Roll No. ☐☐☐☐☐☐☐☐

Q.P. Code 57/4/1

BIOLOGY (THEORY)

CBSE Class XII Board Examination 2025 — with answers

Time allowed: 3 hours **Maximum Marks: 70**

General Instructions:

1. The paper has 33 questions in five sections (A to E); all of them must be answered.
2. Section A: Q1–16, multiple choice (Q13–16 Assertion-Reason), 1 mark each.
3. Section B: Q17–21, very short answer, 2 marks each.
4. Section C: Q22–28, short answer, 3 marks each.
5. Section D: Q29–30, case-based, 4 marks each, with an internal choice in one sub-part.
6. Section E: Q31–33, long answer, 5 marks each.
7. There is no overall choice, but Sections B, D and E have internal choices (OR) – answer only one alternative. Draw neat, labelled diagrams wherever needed.

SECTION A

Q1–16 are multiple choice questions of 1 mark each; Q13–16 are Assertion-Reason.

1. When chromatin is seen in its extended 'beads-on-string' form, what do the 'beads' stand for? **1**

(A) Linker DNA

(B) Histone proteins

(C) Nucleosomes

(D) NHC proteins

ANSWER

(C) Nucleosomes

In eukaryotes, negatively charged DNA wraps around a positively charged histone octamer to form a nucleosome (about 200 bp of DNA per nucleosome).

Under the electron microscope, chromatin looks like a string with beads: each bead is a nucleosome and the thread between beads is linker DNA.

Common mistake: choosing 'histone proteins' – histones are only the core of the bead; the bead itself is DNA + histone octamer = nucleosome.

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2. Read these statements about the accessory ducts of the human male reproductive system: **1**

(i) Seminiferous tubules open into the rete testis, which then opens into the vas deferens.

(ii) The vasa efferentia leave the testis and open into the epididymis.

(iii) The epididymis leads to the vas deferens, which ascends into the abdomen.

(iv) The vas deferens receives a duct from the prostate gland and opens into the urethra as the ejaculatory duct.

(v) The urethra starts from the urinary bladder and runs through the penis to its external opening, the urethral meatus.

Which option lists only the true statements?

(A) (i), (ii), (iv)

(B) (ii), (iii), (v)

(C) (ii), (iv), (v)

(D) (i), (iii), (iv)

ANSWER

(B) (ii), (iii), (v)

Correct path of sperms: seminiferous tubules → rete testis → vasa efferentia → epididymis → vas deferens → ejaculatory duct → urethra.

(i) is false: the rete testis opens into the vasa efferentia, not directly into the vas deferens.

(iv) is false: the vas deferens receives the duct of the seminal vesicle (not the prostate) and opens into the urethra as the ejaculatory duct.

(ii), (iii) and (v) are correct.

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3. During DNA replication, the enzyme DNA-dependent DNA polymerase uses which of the following as its substrate? **1**

(A) Deoxyribonucleotide triphosphate
(B) Deoxyribonucleoside triphosphate
(C) Ribonucleotide triphosphate
(D) Ribonucleoside triphosphate

ANSWER
(B) Deoxyribonucleoside triphosphate

DNA polymerase adds deoxyribonucleoside triphosphates (dATP, dGTP, dCTP, dTTP).
They are called nucleoside triphosphates because the three phosphates are attached to a nucleoside (base + deoxyribose); these dNTPs act both as substrate and as the energy source (two phosphates are released as pyrophosphate).
Ribo- forms are used by RNA polymerase, not DNA polymerase.

4. Pedigree described in words: a normal father and a normal mother have a haemophilic son and a normal daughter. The daughter marries a normal man and they have a haemophilic son (the grandson). What type of inheritance does this pedigree show? **1**

(A) Autosome linked dominant trait
(B) Sex-linked dominant trait
(C) Autosomal recessive trait
(D) Sex-linked recessive trait

ANSWER
(D) Sex-linked recessive trait

The trait skips the parents (both normal) and appears in a son → recessive.
Only males are affected and the trait passes from a normal mother (carrier) to her son, and again from the normal daughter (carrier) to the grandson – the typical criss-cross pattern of an X-linked gene.
Mother = X^HX^h (carrier), father = X^HY → son X^hY affected; daughter X^HX^h carrier → her son X^hY affected.
So haemophilia here is X-linked (sex-linked) recessive.

5. In which of these human diseases does the body's own defence system attack its own cells? **1**

(A) Thalassemia
(B) Phenylketonuria
(C) Filariasis
(D) Rheumatoid arthritis

ANSWER
(D) Rheumatoid arthritis

When the immune system fails to distinguish self from non-self and attacks self-cells, the disease is called an autoimmune disease.
Rheumatoid arthritis is an autoimmune disease (the joints are attacked).
Thalassemia and phenylketonuria are Mendelian (genetic) disorders; filariasis is caused by the worm Wuchereria.

6. Which statements are true for a typical dicot embryo? **1**

(i) It has an embryonal axis and a scutellum.

(ii) The part of the embryonal axis above the level of the cotyledons is the epicotyl.

(iii) The part of the embryonal axis below the level of the cotyledons is the coleorhiza.

(iv) The lower end of the embryo has the radicle covered by a root cap.

(A) (i) and (ii) **(B)** (i) and (iii)

(C) (iii) and (iv) **(D) (ii) and (iv)**

ANSWER

(D) (ii) and (iv)

A dicot embryo has an embryonal axis and two cotyledons.
Above the cotyledons = epicotyl (ends in plumule); below = hypocotyl (ends in radicle with root cap).
(i) is false – scutellum is the single cotyledon of monocots.
(iii) is false – the part below the cotyledons is the hypocotyl; coleorhiza is the radicle sheath of monocots.
So (ii) and (iv) are true.

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7. In human evolution, about 15 million years ago, which primates walked like gorillas and chimpanzees? **1**

(A) Australopithecine and Neanderthal **(B) Dryopithecus and Ramapithecus**

(C) Homo erectus and Homo sapiens **(D)** Homo habilis and Homo erectus

ANSWER

(B) Dryopithecus and Ramapithecus

About 15 mya, Dryopithecus and Ramapithecus existed; they were hairy and walked like gorillas and chimpanzees (Ramapithecus was more man-like, Dryopithecus more ape-like).
Australopithecines appeared about 2 mya; Homo habilis, H. erectus, Neanderthals and H. sapiens are much later.

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8. The coding strand of a structural gene being transcribed has the triplet TAC. Using the codon list – AUC: Isoleucine, AUG: Methionine, UAC: Tyrosine, GUA: Valine – which amino acid will be attached to the 3′ end of the tRNA that reads this codon during translation? **1**

(A) Isoleucine **(B)** Methionine

(C) Tyrosine **(D)** Valine

ANSWER

(C) Tyrosine

The mRNA has the same sequence as the coding strand, with U in place of T.
Coding strand TAC → mRNA codon UAC.
UAC codes for tyrosine, so the charged tRNA (anticodon AUG) carries tyrosine at its 3′ end.
Common mistake: writing the complement of the coding strand (AUG → methionine). The complement rule applies to the template strand, not the coding strand.

9. Which technique, based on antigen–antibody interaction, is used for early detection of a disease? **1**

(A) RNAi
(B) EST
(C) PCR
(D) ELISA

ANSWER
(D) ELISA

ELISA (Enzyme Linked Immuno-Sorbent Assay) works on the antigen–antibody interaction: it detects the antigens of the pathogen or the antibodies made against it.
PCR also gives early diagnosis but works by amplifying nucleic acid, not by antigen–antibody binding. RNAi is gene silencing; ESTs are used in genome sequencing.

10. In the Meselson–Stahl experiment proving semi-conservative DNA replication, which centrifuge tube correctly shows the DNA bands after 40 minutes of growth of ^{15}N-labelled E. coli in ^{14}N medium? (Tubes described in words.) **1**

(A) Two bands: one at the light (^{14}N) position and one at the hybrid (intermediate) position
(B) A single band at the bottom (heavy ^{15}N position)
(C) Two bands, one at the extreme top end and one at the extreme bottom end (light and heavy)
(D) A single band in the middle (hybrid position)

ANSWER
(A) Two bands – light and hybrid

E. coli divides every 20 minutes, so 40 minutes = 2 generations in ^{14}N medium.
After generation 1 (20 min): all DNA is hybrid $^{15}N/^{14}N$ → one intermediate band.
After generation 2 (40 min): each hybrid molecule gives one hybrid and one fully light molecule → equal amounts of hybrid and light DNA → two bands (intermediate and light).
A heavy band never reappears, so (B) and (C) are wrong; a single hybrid band (D) is the 20-minute result.

11. The bioactive molecule cyclosporin A is obtained from: **1**

(A) Propionibacterium sharmanii
(B) Monascus purpureus
(C) Trichoderma polysporum
(D) Aspergillus niger

ANSWER
(C) Trichoderma polysporum

Cyclosporin A, an immunosuppressive drug used in organ-transplant patients, is produced by the fungus Trichoderma polysporum.
Others: Propionibacterium sharmanii – large holes in Swiss cheese; Monascus purpureus – statins (blood-cholesterol lowering); Aspergillus niger – citric acid.

12. In pea, inflated pod shape is dominant over constricted pod shape. What phenotypic ratio is expected in the offspring when two plants, both heterozygous for inflated pods, are crossed? **1**

(A) 1 : 0 **(B)** 1 : 1

(C) 2 : 1 **(D) 3 : 1**

ANSWER

(D) 3 : 1

Let I = inflated (dominant), i = constricted.
Cross: Ii × Ii → 1 II : 2 Ii : 1 ii.
II and Ii are inflated (3), ii is constricted (1).
Phenotypic ratio = 3 inflated : 1 constricted (the genotypic ratio is 1 : 2 : 1).

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13. Assertion (A): Healthy, virus-free plants can be raised from a virus-infected plant by growing parts of it in vitro (tissue culture). **1**
Reason (R): When a plant is infected with a virus, its roots and stems remain free of the virus.

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

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

(C) (A) is true, but (R) is false.

(D) (A) is false, but (R) is true.

ANSWER

(C) A is true, R is false.

Virus-free plants are indeed obtained from infected plants by meristem culture, so A is true.
But it is the meristem (apical and axillary) that stays free of the virus, not the whole root and stem; the virus spreads through the rest of the plant. So R is false.
Hence option (C).

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14. Assertion (A): A person infected with malaria gets chills and high fever that recur every three to four days. **1**
Reason (R): The parasite attacks red blood cells, which rupture and release haemozoin.

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

(B) Both A and R are true but R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

ANSWER

(A) Both true; R explains A

In the human host, Plasmodium multiplies inside RBCs.
When the RBCs burst, a toxic substance haemozoin is released, which causes the chill and high fever.
This rupture happens in cycles, so the fever recurs every 3–4 days.
So A is true, R is true, and R explains A.

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15. Assertion (A): 'Saheli', an oral contraceptive pill, stops ovulation and increases phagocytosis of sperms. **1**

Reason (R): Saheli is a non-steroidal preparation.

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

(B) Both A and R are true but R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

ANSWER

(D) A is false, R is true

Saheli is a once-a-week, non-steroidal oral pill developed by CDRI, Lucknow – so R is true. Increasing phagocytosis of sperms inside the uterus is the action of IUDs (non-medicated/copper IUDs), not of oral pills. Pills act by inhibiting ovulation/implantation and altering cervical mucus. So A is false.

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16. Assertion (A): ABO blood grouping in humans is an example of multiple allelism. **1**

Reason (R): In ABO blood grouping, more than two genes in a population control the same character.

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

(B) Both A and R are true but R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

ANSWER

(C) A is true, R is false

ABO blood groups are controlled by ONE gene (I) with three alleles – I^A, I^B and i – so A is true. Multiple allelism means more than two ALLELES of a single gene in a population, not more than two genes. R wrongly says 'genes', so R is false.

SECTION B

Q17–21 are very short answer questions of 2 marks each.

17. Explain how a person's immunity would be affected if the thymus gland degenerates (atrophies) early in life. **2**

ANSWER

Immunity falls – T-lymphocytes cannot mature, so cell-mediated (and helped humoral) immunity is weakened.

The thymus is a primary lymphoid organ where immature lymphocytes differentiate into antigen-sensitive T-lymphocytes.
If it degenerates early, T-cells will not develop and mature.
Without T-cells, cell-mediated immunity (graft rejection, killing of infected cells) fails and B-cells get less help, so the person's overall immunity decreases and infections become frequent.

OR

(i) What are interferons? How do they help in providing immunity?
(ii) To which type of innate immunity barrier do interferons belong?

ANSWER

(i) Proteins secreted by virus-infected cells that protect nearby uninfected cells from viral infection; (ii) cytokine barrier.

(i) Interferons are proteins released by cells that have been infected by a virus.
They act on neighbouring non-infected cells and protect them from further viral infection.
(ii) Interferons are cytokine barriers – one of the four barriers of innate immunity (physical, physiological, cellular, cytokine).

18. An mRNA (start codon not shown) is translated, in theory, in two reading frames: **2**
(a) Reading frame 1 – translation begins at the first nucleotide of 5′ CUCGCUUGCCGAUCAAGGGUUA 3′.
(b) Reading frame 2 – translation begins at the second nucleotide of 5′ GUGGCACUCAGUCCUUAAUGGCG 3′.
How many amino acids will be coded in case (a) and in case (b)? Justify.

ANSWER

(a) 7 amino acids; (b) 7 amino acids (triplet code, no stop codon in frame).

The genetic code is triplet: every 3 bases = 1 codon = 1 amino acid; a stop codon (UAA, UAG, UGA) ends the chain.
(a) 22 bases read from base 1: CUC GCU UGC CGA UCA AGG GUU + A (left over). 7 complete codons, none is a stop → 7 amino acids.
(b) 23 bases, read from base 2 (22 bases used): UGG CAC UCA GUC CUU AAU GGC + G (left over). 7 complete codons, no stop → 7 amino acids.
Common mistake: reading frame (b) from base 1 – GUG GCA CUC AGU CCU UAA would hit the stop codon UAA.

19. Explain the term MTP. What was the main reason for the Government of India to legalise MTP? **2**

ANSWER

MTP = medical (intentional) termination of pregnancy before full term; legalised to get rid of unwanted/harmful pregnancies safely.

MTP (medical termination of pregnancy) is the intentional or voluntary ending of a pregnancy before full term (induced abortion).
It was legalised (MTP Act 1971, amended 2017) with strict conditions to check illegal, unsafe abortions and to get rid of unwanted pregnancies – due to casual unprotected sex, failure of a contraceptive, rape – or when continuing the pregnancy would harm or even be fatal to the mother, the foetus or both.

OR

Name any two sexually transmitted infections (STIs) that can occur in a human female, and state two of their early symptoms.

ANSWER

e.g. gonorrhoea, syphilis; early symptoms – itching, fluid discharge, slight pain, swelling in the genital region.

STIs (any two): gonorrhoea, syphilis, genital herpes, chlamydiasis, genital warts, trichomoniasis, hepatitis-B, HIV/AIDS.
Early symptoms (any two): itching in the genital region, abnormal fluid discharge, slight pain, swelling or redness in the genital region.
Note: early symptoms are mild, so females often ignore them, which can lead to complications later.

20. A flow diagram of recombinant DNA technology: Step 1 – vector (plasmid) DNA cut with EcoRI is mixed with alien DNA cut with EcoRI and joined by 'Enzyme A'; Step 2 – recombinant DNA molecule; Step 3 – transfer of recombinant DNA into the host E. coli; Step 4 – replication of the recombinant DNA in E. coli. **2**

(a) Name Enzyme A used in Step 1 to join the cut plasmid and alien DNA.
(b) What is the technical term for Step 3?
(c) Why is the same restriction enzyme EcoRI used to cut both the vector and the alien DNA?

ANSWER

(a) DNA ligase; (b) transformation; (c) same enzyme gives complementary sticky ends that can pair and be joined.

(a) DNA ligase joins the cut ends (seals the sugar-phosphate backbone).
(b) Introducing recombinant DNA into a bacterial host cell is called transformation.
(c) EcoRI cuts at its palindrome GAATTC, between G and A, leaving the same single-stranded overhangs (sticky ends) on both DNAs. Because they are complementary, the ends of vector and alien DNA pair by hydrogen bonds and DNA ligase can join them. A different enzyme would give non-matching ends.

21. Explain why the association between sea anemone and clownfish is a classic example of commensalism. **2**

ANSWER

Clownfish benefits (protection among stinging tentacles); sea anemone is neither benefited nor harmed.

Commensalism (+, 0): one species benefits and the other is neither harmed nor benefited.
The clownfish lives among the stinging tentacles of the sea anemone, which protect it from predators – the clownfish benefits.
The sea anemone gets no clear benefit and is not harmed from the clownfish.

OR

Draw (indicating trophic levels) and describe the pyramid of biomass in a sea where a standing crop of 40 phytoplankton supports 90 zooplankton, which in turn support 120 small fishes.

ANSWER

Inverted pyramid of biomass: phytoplankton 40 (PP, narrow base) < zooplankton 90 (PC) < fishes 120 (SC, broad top).

Drawing: three stacked bars widening upwards –
Bottom (narrowest): phytoplankton 40 – primary producers (first trophic level).
Middle: zooplankton 90 – primary consumers (second trophic level).
Top (widest): small fishes 120 – secondary consumers (third trophic level).
Description: biomass increases at higher levels, so the pyramid of biomass in the sea is inverted. This happens because phytoplankton are small, multiply very fast and are eaten quickly, so their standing crop at any moment is low even though productivity is high.

SECTION C

Q22–28 are short answer questions of 3 marks each.

22. Describe how the placenta forms in a human female after the blastocyst is implanted in the endometrium. **3**

ANSWER

Chorionic villi from the trophoblast interdigitate with uterine tissue and maternal blood to form the placenta – a structural and functional link between foetus and mother.

1. After implantation, finger-like projections called chorionic villi grow out from the trophoblast.
2. The chorionic villi become surrounded by uterine tissue and maternal blood.
3. The chorionic villi and uterine tissue become interdigitated (interlocked) with each other.
4. Together they form the placenta, a structural and functional unit between the developing embryo (foetus) and the mother's body.
5. The placenta is connected to the embryo by the umbilical cord and supplies O_2 and nutrients and removes CO_2 and wastes.
6. It also acts as an endocrine tissue (hCG, hPL, oestrogens, progesterone).

23. Mendel carried out hybridisation experiments on garden pea for seven years and proposed the laws of inheritance. **3**

(a) Give two reasons for his success.

(b) State the law of independent assortment that he proposed from dihybrid crosses.

ANSWER

(a) e.g. true-breeding lines with clear contrasting traits, large samples; (b) in a hybrid with two pairs of traits, segregation of one pair is independent of the other.

(a) Any two:

– He chose true-breeding pea varieties.

– He studied traits with clear, contrasting forms (tall/dwarf etc.).

– He carried out artificial self- and cross-pollination carefully.

– He used large sample sizes and statistical analysis.

– He confirmed results over several generations.

(b) Law of independent assortment: when two pairs of traits are combined in a hybrid, the segregation of one pair of characters is independent of the other pair (this is why a 9 : 3 : 3 : 1 ratio appears in F_2).

24. A single DNA strand is drawn as a 'stick' diagram running 5′ → 3′: sugars are vertical lines carrying bases A, T and G (in that order from 5′ to 3′); a phosphate (P) is attached at the 5′ end by a slanting line labelled (a); slanting lines between the 3′ end of one sugar and the 5′ end of the next, one of them labelled (b), link the nucleotides; the 3′ end ends in OH. **3**

(a) Name the covalent bonds shown as (a) and (b).

(b) How many purines are present in this strand?

(c) Draw the chemical structure of this polynucleotide chain.

ANSWER

(a) (a) phosphoester bond, (b) phosphodiester bond; (b) 2 purines (A and G); (c) labelled structure as below.

(a) Bond (a) joins the 5′-OH of the first sugar to a phosphate – a phosphoester bond. Bond (b) links the 3′-C of one sugar to the 5′-C of the next through a phosphate – a 3′–5′ phosphodiester bond.
(b) Purines are adenine and guanine; the strand has A, T, G → 2 purines (A, G). T is a pyrimidine.
(c) The drawing must show:
– Three deoxyribose (pentagon) sugars, each with a base on C1′: adenine, thymine, guanine.
– A free phosphate at the 5′ end (on C5′ of the first sugar).
– Phosphodiester links (–O–P(=O)(O^-)–O–) from C3′ of each sugar to C5′ of the next.
– A free OH on C3′ of the last sugar, with the 5′ and 3′ ends labelled.

25. Explain the biological (secondary) treatment that the primary effluent undergoes in the large aeration tanks of a sewage treatment plant. **3**

ANSWER

Effluent is agitated and aerated → aerobic microbes grow as flocs → they consume most organic matter → BOD falls sharply.

1. Primary effluent is passed into large aeration tanks where it is constantly agitated mechanically and air is pumped in.
2. This allows vigorous growth of useful aerobic microbes into flocs – masses of bacteria associated with fungal filaments forming mesh-like structures.
3. While growing, these microbes consume the major part of the organic matter in the effluent.
4. This significantly reduces the BOD of the effluent. When BOD is reduced enough, the effluent is passed to a settling tank where flocs settle as activated sludge (part is returned as inoculum, rest goes to anaerobic sludge digesters).

26. A flower adapted for the most common kind of abiotic pollination is shown (described in words): it has large, exposed feathery stigmas, versatile anthers on long filaments, a small ovary and tiny petals. **3**

(a) Name the mode of abiotic pollination used by this plant.

(b) Why does the flower need large, exposed feathery stigmas?

(c) Give two important adaptations of the pollen grains of such flowers.

(d) Why are the petals small and non-green?

ANSWER

(a) Wind pollination (anemophily); (b) to trap air-borne pollen; (c) light and non-sticky; (d) no need to attract animals / do not obstruct wind.

(a) Anemophily – pollination by wind.

(b) Wind carries pollen randomly, so large feathery stigmas exposed to air give a big surface to trap air-borne pollen grains.

(c) Pollen grains are light and non-sticky so that wind can carry them; they are also produced in very large numbers.

(d) Wind-pollinated flowers do not need to attract insects, birds or bats, so bright, large petals are not needed; small petals also let wind flow freely to the anthers and stigma.

27. A wildlife report found that the biggest threat to tigers in the Mudumalai Tiger Reserve (MTR) was Lantana camara, an attractive flowering shrub from tropical America that has spread over about 40% of India's tiger range. A Lantana removal drive by the Tamil Nadu forest department helped revive the reserve and reduced human–wildlife conflict. MTR has 25 species of grasses and legumes. **3**

(a) How did removing Lantana help restore the MTR?

(b) Why is the invasion of Lantana camara a matter of concern for MTR?

ANSWER

(a) Native grasses/legumes regrew → more herbivores → more prey for tigers; (b) invasive Lantana suppresses native plants → herbivores and then tigers decline.

(a) Once Lantana was removed, native grasses and legumes could grow again. More fodder supports more herbivores (deer etc.), which means more prey for tigers, so the tiger population and the whole food chain recover; animals also stray less into villages, reducing human–wildlife conflict.

(b) Lantana is an alien invasive species. It spreads fast and does not let native plants grow around it, so the 25 native grass and legume species decline. This reduces the herbivore population, which in turn causes the tiger population to decline – alien species invasion is one of the 'evil quartet' causes of biodiversity loss.

28. List one advantage and two disadvantages of the green revolution. **3**

ANSWER

Advantage: much higher crop yields that could feed a growing population. Disadvantages: e.g. pollution of soil and water by agrochemicals; costly irrigation and inputs; rising soil salinity / loss of natural soil fertility.

Advantage (1 mark): high-yielding, disease-resistant varieties with better irrigation and fertilisers greatly increased food production (especially wheat and rice), making the country self-sufficient in food grains and able to support a larger population.

Disadvantages (any two, 1 mark each):

• Heavy use of fertilisers and pesticides polluted soil and water over time (and can cause biomagnification).

• Irrigation and other crop-management practices are expensive.

• Agrochemicals are costly for small farmers, and crops become dependent on them.

• Excess irrigation raised soil salinity, and chemicals lowered the soil's natural fertility.

SECTION D

Q29–30 are case-based questions of 4 marks each, with an internal choice in one sub-part.

29. *Molecular similarities give strong evidence of evolutionary relationships. A table lists the number of amino acid differences between the haemoglobin of humans and that of other animals: macaque 8, dog 32, bird 45, frog 67, lamprey 125.* **4**

(a) Is the relationship between (i) humans and macaque, (ii) humans and frog, an example of divergent or convergent evolution? (1)

(b) What do the biochemical similarities in haemoglobin suggest about the relationship between humans, frog and lamprey? (1)

(c) (i) Of lampreys and macaques, which is more closely related to humans in evolution, and why? (2)

ANSWER

(a) (i) divergent, (ii) divergent; (b) common ancestry; (c) macaque – only 8 amino acid differences vs 125 for lamprey.

(a) Haemoglobin is the same (homologous) protein inherited from a common ancestor and changed along different lines, so both are divergent evolution: (i) divergent, (ii) divergent.
(b) Similar haemoglobin in humans, frog and lamprey shows that they share a common ancestry.
(c) Fewer amino acid differences mean a more recent common ancestor. Macaque differs from humans by only 8 amino acids while lamprey differs by 125, so the macaque is much more closely related to humans.

OR

(c) (ii) (c) (ii) Of frogs and dogs, which is more closely related to humans in evolution, and why? (2)

ANSWER

Dog – 32 amino acid differences vs 67 for frog.

The number of amino acid differences in haemoglobin is a measure of evolutionary distance.
Dog differs from humans by 32 amino acids; frog by 67.
Fewer differences = more biochemical similarity = more recent common ancestor, so the dog is more closely related to humans than the frog (both are mammals).

30. *A UNODC report estimated about 5,00,000 drug-related deaths in 2019, 17.5% more than in 2009. More than half were due to liver diseases caused by hepatitis B, and about a quarter to overdoses. Opioids used non-medically cause the most severe harm – about two-thirds of direct drug-related deaths worldwide.* **4**

(a) Why are opioid users more likely to get liver disease due to hepatitis B? (1)

(b) What is meant by a direct drug-related disease (death)? (1)

(c) (i) Name the plant (scientific name) from which opioids are obtained, and the part from which they are extracted. (2)

ANSWER

(a) Opioids are often injected – shared/contaminated needles spread hepatitis B; (b) harm caused directly by the drug, e.g. fatal overdose; (c) Papaver somniferum, latex (of unripe capsule).

(a) Opioids such as heroin are commonly taken intravenously; sharing contaminated needles/syringes transmits the hepatitis B virus, which damages the liver.

(b) Direct drug-related disease/death is one caused by the drug itself – mainly fatal overdose of opioids – rather than by an infection picked up indirectly.

(c) Opioids come from the poppy plant Papaver somniferum; they are extracted from its latex (milky juice of the unripe fruit/capsule). Morphine is extracted from this latex and heroin is made from morphine by acetylation.

OR

(c) (ii) State two common warning signs of drug abuse among young people. (2)

ANSWER

Any two: drop in academic performance, unexplained absence from school, lack of interest in personal hygiene, withdrawal/isolation, depression, aggressive behaviour, changes in sleep and eating habits.

Warning signs (any two):

– Drop in academic performance; unexplained absence from school/college.

– Lack of interest in personal hygiene; withdrawal and isolation.

– Depression, fatigue, aggressive and rebellious behaviour.

– Deteriorating relations with family and friends; loss of interest in hobbies.

– Changes in sleeping and eating habits, fluctuation in weight and appetite.

SECTION E

Q31–33 are long answer questions of 5 marks each.

31. (i) Explain how double fertilisation takes place in a flowering plant. **5**

(ii) What is the fate of the products of double fertilisation?

ANSWER

(i) Pollen tube releases 2 male gametes into a synergid; one fuses with egg (syngamy → zygote), the other with two polar nuclei (triple fusion → PEN); (ii) PEC → endosperm, zygote → embryo.

(i) 1. The pollen tube enters one of the synergids through the filiform apparatus and releases two male gametes into its cytoplasm.
2. One male gamete moves to the egg cell and fuses with its nucleus – syngamy – forming a diploid zygote.
3. The other male gamete moves to the two polar nuclei in the central cell and fuses with them – triple fusion – forming the triploid primary endosperm nucleus (PEN); the central cell becomes the primary endosperm cell (PEC).
4. Since two fusions (syngamy + triple fusion) occur in one embryo sac, it is called double fertilisation.
(ii) The PEC develops into the endosperm (nutritive tissue); the zygote develops into the embryo.
(Ovules become seeds and the ovary becomes the fruit.)

OR

(i) Describe the structure of testicular lobules in the human male. Name the two types of cells in seminiferous tubules and give their roles.

(ii) Describe the role of the hypothalamic hormone GnRH in spermatogenesis.

ANSWER

(i) Each lobule has 1–3 highly coiled seminiferous tubules; male germ cells (spermatogonia → sperms) and Sertoli cells (nourish germ cells); (ii) GnRH stimulates anterior pituitary to release LH and FSH.

(i) Each testis has about 250 compartments called testicular lobules.
Each lobule contains one to three highly coiled seminiferous tubules, where sperms are produced.
The tubules are lined by two types of cells:
– Male germ cells (spermatogonia): undergo meiotic divisions that finally form sperms.
– Sertoli cells: provide nutrition to the germ cells.
(Outside the tubules, Leydig/interstitial cells secrete androgens.)
(ii) At puberty, increased GnRH from the hypothalamus acts on the anterior pituitary and stimulates secretion of two gonadotropins:
– LH, which acts on Leydig cells to secrete androgens that stimulate spermatogenesis;
– FSH, which acts on Sertoli cells to secrete factors that help spermiogenesis.

32. Name and explain the biotechnological method by which infection of tobacco roots by the nematode Meloidogyne incognita is prevented using Agrobacterium vectors and RNA interference. **5**

ANSWER

RNA interference (RNAi) – nematode-specific genes introduced via Agrobacterium make sense + antisense RNA → dsRNA → silences nematode mRNA, so the parasite cannot survive.

Strategy: RNA interference (RNAi).

1. RNAi is a natural method of cellular defence in all eukaryotes: a complementary double-stranded RNA binds to and prevents translation of a specific mRNA (silencing).
2. Using Agrobacterium vectors, nematode-specific genes were introduced into the tobacco (host) plant.
3. The DNA was introduced so that it produced both sense and anti-sense RNA in the host cells.
4. These two complementary RNAs formed double-stranded RNA (dsRNA), which initiated RNAi.
5. This silenced the specific mRNA of the nematode, so the parasite could not survive in the transgenic host expressing the interfering RNA – the plant was protected.

OR

Explain how a gene of interest is amplified by the polymerase chain reaction (PCR).

ANSWER

Repeated cycles of denaturation, annealing of two primers, and extension by Taq polymerase; ~30 cycles give about a billion copies.

PCR makes many copies of a gene in vitro. Ingredients: template DNA, two sets of primers, dNTPs, thermostable DNA polymerase.

Each cycle has three steps:

1. Denaturation: the DNA is heated to a high temperature; hydrogen bonds break and the two strands separate.
2. Annealing: on cooling, two sets of primers (short, chemically synthesised oligonucleotides complementary to the ends of the target region) attach at the 3′ ends of the two template strands.
3. Extension: DNA polymerase extends the primers using the nucleotides provided and the DNA as template. The enzyme is Taq polymerase from Thermus aquaticus, which stays active during the high-temperature denaturation.

Repeating the cycle about 30 times amplifies the DNA segment about a billion times. The amplified fragment can then be ligated into a vector for cloning.

33. (i) Describe the growth curve of a natural population of any species that has limited resources. **5**
(ii) Give the equation of this growth.
(iii) Name the growth curve and draw its graph.

ANSWER

(i) Lag → acceleration → deceleration → asymptote at carrying capacity K; (ii) dN/dt = rN(K − N)/K; (iii) logistic (Verhulst–Pearl) sigmoid S-shaped curve.

(i) With limited resources, competition sets a limit – the carrying capacity (K). The population first shows a lag phase, then phases of acceleration and deceleration, and finally an asymptote when population density reaches K.
(ii) Verhulst–Pearl logistic equation:

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

N = population density at time t, r = intrinsic rate of natural increase, K = carrying capacity.
(iii) Logistic growth curve – an S-shaped (sigmoid) curve.
Graph: x-axis time (t), y-axis population density (N); the curve rises slowly, then steeply, then levels off along a horizontal line marked K.
It is considered more realistic than exponential growth because resources in nature are finite.

OR

(i) Explain the species–area relationship in a natural region and predict the shape of the graph when species richness is plotted against area for many taxa.
(ii) Show the species richness – area relationship as a graph.
(iii) Give the equation of the species–area relationship on a logarithmic scale.

ANSWER

(i) Species richness increases with area, but only up to a limit; rectangular hyperbola; (ii) curve rising and flattening (straight line on log–log); (iii) log S = log C + Z log A.

(i) Alexander von Humboldt observed that within a region, species richness increases with increasing explored area, but only up to a limit. For a wide variety of taxa (angiosperms, birds, bats, freshwater fishes) the curve of species richness against area is a rectangular hyperbola.
(ii) Graph: x-axis area (A), y-axis species richness (S); the curve rises steeply then flattens. On a log–log scale the relationship is a straight line.
(iii) $\log S = \log C + Z \log A$
S = species richness, A = area, Z = slope of the line (regression coefficient), C = Y-intercept.
Z is usually 0.1–0.2 for smaller areas but steeper (0.6–1.2) for very large areas such as whole continents.

— END —

Questions restated from the CBSE Class XII Board Examination 2025 (set 57/4/1) for practice. Reading passages and map items are described, not reproduced.