Disease Detection using rDNA Technology
Recombinant DNA technology allows diagnosis long before clinical symptoms present, at a stage when the pathogen concentration is otherwise undetectable:
• Polymerase Chain Reaction (PCR): Even if a single virus or bacterium is present in the body, its nucleic acid (DNA/RNA) can be amplified billions of times in a few hours. This allows early detection of viral replication (like HIV or localized cancers) before symptoms manifest.
• DNA Probes and Autoradiography: A single-stranded DNA or RNA molecule is tagged with a radioactive molecule to serve as a probe. This probe is allowed to hybridize with complementary genomic strands in a patient's cell clone. Upon detection via autoradiography, if a targeted gene has mutated, it will fail to bind with the probe and will not appear on the photographic film, revealing genetic disorders at a molecular stage.

55. **(A)** RNA Polymerase and hnRNA Processing
(i) RNA Polymerases: There are three main types of RNA polymerases in a eukaryotic cell. RNA polymerase II is the one responsible for transcribing hnRNA (heterogeneous nuclear RNA).
(ii) Post-transcriptional Changes (Processing): Before leaving the nucleus as mRNA, hnRNA undergoes:
(1) Splicing: Removal of non-coding regions (introns) and joining of coding regions (exons).
(2) Capping: Addition of an unusual nucleotide (methyl guanosine triphosphate) to the 5′ end.
(3) Tailing: Addition of adenylate residues (poly-A tail) to the 3′ end.

OR

(B) DNA Packaging in Eukaryotes
To fit inside a tiny nucleus, DNA is wrapped around a core of eight positively charged histone proteins to form a nucleosome. These "beads-on-a-string" structures further coil into chromatin fibers, which then condense into chromosomes during cell division.

56. ART Techniques
(A) GIFT (Gamete Intra-Fallopian Transfer): Transfer of an ovum collected from a donor into the fallopian tube of another female who cannot produce one but can provide a suitable environment for fertilization.
(B) ZIFT (Zygote Intra-Fallopian Transfer): The zygote or early embryo (up to 8 blastomeres) is transferred into the fallopian tube.
(C) IUI (Intra-Uterine Insemination): Semen collected from the husband or a donor is artificially introduced into the vagina or the uterus of the female.

57. Seminiferous Tubule
(A) Developmental Processes
(i) 'b' (Primary spermatocyte) from 'a' (Spermatogonium): Mitosis and differentiation.
(ii) 'e' (Spermatozoa) from 'd' (Spermatid): Spermiogenesis.
(iii) 'd' (Spermatid) from 'b' (Primary spermatocyte): Meiosis (I and II).
(B) Identification
a: Spermatogonium
b: Primary spermatocyte
c: Sertoli cell (Nurse cell)

58. Evolution and Natural Selection
(A) Limitations of Darwin's Theory
• Origin of variations: Darwin recognized that variations exist, but he could not explain how or why these variations arise in a population.
• Mechanism of inheritance: He had no knowledge of genetics to explain how variations are transmitted from parents to offspring.
• Distinction between variations: He did not differentiate between somatic variations (non-heritable) and germinal variations (heritable).
(B) Most Accepted Modern Theory
• Name: Modern Synthetic Theory of Evolution (also known as Neo-Darwinism).

• Statement: Evolution occurs through gradual changes in the allele frequencies of a population over generations, driven by the combined effects of genetic variation (mutations, recombination), natural selection, and reproductive isolation.

(C) Explanation of Limitations in Modern Biology

Modern biology explains Darwin's missing links primarily through:

(1) Gene Mutations: Spontaneous alterations in DNA sequences that introduce brandnew alleles into a population's gene pool.

(2) Genetic Recombination: Re-shuffling of existing alleles due to crossing over during meiosis, producing new combinations of traits in offspring.

59. Biomolecules and Drugs

The structure displayed is Morphine.

(A) Category of Drugs

• Opioids (or Narcotic Analgesics)

(B) Name of the Compound

• Heroin (chemically known as Diacetylmorphine, commonly called Smack).

(Note: While the question text mentions substituting the methyl group, standard chemical synthesis of this bitter crystalline compound involves the acetylation of the two hydroxyl groups on morphine).

(C) Natural Source

• Latex of the Poppy plant (Papaver somniferum).

(D) Harmful Effects on the Human Body

• Acts as a potent central nervous system depressant.

• Significantly slows down overall body functions (including heart rate and respiration).

• Causes intense physical and psychological dependence/addiction.

60. Biotechnology and Pest Resistance

(A) Nematode Details

• Scientific Name: Meloidogyne incognita

• Part Infested: Roots of the tobacco plant.

(B) Role of Agrobacterium in Protection (RNA Interference)

• Vector Delivery: Agrobacterium vectors are modified to introduce nematode-specific genes directly into the genome of the host tobacco plant.

• RNA Production: The introduced DNA is designed such that it produces both sense and anti-sense RNA inside the host plant cells.

• Double-Stranded RNA (dsRNA) Formation: Being complementary to one another, these two RNA strands bind together to form a stable molecule of double-stranded RNA (dsRNA).

• Gene Silencing: This dsRNA triggers a cellular defense mechanism called RNA interference (RNAi), which cuts up and silences the specific mRNA of the invading nematode. Without this mRNA, the parasite cannot synthesize essential proteins, preventing it from surviving inside the transgenic plant.

61. Population Interactions

(A) Brood Parasitism

• Explanation: This is a specialized form of parasitism found in birds where the parasitic species lays its eggs in the nest of a host bird species, leaving the host to incubate and rear the young. Over evolutionary time, the eggs of the parasite have come to mimic the host's eggs in size, color, and patterns to minimize detection and rejection.

• Example: The Cuckoo (Koel) lays its eggs in the nest of the Crow.

(B) Co-evolution of Mutualists

• Explanation: This is an evolutionary phenomenon where two mutually dependent species exert selective pressure on each other, causing them to evolve together. A structural or behavioral change in one species necessitates a corresponding adaptation in the partner species to maintain the integrity of their symbiotic relationship.

• Example: The mutualism between the Fig tree and its partner Wasp species. A particular fig species can only be pollinated by its specific wasp partner, which in turn depends entirely on that fig variety for egg-laying and larval nutrition.

62. Pedigree Chart Analysis

(i) Linkage Type

• Answer: The disease is Autosomal.

• Reason: An affected father (' E ') has passed the trait down to his son (' I '). In X-linked inheritance, a father passes only his Y-chromosome to his sons, meaning father-toson transmission is impossible for X-linked traits.

(ii) Dominant or Recessive

• Answer: It is a Recessive disorder.

• Reason: The condition can bypass generations or express itself through unaffected parents if they are carriers (as explicitly indicated by the mention of a "carrier" state in sub-question iv-B).

(iii) Genotypes of Individuals

(Let 'A' represent the normal dominant allele and 'a' represent the affected recessive allele):

• Individual 'C': Aa (Must inherit a recessive ' a ' allele from her affected father 'A')

• Individual 'D': Aa (Must inherit a recessive ' a ' allele from her affected father 'A')

• Individual 'H': Aa (Must inherit a recessive ' a ' allele from her affected father ' E ')

(iv) Probability Calculations

(A) 0% (or 0)

• Reasoning. Female "D' has the genotype Aa. A standard "normal man" is homozygous dominant (AA). A cross between Aa × AA produces only AA and Aa genotypes, ensuring that none of their daughters will manifest the recessive disease.

OR

(B) 50% (or $\frac{1}{2}$)

• Reasoning. The affected father ' A ' is a a . If mother ' B ' is a carrier (A a), a cross between them (aa × Aa) yields a I: I ratio of carrier (Aa) to affected (aa) offspring. Therefore, any daughter born to them has a 50% chance of being a sufferer.

63. (i) Parasitic Stage Transferred

Sporozoites: This is the infectious, spindle-shaped stage present in the salivary glands of the mosquito that enters the human bloodstream upon biting.

(ii) Changes in the Liver

The sporozoites reach the liver cells through the blood.

Inside liver cells, they reproduce asexualy (by schizogony) to produce thousands of new forms called merozoites.

The infected liver cells eventually rupture, releasing these merozoites into the blood circulation.

(iii) Changes in the Red Blood Cells (RBCs)

• The released merozoites invade the RBCs.

• They multiply asexualy inside the RBCs, causing them to enlarge and eventually rupture to infect fresh RBCs.

• Some of these merozoites differentiate into the sexual stages, namely male and female gametocytes, which remain in the bloodstream.

(iv) (A) Changes inside Host ' X ' (Mosquito) after blood meal:

(1) Ingestion: The mosquito sucks up blood containing male and female gametocytes from the infected human.

(2) Fertilization: These gametocytes mature into gametes and fuse in the mosquito's gut to form a zygote (sexual reproduction).

(3) Development: The zygote elongates into a mobile ookinete, penetrates the gut wall, and develops into an oocyst.

(4) Sporogony: Inside the oocyst, the parasite multiplies asexually to form thousands of sporozoites.

(5) Migration: The oocyst bursts, and the sporozoites migrate to the salivary glands of the mosquito, making it infectious.

OR

(B) Symptom onset details:

• Stage of Symptoms: Symptoms appear during the erythrocytic cycle, specifically when the infected red blood cells (RBCs) rupture periodically.

• Name of Disease: Malaria

• Toxic Substance: Haemozoin (a crystalline toxic byproduct released along with merozoites when RBCs burst, responsible for inducing high fever and chills).

64. (A) (i) Importance and Sources of Plasmids:

• Why it is an important tool: Plasmids are extra-chromosomal, circular, doublestranded DNA molecules that can replicate autonomously inside host cells. They act as vectors to carry a foreign piece of DNA (gene of interest) into a host organism.

• Two Sources: They can be isolated from bacteria (e.g., Escherichia coli) and certain fungi/yeast (e.g., Saccharomyces cerevisiae).

(ii) Roles in a Cloning Vector:

• 'ori' (Origin of Replication): This is a specific DNA sequence where replication initiates. Any piece of foreign DNA linked to this sequence can replicate inside the host cell. It also controls the copy number of the linked DNA.
• Selectable Marker: This gene helps in identifying and eliminating nontransformants while selectively permitting the growth of transformants (e.g., antibiotic resistance genes like amp^R or $tett^R$).
(iii) Justification for Restriction Endonucleases:
• Recombinant DNA technology depends on cutting a specific donor DNA sequence containing the target gene and splicing it into a vector. Restriction endonucleases act as "molecular scissors" that recognize specific palindromic sequences to make precise cuts, creating matching sticky ends. Without them, DNA cannot be sliced out or combined into a vector to create recombinant strands.

OR

(B) (i) Why Farmers Prefer Bt Cotton:
• Bt cotton provides inherent resistance to specific insect pests (like bollworms) without requiring frequent applications of expensive chemical insecticides. This reduces cultivation costs, minimizes chemical exposure to the ecosystem, and increases overall crop yield.
(ii) Two Insects Killed by Bt Toxin:
• Cotton bollworms (Helicoverpa armigera) and Corn borer (Ostrinia nubilalis).
(iii) Mechanism of Action and Bacterial Safety:
• Why it does not kill the bacterium: The bacterium (Bacillus thuringiensis) produces the toxin as an inactive, crystalline protoxin. It remains harmless inside the bacterial cell.
• How it kills insects: Once an insect ingests the protoxin, the alkaline pH of its midgut solubilizes the crystals. Proteolytic enzymes convert the protoxin into its active toxic form. The active toxin binds to the surface of midgut epithelial cells, creating pores that cause cell swelling, lysis, and eventually lead to the death of the insect.

65. (A): Role of RNAs in Prokaryotic Protein Synthesis

In prokaryotes, protein synthesis (translation) relies on the coordinated action of three types of RNA:
• m-RNA (Messenger RNA): Acts as the template. It carries the genetic code from the DNA in the form of triplets called codons, which dictate the specific amino acid sequence of the protein.
• t-RNA (Transfer RNA): Acts as an adapter molecule. It reads the codons on the mRNA via its anticodon loop and brings the corresponding amino acids to the ribosome for protein assembly.
• r-RNA (Ribosomal RNA): Provides the structural and catalytic framework for the ribosome. It ensures the correct alignment of m-RNA and t-RNAs and, in its catalytic role (as a ribozyme), facilitates the formation of peptide bonds between amino acids.

OR

(B): Dihybrid Cross in Pea Plants
Initial Setup:
• Parents: Homozygous Tall, Green (TTyy) × Homozygous Dwarf, Yellow (ttYT).
• Note: In pea plants, Yellow (Y) is dominant over green (Y), and T all (T) is dominant over dwarf (t).
(i) F_1 Generation
• Genotype: TtYy (All are heterozygous for both traits).
• Phenotype: Tall with Yellow seeds.
(ii) Mendel's Laws Proven
(1) Law of Dominance: Only the dominant traits (Tall and Yellow) are expressed in the F_1 phenotype.
(2) Law of Segregation: Alleles for a trait separate during gamete formation, ensuring the F_1 receives one allele from each parent.
(iii) F_2 Phenotypic Ratio
The phenotypic ratio is $9:3:3:1$.
• 9: Tall, Yellow
• 3: Tall, Green
• 3: Dwarf, Yellow
• 1: Dwarf, Green
(iv) Gametes Produced by F_1 Progeny
The F_1 plant (TtYy) produces four types of male and female gametes through independent assor tment:
• TY
• Ty
• tY
• ty

66. (A) (i) Identify the parts ' a ', ' b ' and ' c '

In the diagram of the human ovum:

- a - Corona radiata (outer layer of follicular cells)
- b - Zona pellucida (non-cellular glycoprotein layer around the ovum)
- c-Nucleus (female pronucleus/germinal vesicle)
- d - Cytoplasm (ooplasm)

(ii) This ovum is released from the ovary with incomplete meiotic division. When, where and how is meiosis completed?

- The secondary occyte is released from the ovary at metaphase-II stage.
- Meiosis-II is completed only after the entry of a sperm during fertilisation.
- It occurs in the ampullary-isthmic junction of the fallopian tube (oviduct).
- The secondary oocyte undergoes meiosis-II and forms:
- One mature ovum (haploid, n)
- One second polar body (haploid, n)

(iii) How does an ovum ensure the entry of a single sperm during fertilisation?

After the first sperm enters the ovum:

(1) Cortical granules present beneath the plasma membrane release their contents.

(2) This causes changes in the zona pellucida (zona reaction).

(3) The zona pellucida becomes impermeable to other sperms.

(4) Thus, polyspermy is prevented, ensuring entry of only one sperm.

OR

(B) (i) Double fertilisation is unique to flowering plants. Explain.

Double fertilisation involves two fusion events:

(1) Syngamy

- One male gamete fuses with the egg cell.
- Forms a diploid zygote (2n).

$n + n = 2n$

(2) Triple Fusion

- The second male gamete fuses with two polar nuclei (secondary nucleus) in the central cell.
- Forms the triploid primary endosperm nucleus (PEN) (3n).

$n + n + n = 3n$

Since two fertilisation events occur in the same embryo sac, it is called double fertilisation, a characteristic feature of angiosperms.

(ii) Give reasons for the following

(1) A seed of orange has many embryos.

Orange seeds show polyembryony.

- Besides the normal zygotic embryo, additional embryos develop from nucellar cells of the ovule.
- Therefore, a single seed contains many embryos.

(2) Cashew is a false fruit but Guava is a true fruit.

Cashew - False Fruit

- The edible fleshy part develops from the thalamus (receptacle) and not from the ovary alone.
- Hence, cashew is a false fruit (pseudocarp).

Guava - True Fruit

- The fruit develops only from the ovary after fertilisation.
- Hence, guava is a true fruit.

67. (b) Neanderthal man used hides to protect their bodies and buried their dead bodies. They used animal hides as clothing too.

68. (d) (a) Gamete intrafallopian transfer (GIFT): In this procedure, a woman's ovaries are removed, and the man's sperm and eggs are put in one of the fallopian tubes.

(b) Intracytoplasmic sperm injection (ICSI): In this method, the zygote is created in vitro, or in a lab, when the sperm is directly placed into an ovum. Now ZIFT is transferring this zygote into the female's body.

(c) Zygote intrafallopian transfer (ZIFT): Following fertilisation, the embryo is transferred using this method directly into the female's fallopian tube.

(d) Intrauterine insemination (IUI): In this technique, the sperm are transferred into a female uterus using a long, narrow tube.

69. **(b)** The decrease in the T-lymphocyte count in human blood will result in Decrease in antibodies.
T-lymphocytes (T-cells) play a key role in the immune response, especially by helping B-lymphocytes to produce antibodies. If the Tlymphocyte count decreases, the immune response weakens, leading to a decrease in antibody production.

70. **(a)**

3' AUCAGGUUUGUGAUGGUACGA 5'	
↑	↑
Position	Position
3	5

Codons UUU and AUG represent the amino acids phenylalanine and methionine, respectively. Therefore, during the process of translation, the amino acids phenylalanine and methionine would be merged at codon positions 3 and 5, accordingly.

71. **(d)** A Tight one-to-one relationship between many species of fig tree and certain wasps is an example of Mutualism.
There is mutualism connection between fig trees and wasps. A wasp pollinator species has a one-to-one association with fig trees.

72. **(d)** Entamoeba histolytica, a tiny organism that is transmitted through human faeces, causes the intestinal disease amoebiasis. Sometimes it results in diarrhoea (loose stools/poop), nausea (a sense of illness in the stomach), and weight loss, but most of the time there are no symptoms.
Ringworm is a disease caused by a variety of fungi belonging to the genera Microsporum, Trichophyton, and Epidermophyton. The primary signs and symptoms of this condition are the development of dry, scaly lesions on the scalp, nails, and skin.
A parasite condition known as elephantiasis results in significant swelling in the arms and legs. Wuchereria bancrofti, a filarial worm that spreads from person to person when a female mosquito feeds on blood, is the disease's main cause.
Meningitis (inflammation of the membranes encasing the spinal column and brain), bacteremia (infection of the blood), and pneumonia (infection of the lungs) are just a few of the illnesses caused by Haemophilus infiuenzae.

73. **(a,c)** The primary productivity in an ecosystem is expressed as $gm^{-2}yr^{-1}$ or $Kcalm^{-2}yr^{-1}$.
Primary production is defined as the amount of biomass or organic matter produced per unit area over a time period by plants during photosynthesis. It is expressed in terms of weight (gm^{-2}) or energy ($kcalm^{-2}$). The rate of biomass production is called productivity. It is expressed in terms of $gm^{-2}yr^{-1}$ or $(kcalm^{-2})yr^{-1}$ to compare the productivity of different ecosystems.

74. **(d)** The recognition sequence of Pst-I is:
$5'CTGCA \downarrow G3'$
$3'G \uparrow ACGTC5'$
So the cuts occur:
• Top strand: between A and G
• Bottom strand: between G and A
Thus the DNA is cleaved into:
Fragment 1
$5'C-T-G-C-A$
$3'G$
and
Fragment 2
$5'G3'$
$3'A-C-G-T-C5'$
which produces a $3'$ overhang (TGCA).

75. **(c)** The IUCN Red Data List (2004) in the last 500 years documents the extinction of nearly 784 species including **359** invertebrates.

The IUCN Red List (2004) documents the extinction of 784 species (including 338 vertebrates, 359 invertebrates and 87 plants) in the last 500 years.

76. (d)

List A Bioactive Products		**List B Microbes (Source Organism)**	
(A)	Cyclosporin - A	**(II)**	Trichoderma polysporum
(B)	Statins	**(IV)**	Monascus purpureus
(C)	Streptokinase	**(I)**	Streptococcus
(D)	Penicillin	**(III)**	Penicillium notatum

77. (d) A population is a collection of people who belong to the same species and live in a specific location. Population density, sex ratio, age distribution pattern, birth rate, and death rate are characteristics of a population, not an individual.

78. (c) X - Suspensor (2n), Y - Cotyledon (2n), Z - Radicle (2n), U - Plumule (2n).

79. (b) Amniocentesis is the examination of amniotic fluid to find any chromosomal or congenital genetic abnormalities in the foetus.
Amniocentesis being used improperly to identify an unborn child's gender is one possible trend. When a female foetus is discovered, MTP (medical termination of pregnancy), which is completely outside the law, often takes place.

80. (a) In order to base-pair with a strand of DNA or RNA, oligonucleotides are created. Oligonucleotides are most frequently used as polymerase chain reaction primers. The 5 ' end of the sequence intended for amplification serves as the complement to at least part of the sequence used in the construction of primers. The primers anneal to the complementary sequences on the DNA templates during the annealing process.

81. (b) Decomposition is the conversion of organic material into basic inorganic material. The rate of decomposition changes under the same environmental conditions because detritus composition fluctuates. The decomposition rate is slow if the waste material contains a lot of lignin and cutin.

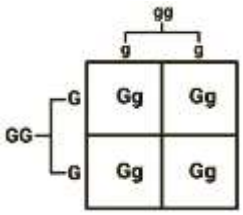
82. (d) Thalassemia is an autosomal recessive blood disorder caused by either variation or elimination, which ultimately results in a decreased rate of synthesis of one of the globin chains (α or β chains) that make up haemoglobin. Anaemia, a defining feature of the disease, results from the development of abnormal haemoglobin molecules as a result of this. The chain of the haemoglobin molecule that is imposed can help to categorise thalassemia. Production of the α-globin chain is impacted by α-thalassemia. The HBA-1 and HBA-2 genes on chromosome 16 of each parent regulate thalassemia, which is caused by mutation or deletion of one or more of the four genes.

83. (A) 50 years
(B) 10 years

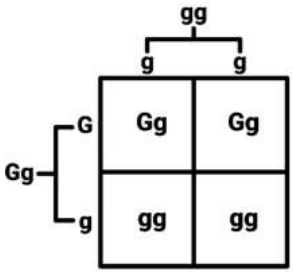
84. Organisms have evolved features that allow them to survive in the complex food chain and protect them from predators. A good example of this is calotropis. Calotropis, often known as milkweed, produces cardiac glycosides, which are extremely dangerous chemicals that harm a mammal's heart. The calotropis plant uses this defence strategy to keep animals away from it. Cattle and goats do not eat or browse on this plant because of this.

85. A test cross is formed by crossing a parent with an unknown genotype with another parent who has a homozygous recessive genotype. A test cross determines or reveals the original person's genotype. A test cross can help determine whether a dominant phenotype is homozygous or heterozygous for a specific trait.
Given:
Dominant allele: G

Dominant trait: Green pod colour
Recessive allele: g
Recessive trait: yellow pod colour
Case 1:



Genotypic ratio: 100% heterozygous dominant i.e., 1 : 0 ratio.
Phenotypic ratio: all green
Inference: Unknown is homozygous dominant
Case 2:



Genotypic ratio: 50% heterozygous dominant and 50% homozygous recessive i.e., 1 : 1 ratio.
Phenotypic ratio: 50% Green: 50% Yellow
Inference: Unknown is heterozygous dominant.

86. **(A) (i)** Most of the baculoviruses used as biological control agents are in the genus Nucleopolyhedrovirus.
(ii) Baculoviruses (Nucleopolyhedroviruses) are great biocontrol agents for species-specific, narrow-spectrum insecticidal applications. They have no adverse effects on plants, mammals, birds, fish, or non-target insects. These are especially crucial when it comes to preserving beneficial insects as part of an overall Integrated Pest Management (IPM) programme. These viruses aid in the control of pests such as potato beetles, aphids, and corn borers.

OR

(B) Malignant refers to the tumour's pattern of cancer cells, which have the potential to spread to surrounding tissues and develop out of control. Malignant tumours are much more harmful than benign tumours, which are sometimes painful and deadly. Malignant cells are more likely to grow in size or spread to other parts of the body than benign tumours are. They also grow more quickly.

87. **(A)** Thermus aquaticus is the scientific name of the organism that produces thermostable DNA polymerase for PCR. This bacterium is thermophilic, which means it thrives in hot settings.

OR

(B) Taq polymerase is frequently used in PCR to amplify target DNA because it processes several advantages, such as:
(1) Thermostability: A bacterium found in hot springs produces Taq polymerase, a thermostable DNA polymerase. It can endure the high temperature of $> 90^{\circ}C$ necessary for the PCR reducing stage and still maintain its enzyme activity after each cycle.
(2) Efficiency: Normal DNA polymerases are unable to tolerate the high temperatures in PCR since their optimal operating temperature is around $37^{\circ}C$. After each cycle, new enzymes must be introduced, requiring vast quantities of DNA polymerase and constant handling throughout the PCR procedure. Taq polymerase continues to show enzymatic activity following each high-temperature cycle, which greatly increases efficiency and lowers the cost.
(3) High amplification capacity: The ideal range for Taq polymerase's enzymatic activity is between 75 and $80^{\circ}C$. At $72^{\circ}C$, it can replicate a 1000 base pair segment of DNA in less than ten seconds after it achieves its optimum temperature.

88. Male sterilisation, sometimes known as a vasectomy, is a permanent method of prevention that involves cutting and tying the vasa deferens, which transports sperm from the testes to the penis. This stops the sperm from

dispersing into the semen during the procedure. For males who are convinced they don't want to be a father in the future, it is an easy and reliable technique of birth control.

89. **(A)** Human Genome Project was initiated by Francis Collins and Roderick, in 1990.

(i) The Human Genome Project aims to determine the complete and accurate sequence of 3 billion nucleotides that make up the whole human DNA.

(ii) It aims to find out all estimated, 20000-25000 genes, in humans.

(iii) It also aims to sequence the entire genome of several organisms, which are important in medical research identification of diseasecausing genes and their elimination.

(iv) To introduce new genes that code for desired protein products.

(B) Caenorhabditis elegans (a free-living non-pathogenic nematode).

90. Industrial melanism is a phenomenon that occurs in soot-covered industrial environments where organisms develop to become more melanistic in order to blend in with the surroundings. This protects them from predators. Around the period of the Industrial Revolution, the first cases of industrial melanism were reported in the UK. The peppered moth species, which is bright grey, was more prevalent before the Industrial Revolution. By blending in with their surroundings, they were able to avoid being eaten by birds and other natural predators. Dark-coloured or melanistic moths, on the other hand, were uncommon.

But throughout the revolution, air pollution brought on by soot from coal-powered enterprises clouded the surroundings. Due to their inability to blend in with a dark background, these light-coloured moths were chased more frequently by their predators. Their population fell as a result, particularly in the industrial zones. Natural selection is a form of evolution where individuals who are more suited to their environment are chosen to live and generate offspring. Hence, industrial melanism is an example of directional selection where because of environmental changes, a single phenotype is preferred. It causes the allele frequency to move continuously in a particular direction.

91. When the desired polin greis are used for pollination and fertilisation to get desired progeny, is called artificial hybridization.

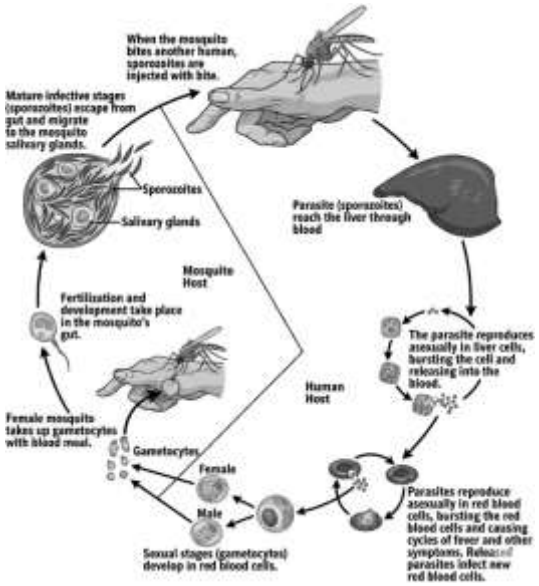
Steps of artificial hybridization:

Emasculation: In this step, the anthers (male part) are removed from a bisexual flower to avoid unwanted fertilisation from the anthers of the same flower. Unisexual flowers do not require this step.

Bagging: In this, the flowers are covered with a bag to avoid landing of unwanted pollen grains on the stigma. The bagging is done till the flower attains receptivity.

Pollination: Pollens with desired traits are dusted onto the flower after the flower is ready to receive the pollens.

92. **(A)** A healthy person gets bitten by an infected female anopheles mosquito, which injects the sporozoite infection stage into their outer blood vessels. The infectious stage multiplies repeatedly in the liver and red blood cells. The sporogonic cycle describes how the parasites multiply inside the mosquito. The micro gametes enter the macro gametes while in the mosquito's stomach, creating zygotes. The zygotes later mature into lengthy, motile structures called ookinetes, which enter the mosquito's gut wall and develop into the eggs. The sporozoites are released when the oocysts expand, burst, and go to the salivary glands of the mosquito. The malaria life cycle is continued by sporozoite inoculation into a new human host



OR

(B) (i) Eat healthy food: There are strong links between what we eat and how we feel. A healthy diet is one that has enough essential nutrients, and provides the right amount of calories to maintain a healthy weight.
(ii) Play games and sports: It helps to concentrate, sleep, look, and feel better. Enjoying through games helps in beating stress also.
(iii) Get enough sleep: Every day our body needs time to rest and heal. Sleeping for about eight hours is a must for all, especially for children.
(iv) Do not consume tobacco products or alcohol: Tobacco and alcohol result in illness in proportion to their consumption.
(v) Personal Hygiene
(vi) Proper disposal of waste.

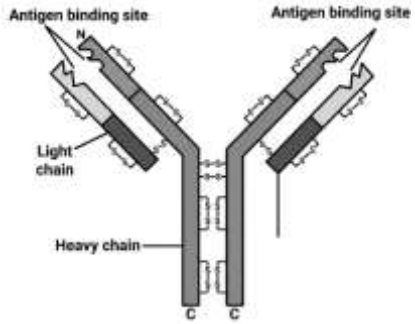
93. Bacillus thuriengiensis is a microorganism that produces the bt toxin. These bacteria produce intracellular crystal structures known as endotoxin during the sporulation process, which contains an insecticidal protein. Because the endotoxin that builds up in the bacteria is an inactive precursor, bt toxin kills the insect that consumes it but not the bacterium that makes it. Only the alkaline stomach of insects can activate it. By attaching to the interior of the insect's midgut, the protoxin damages the surface barrier by causing holes that result in swelling and lysis. This damage is done by the protoxin being cleaved by proteases (alkaline conditions in the gut) when the insect ingests it. As a result, the insect is unable to consume and dies from starvation.

94. **(A)** The broadly utilitarian argument described as biodiversity plays a major role in many ecosystem services that nature provides.
(i) Broadly utilitarian mainly explains the general and extensive uses of biological diversity, such as the production of oxygen, pollination, and aesthetic value that are not specific to any one species.
(ii) 20 percent of the oxygen in the earths atmosphere is thought to be produced by photosynthesis in the rapidly disappearing Amazon forest.
(B) The primary moral basis for conserving biodiversity is the obligation we owe to the variety of plant, animal, and microbial species that stay in this world. The extinction of one species, it is stated, could have an effect on the other members of the community because all species are interdependent. The same ecological limits that apply to other organisms should apply to humans as well. It is crucial for us to realise that every species has a fundamental worth, even though that value may not be directly related to our economic well-being. In order to preserve biodiversity, this value is crucial. In addition, we owe it to them morally to watch out for their welfare, safeguard them for the future, and make sure that the biological history we leave behind is preserved for future generations.

95. **(A)** Period of illness: The number of disease-causing microorganisms reaches its maximum during the period of illness so, there are maximum chances of a person transmitting a disease/infection at this stage.
(B) The incubation period refers to the period from the absence of symptoms to the beginning of minor symptoms. The incubation period is the length of time between the introduction of germs and the onset of the first illness symptoms. For instance, chickenpox takes 14-16 days to incubate. The sexually transmitted illness that can spread during this time is AIDS. The pathogen in this disease targets a specific type of cell called a macrophage.

OR

(B)



Structure of an antibody molecule

(C) In a person suffering from pneumonia, the number of immune cells forming antibodies will be at its highest during the period of illness.

Antibodies are produced by B-lymphocytes.

96. **(A)** Aneuploidy is defined as the condition of the abnormal number of chromosomes in a cell. It may occur due to an extra or less number of chromosomes.

(B) $22 + 0,22 + XY$

(C) Klinefelter syndrome: Klinefelter syndrome (sometimes called Klinefelter's, KS or XXY) is where males are born with an extra X chromosome.

Symptoms:

(1) Males with feminine characteristics, decreased facial and body hair.

(2) In babies and toddlers - weak muscles and very flexible (hypermobile) joints, learning to sit up, crawl, walk and talk later than usual, being quieter and more passive than usual, having undescended testicles, only one testicle, or smaller penis.

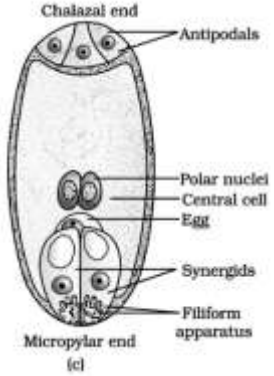
OR

(C) Aneuploidy is a genetic disorder that develops when a cell has an unusually high number of chromosomes. Trisomy of chromosome 21 where three copies of chromosome 21 are present in the patient is the most well-known aneuploidy in the autosomal chromosome. Down's syndrome is a trisomy of the 21 -chromosome disorder. Short size, a protruding tongue, a flattened face, and upward-slanting eyelids are the four symptoms of Down's syndrome.

97. **(A) (i)** Development of embryo sac:

The first cell of the female gametophyte is represented by the functional megaspore that grows along the micropylar known as the chalazal axis and is primarily chalazal. The functioning megaspore's nucleus divides during phase to produce two cells that migrate to the opposing poles to form the 2 -nucleate embryo sac. The 4 -nucleate and eventually the 8 -nucleate stages of the embryo sac are created by two more consecutive mitotic nuclear divisions. One nucleus from each group at a pole migrates to the cell's core, becoming known as a polar nucleus. The three remaining cells form antipodals and are encircled by a wall towards the end of the chalazal. The egg apparatus is made up of three cells at the micropylar end, one of which is an egg or female gamete and the other two are synergids. The adult female gametophyte or embryo sac is the entire structure with two polar cells, three antipodals, one egg, and two synergids.

(ii)

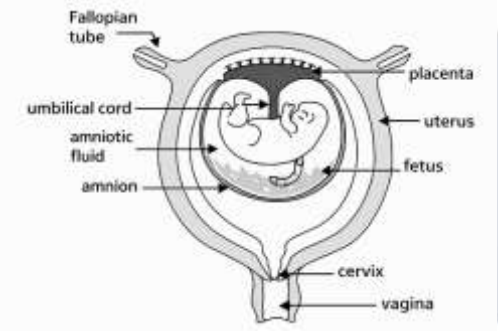


Mature Embryo Sac

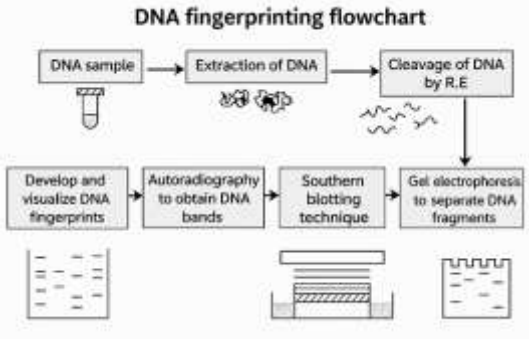
OR

(B) (i) The placenta, which supplies nutrition to the developing foetus, is a unique characteristic of placental mammals. The placenta, which serves as a structural and functional link between the developing embryo (foetus) and the mother's body, develops between the chorionic villi and uterine tissue after around 12 weeks of pregnancy. Upon the implantation of a blastocyst in the mother's endometrium, the placenta starts to grow. Two different cell types make up the blastocyst: the inner cell mass and the outer trophoblast cells. The trophoblas cells grow to create the placenta, while the inner cell mass gives rise to the foetus and the protective barrier around it. Between 18 and 20 weeks of pregnancy, the placenta is developed, and it keeps expanding. A chorio-allantoic placenta is one that develops from the chorion and allantois in the human placenta. The placenta protects the foetus from the typical immune reaction that releases antibodies, even though the mother's body may perceive it as a foreign body.
(1) After implantation, the trophoblast develops finger-like structures called chorionic villi, which are surrounded by uterine tissue and maternal blood.
(2) The chorionic villi interlock with the uterine tissue to form the placenta.
(3) The placenta acts as a structural and functional link between the embryo (foetus) and the mother's body.
(4) It is connected to the embryo through the umbilical cord, which carries substances to and from the developing embryo.

(ii) Foetus developing in the uterus

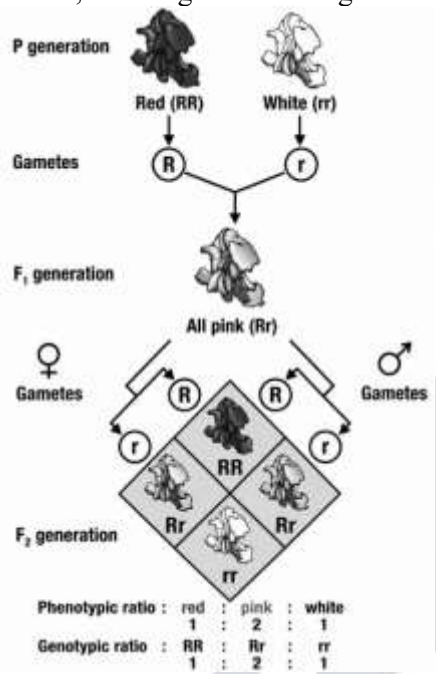


98. (A) DNA fingerprinting is a technology used to do a paternity test to determine the true parents of a newborn infant. This approach is also known as "DNA profiling" since the DNA sequences of both parents and child are matched. To perform the paternity test, the following steps are involved:
(1) DNA sample: A DNA sample to be analysed is first collected.
(2) Extraction of DNA: DNA is then extracted from the sample by lysis method.
(3) Digestion by restriction endonucleases: Using a specific restriction enzyme, a DNA fragment is cut at a specific site. This is done to obtain RFLP (Restricted Fragment Length Polymorphism).
(4) Electrophoresis: Using gel electrophoresis, DNA fragments of various sizes are obtained.
(5) Denaturing DNA fragments: The gel containing DNA fragments is then immersed in NaOH solution. This will denature DNA into single-stranded DNA.
(6) Southern blotting technique: This is performed to transfer single-stranded DNA from the gel onto the nitrocellulose membrane.
(7) Hybridization: This DNA fragment is subjected to hybridization with a suitable DNA probe tagged with a radioactive substance.
(8) Comparing the sample: Using X-ray films, the DNA samples showing radioactivity are compared. This is the most reliable technique to find the parents of the newborn baby.



OR

(B) It's called incomplete dominance or partial dominance when a heterozygote has a phenotype that falls between the two homozygous parents. Snapdragons' blossom colour serves as a perfect example of incomplete dominance. Two alleles make up the flower colour gene in snapdragons: the red allele (R) and the white allele (W). The red allele is dominant, whereas the white allele is recessive. The homozygous white snapdragon (WW) will have white flowers, but the homozygous red snapdragon (RR) will have red blooms.
If a homozygous red snapdragon (RR) and a homozygous white snapdragon (WW) are crossed to produce a heterozygous snapdragon (RW), the F_1 generation will have pink flowers, which are a mid-phenotype between red and white. This is due to the fact that the heterozygote's flower colour is expressed by both the red and white alleles, resulting in a blending of the two colours.



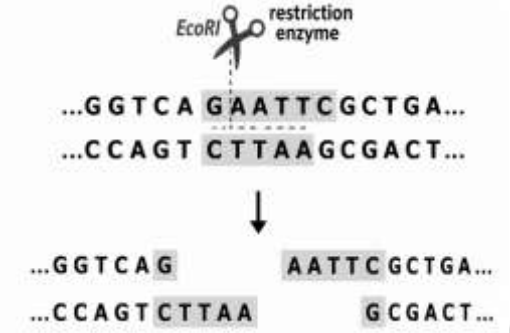
Monohybrid cross in Snapdragon, where one allele is incompletely dominant over the other allele.

99. (A) (i) The following operational rules must be followed to optimise the bioreactor system:
(1) Monitoring and control of critical factors: For the biological system to function optimally and generate at its optimum, it's critical to monitor and control critical factors including temperature, pH , dissolved oxygen levels, and nutrient concentrations. This can be done by using sensors and control systems that can adjust these parameters as needed.
(2) Optimization of mixing and aeration: To ensure that nutrients and oxygen are supplied evenly throughout the biological system, effective mixing and aeration are essential. The mixing and aeration rate should be tailored to the specific needs of the system and the characteristics of the used bioreactor.
(3) Contamination reduction: Maintaining aseptic conditions is essential to prevent contamination throughout the procedure because contamination can severely impair the biological system's production. To accomplish this, sterile tools, air filtering devices, and other appropriate techniques can be used.
(4) Bioreactor upkeep and cleaning: The bioreactor needs to be regularly maintained and cleaned in order to operate at its best and last for a long time.
(ii) In the sentence "Optimization of growth and metabolic activity of the cells," the term "exponential phase of growth" is used to describe this stage of growth.
(iii) The biological product in the bioreactor may or may not be suitable for immediate use, depending on the specific product and how it will be used. A biological product frequently needs to be further processed and purified before it can be used for its intended purpose. This is because there's a chance the product includes impurities or other components that could be hazardous or alter how well it works. The purification process can make use of several techniques, including filtration, chromatography, centrifugation, and others. Additionally, some biological products would require testing and validation to guarantee that they meet the statutory and regulatory requirements essential for their intended use. Tests and analyses may be performed to determine the product's purity, activity, and safety.

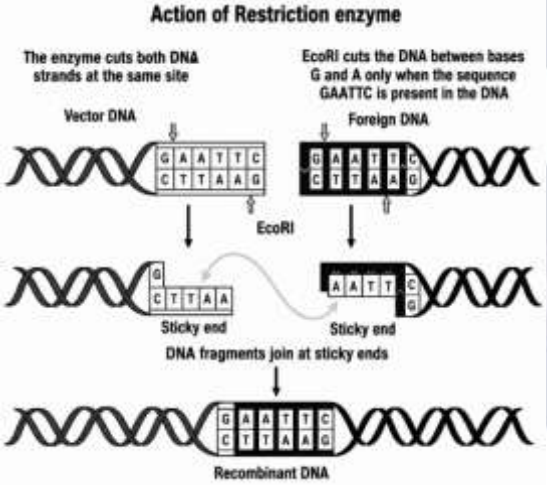
OR

(B)(i) (I) Restriction endonucleases are named as follows:
1st alphabet represents the genus of the organism from which the enzyme is isolated.
2nd and 3rd alphabet represent the species of the organism.

4th alphabet represents the strain.
The Roman number represents the order of isolation or discovery of the enzyme.
EcoRI comes from the Escherichia coli RYB strain.
In EcoRI, 'E' comes from the genus 'Escherichia' and 'co' comes from the species name 'Coli'.
The letter ' R ' is derived from the name of the strain RYB.
Roman numbers following the names indicate the order in which the enzymes were isolated from that strain of bacteria.
(II) The recognition sequence where EcoRI cleaves the DNA molecule is G/AATTC. Such sequences have a complementary sequence, CTTAA/G, which is known as a palindromic sequence.



(ii) The DNA strand is cut by restriction enzymes between the similar two bases on the opposing strands, but just outside of the palindromic sites: The enzyme cuts both the foreign DNA and the vector DNA similarly. Only when the DNA sequence GAATTC is present does EcoRI cut the DNA between the nucleotides G and A. As a result, there are single-stranded, overhanging lengths at the end that are known to as sticky ends. Hydrogen bonds are formed between sticky ends and their complementary sliced opposites. The DNA ligase enzyme's function is made easier by the end's stickiness. Recombinant DNA was created as a result.



100. **(b)** Hormone-releasing IUDs (like LNG-20) release progesterone or its derivatives. These hormones thicken cervical mucus, making it difficult for sperms to pass through, and also reduce sperm motility and fertilization chances.

101. **(b)** Let's match Column I with Column II correctly:

Column I (Objectives of RCH Programme)		**Column II (Purpose)**	
(P)	Introduction of sex-education in schools	**(III)**	To discourage children from believing in myths and misconceptions in sex-related matters

(Q)	Advocating programmes for married couples	**(IV)**	Be aware of available birth control options
(R)	Awareness of problems due to uncontrolled population growth	**(II)**	To avoid social evils like sex-abuse and sex-related crimes
(S)	Knowledge and diagnosis of STD infections	**(I)**	To encourage the infected persons to consult experts for timely detection and proper treatment

102. **(a)** The backbone (basic chemical structure) of a DNA molecule is composed of:
The DNA "ladder" rails are made of alternating sugar (deoxyribose) and phosphate groups.

103. **(c)** The correct reason for survival of certain moth population in postindustrialisation period in England was due to:
This refers to "industrial melanism," where darker moths survived better on soot-covered trees.

104. **(b)** Column I lists some infectious diseases and Column II lists the mode of their spreading. Identify the correct pair.
- Typhoid: Contaminated food and water (a-II)
- Malaria: Vector-borne (b-I)
- Chikungunya: Vector-borne (c-I)
- Pneumonia: Airborne/Droplets (d-III)

105. **(b)** Which one of the following option is not a characteristic of acquired immunity?
Note: Acquired immunity is characterized by immunological memory.

106. **(b)** Which one of the following options is a correct example of fungus as a source organism?
Note:Yeast (Saccharomyces cerevisiae) is a fungus used in fermentation.

107. **(a)** The correct method of introducing alien DNA into the appropriate host is:
Microinjection is a direct method specifically used to inject DNA into the nucleus of animal cells.

108. **(d)** In mutualism (e.g., lichens, mycorrhizae), both interacting species benefit from the relationship.

109. **(d)** Cryptic coloration (camouflage) allows an organism to blend into its natural surroundings, helping it hide from predators.

110. **(d)** According to the 10% law of energy transfer, only about 10% of energy is transferred from one trophic level to the next.
- Producers = 10,000 J
- Primary Consumers = 1,000 J
- Secondary Consumers = 100 J
- Tertiary Consumers = 10 J

111. **(b)** The largest species-rich taxonomic group of plants among the following is:
Angiosperms (flowering plants) are the most diverse and species-rich group of land plants, comprising over 300,000 known species.

112. **(c)** In angiosperms, the development of the endosperm does precede embryo development to ensure the embryo is adequately nourished as it grows. However, endosperm development is not exclusive to dicotyledonous plants; it occurs in both monocotyledonous and dicotyledonous plants.

113. **(c)** ABO blood grouping is a classic example of co-dominance because both I^A and I^B alleles are expressed equally, resulting in the AB blood type. The reason provided (the first filial generation expressing both parental and new characters) is factually incorrect for this phenomenon.

114. **(b)** Transgenic animals possess an extra foreign gene in their DNA, and they can also pass these manipulated genes to their offspring. The offspring's ability to inherit the gene is a consequence of the modification, but it does not explain why the animal possesses the extra gene in the first place.

So, Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

115. **(a)** Species diversity exhibits a latitudinal gradient, meaning it is highest in the tropics and decreases as you move toward the poles. The fact that tropics harbor more species than temperate regions perfectly explains this latitudinal decrease.

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

116. **(A)** The cervical canal is the narrow, lower portion or neck of the uterus that opens into the vagina.

(B) The cervical canal, along with the vagina, is referred to as the birth canal during the process of childbirth (parturition), as the fetus passes through this passage to be delivered.

117. **(A)** Walter Sutton and Theodor Boveri (in 1902).

(B) They explained that both genes and chromosomes occur in pairs in diploid cells. During gamete formation (meiosis), both the homologous pairs of chromosomes and the alleles of a gene pair segregate. Only one member of each pair is transmitted to a gamete, and different pairs assort independently.

118. **(A)** Abiotic agents (specifically wind and water).

(B) Wind pollination is predominantly found in monocots (like grasses), while water pollination is restricted to a few genera of aquatic plants (such as Vallisneria and Hydrilla).

(C) Two examples of aquatic plants where water is not the pollinating agent are Water Hyacinth and Water Lily (these are pollinated by insects or wind).

119. Selectable Markers

The piece of DNA introduced into E. coli codes for antibiotic resistance (e.g.resistance to ampicillin, tetracycline, kanamycin, or chloramphenicol). Unlike normal/untransformed E. coli cells, which lack this resistance, the transformed cells gain the ability to survive in environments treated with these specific antibiotics.

120. **(A):** Changes in Population Density

The density of a population fluctuates due to changes in natality, mortality, immigration, and emigration.

(i) Increase in population density:

• Natality (birth rate)

• Immigration (individuals entering the habitat from elsewhere)

(ii) Decrease in population density:

• Mortality (death rate)

• Emigration (individuals leaving the habitat)

OR

(B): Population Growth Curves

(i) Difference between ' J ' and ' S '-shaped growth curves

Feature	'J'-shaped Curve (Exponential)	'S'-shaped Curve (Logistic)
Growth Pattern	Increases rapidly and exponentially.	Starts slow, accelerates, and then levels off.
Resources	Assumed to be unlimited.	Limited (environmental resistance is present).

Carrying Capacity (K)	Does not level off at carrying capacity; crashes abruptly when resources are exhausted.	Levels off and stabilizes at the carrying capacity of the environment.
Equation	$\frac{dN}{dt} = rN$	$\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$

(ii) Which curve is more realistic and why?

The 'S'-shaped curve is more realistic. In the natural world, resources-such as food, space, and water-are strictly limited. Because of this "environmental resistance," a population cannot grow exponentially forever; instead, it slows down as it reaches its carrying capacity.

121. Hormones Leading to Ovulation and the Corpus Luteum

Ovulation is driven by a precise sequence of hormonal

• GnRH (Gonadotropin-Releasing Hormone): Secreted by the hypothalamus, it stimulates the anterior pituitary to release FSH and LH.

• FSH (Follicle Stimulating Hormone): Stimulates the growth and maturation of the ovarian follicles.

• Estrogen: As the follicle matures, it secretes high levels of estrogen. This rise in estrogen triggers a sudden, massive surge of LH.

• LH (Luteinizing Hormone): The LH surge is the direct trigger that ruptures the mature Graafian follicle, leading to ovulation.

Structure formed after ovulation: The ruptured follicle transforms into the Corpus Luteum.

Function: It acts as a temporary endocrine gland, secreting high amounts of progesterone. Progesterone is essential for preparing and maintaining the uterine lining (endometrium) for potential implantation and pregnancy.

122. Double Fertilisation and Triple Fusion in Angiosperms

Double fertilization is a unique and defining characteristic of angiosperms (flowering plants).

• Double Fertilisation: After reaching the embryo sac, one of the two haploid male gametes fuses with the haploid egg cell. This produces a diploid zygote ($n + n = 2n$), which will eventually develop into the embryo.

• Triple Fusion: The second haploid male gamete moves towards the central cell and fuses with the two haploid polar nuclei (or secondary nucleus) present there. Because this fusion involves three haploid nuclei ($n + n + n = 3n$), it is called triple fusion. This creates the triploid Primary Endosperm Nucleus (PEN).

• The central cell with the PEN develops into the endosperm, which provides nourishment to the developing embryo.

123. DNA Replication in E. coli

• Main Enzyme: The primary enzyme responsible for DNA replication in E. coli is DNA Polymerase III (though DNA Polymerase I is involved in repair and primer removal, Polymerase III handles the bulk of synthesis).

• Characteristics of the Enzyme:

• Strict Dependency: It cannot initiate DNA synthesis from scratch; it requires an existing RNA primer to attach new nucleotides.

• Template-Dependent: It strictly reads the existing DNA strand in the $3'$ to $5'$ direction and synthesizes the new complementary strand only in the $5'$ to $3'$ direction.

• If mistakes occur: DNA Polymerase III has a built-in proofreading mechanism (exonuclease activity). If it incorporates the wrong nucleotide, it cuts it out and replaces it. If a mistake escapes proofreading, it leads to a mutation, which can cause permanent alteration in the DNA sequence, potentially leading to varied traits, diseases, or cell death.

124. Analogous Structures and Convergent Evolution

Analogous structures are organs or body parts that perform similar functions and look superficially similar, but have completely different anatomical structures and embryonic origins. This phenomenon is known as convergent

evolution, where unrelated species independently evolve similar adaptations to survive in similar environments or ecological niches.

• Example in Plants: The modification of stems into tendrils in grapes and the modification of leaves into tendrils in peas.

• Both structures perform the exact same function (climbing and providing support to weak plants).

• However, they have completely different evolutionary and anatomical origins (one is a modified stem, while the other is a modified leaf).

• Another Plant Example: Succulent desert plants like Cacti (native to American deserts) and Euphorbias (native to African deserts). Both independently evolved thick, fleshy, water-storing stems and spines to survive in harsh, arid climates, despite belonging to completely different plant families.

125. **(A)** Features Common to AIDS and Hepatitis-B

• Transmission Routes: Both are transmitted through sexual contact with an infected person and through the sharing of infected needles or syringes (e.g., intravenous drug use).

• Blood-Borne: Both viruses are spread through contact with infected blood.

• Mother-to-Child: Both infections can be transmitted from an infected mother to her baby during pregnancy, delivery, or childbirth.

• Chronic and Fatal Nature: Both can lead to chronic, long-term health complications and are potentially fatal.

OR

(B) Adolescence and Drug Dependence

(i) Adolescence Changes and Vulnerability:

• Characteristic Changes: Adolescence is the transitional phase between childhood and adulthood. It involves rapid physical and physiological changes (e.g., puberty. development of reproductive organs, and height spurts), as well as significant psychological and emotional changes (e.g., mood swings, identity crisis, and developing new relationships).

• Why it is Vulnerable: It is a vulnerable phase because adolescents experience a high degree of peer pressure, curiosity, a desire for more freedom, and stress regarding their future or academics. This often makes them susceptible to experimenting with psychoactive substances or engaging in risky behaviors.

(ii) Drug Dependence and Causes:

• What it Leads to: Drug dependence creates a psychological and physiological compulsion to take the drug regularly. It leads to a deterioration in physical, psychological, and intellectual capabilities, behavioral changes (such as becoming antisocial or aggressive), and can eventually cause vital organ damage.

• Why it Happens: It happens because repeated or continuous use of drugs causes the body's receptors to adapt to the substance. The brain's natural reward system is altered, leading to a state where the individual's central nervous system craves the drug simply to function normally and avoid severe withdrawal symptoms.

126. Process of Isolation of DNA from a Plant Cell

To isolate pure DNA from a plant cell for recombinant DNA technology, the following sequential steps are performed:

(1) Cell Lysis / Homogenization: Plant tissues are crushed or ground using a mortar and pestle. Enzymes like cellulase are used to break down the tough plant cell wall, and lysozyme or pectinase may be used to break down the cell membrane, exposing the cellular contents.

(2) Deactivation of Nucleases: A detergent (like SDS) is added to dissolve the lipids of the cell and nuclear membranes, while specific chemicals are used to inhibit DNase enzymes from degrading the target DNA.

(3) Separation of Cellular Components: Cellular debris, proteins, and RNA are removed. Proteins are broken down using protease enzymes, and RNA is removed by adding ribonuclease (RNase).

(4) DNA Precipitation: Ice-cold ethanol or isopropanol is carefully added to the solution. This decreases the solubility of the DNA, causing it to precipitate out of the solution as fine, white thread-like fibers.

(5) DNA Spooling: The precipitated DNA fibers are spooled out using a glass rod or a hook, resulting in purified DNA suitable for downstream processes in recombinant DNA technology.

127. Examples of Population Interactions

(A) Morphological defence in plants against herbivores:

• Example: Thorns present on Acacia or rose plants, or spines on cactus (Opuntia) leaves to deter herbivores from grazing.

(B) Chemical defence in animals against predators:

• Example: The Monarch butterfly is highly distasteful (and toxic) to birds because it accumulates specialized chemicals from its larval food plant (milkweed).

(C) Brood parasitism:

• Example: The Koel (cuckoo) laying its eggs in the nest of a crow, allowing the crow to incubate and raise the cuckoo's chicks as its own.

128. Hershey and Chase Experiment

(i) (A) Radioactive Phosphorus (^{32}P): Viruses were grown in this medium because DNA contains phosphorus in its sugar-phosphate backbone, while proteins do not. This specifically labeled the viral DNA with radioactivity.

(B) Radioactive Sulfur (^{35}S): When grown in this medium, the viral proteins became radioactively labeled because certain amino acids (like cysteine and methionine) contain sulfur, whereas DNA contains no sulfur.

(ii)

• Bacteriophages (viruses) have a very simple structure consisting only of a DNA core wrapped in a protein coat.
• E. coli acts as a simple bacterial host.
• This specific pairing was used because bacteriophages naturally inject only their genetic material into the bacteria while leaving their outer coats behind, making it the perfect model to track whether DNA or protein enters the cell.

(iii) (A) Conclusion: Hershey and Chase concluded that DNA is the genetic material. They proved this because only radioactive phosphorus ($^{(32}P$) entered the bacterial cells, showing that DNA passed from the virus to the bacteria to guide viral reproduction.

OR

(B) Purpose of the Blender: The blender was used during the blending/agitation step to exert mechanical force. This detached the empty viral protein coats (ghosts) from the surface of the E. coli cell walls after infection took place.

129. Pathogenic Diseases & Hygiene

(i) Causal Organisms

• Filariasis (Elephantiasis): Wuchereria bancrofti and Wuchereria malayi
• Ringworm: Fungi belonging to the genera Microsporum, Trichophyton, and Epidermophyton.

(ii) Symptoms

• Filariasis:
(1) Chronic inflammation and severe swelling of the lower limbs (elephantiasis).
(2) Deformities of the genital organs.
• Ringworm:
(1) Appearance of dry, scaly lesions on the skin, nails, and scalp.
(2) Intense itching around these lesions.

(iii) (A) How they spread:

• Filariasis: Transmitted to a healthy person through the bite of an infected female Culex mosquito vector.
• Ringworm: Transmitted through direct skin-to-skin contact, using contaminated articles (like towels, clothes, or combs) of an infected person, or acquired directly from contaminated soil.

OR

(B) Preventive Measures:
(1) Filariasis:
• Eradicate mosquito vectors by eliminating stagnant pools of water.
• Use mosquito nets, repellents, or window screens to prevent insect bites.
(2) Ringworm:
• Maintain strict personal hygiene by keeping skin dry, clean, and avoiding shared clothing or towels.
• Avoid direct contact with infected individuals, pets, or contaminated soil surfaces.

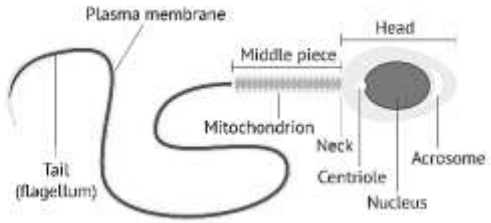
130. **(A)** Artificial Hybridisation

• Main Purpose: To intentionally cross-breed two different, genetically distinct plants to combine the best characteristics of both parent plants, creating improved hybrids with traits like higher yields, disease resistance, and better adaptability.
• The Process:
(1) Emasculation: The removal of anthers (the male reproductive parts) from the flower buds of the chosen female parent before the anthers mature and split. This prevents accidental self-pollination.
(2) Bagging: The emasculated flower is immediately covered with a bag (typically made of butter paper) to protect the stigma from being contaminated by unwanted pollen.
(3) Dusting: Once the stigma of the bagged flower becomes receptive, mature pollen grains collected from the desired male parent are manually dusted onto the stigma.
(4) Re-bagging: The pollinated flower is re-covered to allow the fruit and seeds to develop in a controlled manner.

• Plants That Don't Require This: Plants that naturally produce unisexual flowers (e.g., dioecious plants like papaya) do not require emasculation because there are no anthers on the female flowers.

OR

(B) Human Sperm



(i) Major Parts and Functions:

• Head: Contains a condensed haploid nucleus (which carries the male's genetic material/DNA) and is capped by an acrosome, which stores enzymes that help the sperm penetrate and fertilize the ovum.

• Middle Piece: Packed with numerous mitochondria that generate the ATP (energy) required for the movement and propulsion of the sperm.

• Tail: Consists of a flagellum that provides vigorous, whip-like motility, allowing the sperm to swim actively through the female reproductive tract towards the egg.

(ii) Sperm Count:

• During a single normal coitus (ejaculation), a human male releases about 200 to 300 million sperms. According to World Health Organization (WHO) standards, a normal, healthy ejaculate contains at least 15 to over 200 million sperms per milliliter, totaling roughly 39 million to over 900 million sperms per entire ejaculation.

131. **(A)** Five Reasons Thomas Hunt Morgan Chose Drosophila melanogaster

(1) Easy Cultivation: They could be grown very easily on a simple, inexpensive synthetic medium in the laboratory.

(2) Short Life Cycle: They complete their entire life cycle in a very short span of about two weeks, allowing for rapid data collection.

(3) High Progeny Number: A single mating produces a large number of offspring, making statistical analysis more accurate.

(4) Clear Sex Differentiation: The male and female flies are distinct and easily distinguishable (females are noticeably larger than males).

(5) Low-Power Hereditary Variations: They have many types of distinct, contrasting hereditary variations (like red eyes vs. white eyes) that can be easily observed under a simple low-power microscope.

OR

(B) (i) Two Objectives of the Human Genome Project (HGP)

(1) Identify all the approximately 20,000-25,000 genes present in human DNA.

(2) Determine the sequences of the 3 billion chemical base pairs that make up human DNA.

(ii) Two Types of Methodologies Used

(1) Expressed Sequence Tags (ESTs): This approach focuses solely on identifying and sequencing the regions of DNA that are expressed specifically as RNA.

(2) Sequence Annotation: A blind approach where the entire genome-containing all coding exons and non-coding introns-is sequenced completely. Later, functions are assigned to different regions based on sequence markers.

(iii) Two Hosts Commonly Used for Cloning

(1) Bacteria (using Bacterial Artificial Chromosomes or BAC vectors)

(2) Yeast (using Yeast Artificial Chromosomes or YAC vectors)

(iv) Contribution of Frederick Sanger

Frederick Sanger developed the fundamental principle of automated DNA sequencing based on chain termination. This precise biochemical method was instrumental in automating the sequencing process for the entire Human Genome Project. Furthermore, he is also credited with developing the method for sequencing amino acids in proteins.

132. **(A) (i)** Cause of ADA Deficiency

• Genetic Deletion: ADA deficiency is caused by the deletion of the gene responsible for producing the enzyme Adenosine Deaminase.

• Immune System Failure: This enzyme is crucial for the proper functioning of the immune system. Without it, toxic metabolic byproducts accumulate and destroy Tlymphocytes, leading to Severe Combined

Immunodeficiency (SCID).

(ii) How Gene Therapy is Used to Treat This Deficiency

Gene therapy introduces a fully functional copy of the missing gene into the patient's cells through the following steps:

(1) Isolation: Lymphocytes (white blood cells) are extracted from the blood of the affected child.

(2) In Vitro Culture: These isolated lymphocytes are grown in a specialized culture media inside a laboratory.

(3) Gene Transfer: A functional human ADA cDNA (complementary DNA) gene is inserted into these cultured lymphocytes using a modified, harmless retroviral vector.

(4) Re-infusion: The genetically engineered lymphocytes, which can now produce the missing ADA enzyme, are injected back into the patient's bloodstream.

(iii) Why Periodic Infusion is Required

• Finite Lifespan: Genetically engineered lymphocytes are not immortal; they naturally age and die off in the bloodstream over time.

• Lack of Regeneration: Because these cells cannot multiply indefinitely on their own inside the body, the patient requires regular, lifelong infusions of freshly modified cells to maintain their immune defense.

• (Note: A permanent cure is only possible if the functional gene is introduced into bone marrow stem cells at an early embryonic stage).

OR

(B) (i) How RNA Interference (RNAi) Saves Tobacco Plants

RNA interference works on the principle of cellular defense by silencing a specific messenger RNA (mRNA) essential for the nematode's survival:

(1) Vector Introduction: Using Agrobacterium vectors, nematode-specific genes are introduced into the host tobacco plant.

(2) dsRNA Production: The introduced genes are designed to produce both sense and antisense RNA strands inside the plant cells. Being complementary, these two strands bind together to form double-stranded RNA (dsRNA).

(3) Ingestion & Silencing: When the parasitic nematode feeds on this transgenic tobacco plant, it ingests the dsRNA.

(4) Nematode Death: The ingested dsRNA triggers a cellular mechanism within the parasite that identifies and silences (blocks the translation of) the specific target mRNA of the nematode. Without these vital proteins, the parasite cannot survive, making the host plant completely resistant.

(ii) Infected Plant Part & The Harm Caused

• Part Infected: The nematode (Meloidogyne incognita) specifically infects the roots of the tobacco plant.

• Harm Caused: The infection induces root-knot galls that severely disrupt the plant's ability to absorb water and vital nutrients from the soil, leading to a drastic reduction in total crop yield.