Roll No. ☐☐☐☐☐☐☐☐

Q.P. Code 57/1/1

BIOLOGY (THEORY)

CBSE Class XII Board Examination 2023 — 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 and 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.
6. Section E: Q31–33, long answer, 5 marks each.
7. There is no overall choice, but one question in Section B, one in Section C, both in Section D and all three in Section E offer an internal choice (OR). Calculators are not allowed.

SECTION A

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

1. Which of the processes listed below give rise to recombinants in the next generations? **1**

(i) Mutation

(ii) Independent assortment during meiosis I

(iii) Independent assortment during meiosis II

(iv) Crossing over between homologous chromosomes of a bivalent

(A) (iv) only

(B) (ii) and (iv)

(C) (i), (ii) and (iii)

(D) (i), (ii), (iii) and (iv)

ANSWER

(b) (ii) and (iv)

Recombinants are offspring with new combinations of parental genes, not new genes.
Independent assortment of homologous chromosomes happens in meiosis I (anaphase I), giving new combinations of non-linked genes.
Crossing over between non-sister chromatids of a bivalent (pachytene of prophase I) recombines linked genes.
Meiosis II separates sister chromatids, so it does not assort homologues independently.
Mutation creates a new allele (a new variation) rather than reshuffling existing ones.
Common mistake: calling every source of variation 'recombination'.

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2. A schematic of transcription in a prokaryote shows a DNA double helix. The region 'X' is the stretch of DNA at the start of the transcription unit where the enzyme first sits; 'Y' is a small factor attached to the enzyme; 'Z' is the large enzyme sitting on the DNA. Identify X, Y and Z (Region X / Factor Y / Enzyme Z). **1**

(A) Terminator / Sigma (σ) / RNA polymerase

(B) Promoter / Rho (ρ) / RNA polymerase

(C) Promoter / Sigma (σ) / RNA polymerase

(D) Promoter / Sigma (σ) / DNA polymerase

ANSWER

(c) X = Promoter, Y = Sigma factor, Z = RNA polymerase

Transcription in bacteria starts when RNA polymerase binds the promoter of the transcription unit.
The initiation factor sigma (σ) associates with RNA polymerase and helps it recognise the promoter and begin transcription.
Rho (ρ) is the termination factor, and the terminator lies at the other end, so options with Rho or terminator are wrong.
DNA polymerase is used in replication, not transcription.

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3. An age pyramid of a human population has a narrow base (pre-reproductive group), becomes widest in the middle (reproductive group) and narrows again at the top (post-reproductive group). What does this pyramid show about the population? **1**

(A) Declining population

(B) Stable population

(C) Expanding population

(D) Extinct population

ANSWER

(a) Declining population

In an age pyramid the width of each bar shows the number of individuals in that age group. Triangular shape (very broad base) = expanding; bell shape (pre-reproductive ≈ reproductive) = stable; urn shape (pre-reproductive smaller than reproductive) = declining.
Here the pre-reproductive base is narrower than the reproductive group, so fewer young individuals will enter the reproductive age: an urn-shaped, declining population.

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4. Biology students measured two quantities at points along a river flowing past their city and plotted them against distance along the river. In the graph, the dissolved-oxygen curve starts low and steady, begins to rise just after point (i), reaches a peak between points (iii) and (iv), and falls again after (iv). The mineral-ion curve starts high, begins to fall just after point (i), reaches its lowest value near (iii), and rises again to a high level after (iv). At which point does untreated sewage enter the river? **1**

(A) Point (i)

(B) Point (ii)

(C) Point (iii)

(D) Point (iv)

ANSWER

(a) Point (i)

Marking scheme answer: (a) Point (i).
Point (i) is where both curves first start to change, so this is where untreated sewage is discharged: microbes decomposing its organic matter use up oxygen and the released nutrients alter the mineral-ion level; conditions recover only further downstream.

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5. Match the enzymes (Column I) with their functions (Column II). **1**

Column I: P. DNA ligase; Q. Restriction exonuclease; R. Taq polymerase; S. Restriction endonuclease

Column II: i. Removes nucleotides from the ends of DNA; ii. Extends the primer on a DNA template; iii. Joins DNA fragments; iv. Cuts DNA at a specific position

(A) P-i, Q-ii, R-iv, S-iii

(B) P-iv, Q-iii, R-ii, S-i

(C) P-i, Q-iv, R-iii, S-ii

(D) P-iii, Q-i, R-ii, S-iv

ANSWER

(d) P-iii, Q-i, R-ii, S-iv

DNA ligase seals the sugar–phosphate backbone, joining DNA fragments → iii.
Exonucleases remove nucleotides from the free ends of DNA → i.
Taq polymerase (thermostable, from Thermus aquaticus) extends primers during PCR → ii.
Restriction endonucleases cut within DNA at specific recognition (palindromic) sequences → iv.

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6. DNA fingerprinting was done for a child X and three individuals 1, 2 and 3. Every band in the child's lane matches a band present either in individual 1 or in individual 3; individual 2's bands do not account for the child's bands. Which option shows the possible parents of child X? **1**

(A) 1 and 2

(B) 2 and 3

(C) 1 and 3

(D) Only individual 3

ANSWER

(c) 1 and 3

A child inherits half of its VNTR/satellite pattern from the mother and half from the father.
So every band of the child must be found in one of the two biological parents.
The child's bands are fully explained by individuals 1 and 3 together; individual 2 contributes no matching set.
Hence 1 and 3 are the possible parents.

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7. A graph of number of giraffes (y-axis) against neck length (x-axis) is shown as a single bell-shaped curve. Choose the option that correctly describes natural selection with respect to neck length in giraffes. **1**

(A) Stabilising selection, as giraffes with longer necks are selected further

(B) Disruptive selection, as giraffes with both shorter and longer necks are selected

(C) Directional selection, as giraffes with longer necks are selected

(D) Stabilising selection, as giraffes with medium neck lengths are selected

ANSWER

(c) Directional selection – longer necks were favoured (CBSE also accepted (d))

In the evolution of the giraffe's neck, individuals with slightly longer necks could reach higher leaves, survived and reproduced more, so the population mean shifted towards longer necks – directional selection.

Stabilising selection favours the mean value; disruptive selection favours both extremes.

Note: because the graph drawn was a single bell curve (which by itself looks like stabilising selection), the CBSE marking scheme accepted both (c) and (d).

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8. 325 microspore mother cells go through microsporogenesis. How many pollen grains are formed? **1**

(A) 325

(B) 650

(C) 1300

(D) 975

ANSWER

(c) 1300

Each microspore mother cell (2n) divides by meiosis to form a tetrad of 4 microspores, and each microspore becomes a pollen grain.

Number of pollen grains = 325 × 4 = 1300.

Common mistake: multiplying by 2 (one meiotic division gives 4 cells, not 2).

9. Match the contraceptives (Column I) with their modes of action (Column II). **1**

Column I: P. Lippes loop; Q. Multiload 375; R. Subcutaneous Norplant; S. Saheli

Column II: i. Inhibits ovulation; ii. Phagocytosis of sperms inside the uterus; iii. Thickens the cervical mucus; iv. Makes the cervix hostile to sperms

(A) P-ii, Q-iv, R-iii, S-i

(B) P-i, Q-ii, R-iii, S-iv

(C) P-iii, Q-i, R-iv, S-ii

(D) P-iv, Q-iii, R-ii, S-i

ANSWER

(a) P-ii, Q-iv, R-iii, S-i

Lippes loop is a non-medicated IUD – it increases phagocytosis of sperms in the uterus → ii.
Multiload 375 is a copper-releasing IUD – Cu ions suppress sperm motility and make the cervix/uterus hostile to sperms → iv.
Norplant implants release progestogen, which thickens cervical mucus (and inhibits ovulation) → iii.
Saheli, the once-a-week non-steroidal pill, is matched with inhibition of ovulation → i.

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10. Which option correctly matches an endocrine source with its hormone and function? (Gland – Hormone – Function) **1**

(A) Sertoli cells – Testosterone – Development of secondary sexual characters

(B) Placenta – Estrogen – Starts secretion of milk

(C) Leydig cells – Androgen – Starts the production of sperms

(D) Ovary – FSH – Stimulates follicular development

ANSWER

(c) Leydig cells – Androgen – initiates spermatogenesis

Leydig (interstitial) cells secrete androgens (testosterone), which stimulate spermatogenesis and male secondary sexual characters → (c) is correct.
(a) Sertoli cells nourish germ cells; they do not secrete testosterone.
(b) Milk secretion is started by prolactin, not placental estrogen.
(d) FSH is secreted by the anterior pituitary, not the ovary.

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11. In 1972 Stanley Cohen and Herbert Boyer made the first recombinant DNA. Which organism's plasmid/gene was used? **1**

(A) E. coli

(B) Salmonella typhimurium

(C) Agrobacterium tumefaciens

(D) Bacillus thuringiensis

ANSWER

(b) Salmonella typhimurium

Cohen and Boyer isolated the antibiotic-resistance gene from a native plasmid of Salmonella typhimurium, cut it with a restriction enzyme and linked it to a plasmid vector using DNA ligase.
E. coli was later used as the host to clone it, which is why many students wrongly choose (a).

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12. Who challenged the patent granted to a US university (on the wound-healing use of turmeric, a traditional Indian remedy)? **1**

(A) Mr. Ajay Phadke
(B) Ms. Vandana Shiva
(C) Dr. Venugopalan
(D) Dr. R.A. Mashelkar

ANSWER
(d) Dr. R.A. Mashelkar

The University of Mississippi Medical Center was granted a US patent on the use of turmeric for wound healing.
CSIR, led by its Director-General Dr. R.A. Mashelkar, challenged it using ancient Indian texts as prior art, and the patent was revoked (1997).
This is a classic case of biopiracy – using traditional knowledge without authorisation or compensation.

13. Assertion (A): A patient with ADA deficiency treated by gene therapy needs repeated infusions of genetically engineered lymphocytes. **1**
Reason (R): Lymphocytes are immortal.

(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

In gene therapy for ADA deficiency, lymphocytes from the patient are given a functional ADA cDNA (via a retroviral vector) and returned to the body.
These lymphocytes are NOT immortal – they have a limited life span, so infusions must be repeated periodically.
So A is true, R is false. (A permanent cure needs the gene introduced into bone-marrow cells at an early embryonic stage.)

14. Assertion (A): Cattle egrets living closely with grazing cattle are a classic example of commensalism. **1**

Reason (R): As the cattle walk through the vegetation they disturb and flush out insects that the egrets would otherwise find hard to locate and catch.

(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

Commensalism: one species benefits, the other is neither harmed nor benefited.
Egrets forage close to grazing cattle because the cattle stir up insects – the egret benefits, the cattle are unaffected.
This is exactly why the association is commensalism, so R correctly explains A.

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15. Assertion (A): In non-albuminous (ex-albuminous) seeds the endosperm is fully used up during embryo development. **1**

Reason (R): Castor, pea and beans are all non-albuminous seeds.

(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

Non-albuminous seeds (pea, groundnut, beans) have no residual endosperm because it is completely consumed by the developing embryo – A is true.
Castor is an albuminous seed (endosperm persists, like wheat, maize, barley), so R is false.

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16. Assertion (A): In birds such as the pigeon, females are heterogametic and males are homogametic. **1**

Reason (R): Female pigeons carry Z and W sex chromosomes while males carry ZZ.

(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

Birds show ZW–ZZ sex determination.

Females (ZW) produce two kinds of eggs (Z or W) – heterogametic; males (ZZ) produce only Z sperms – homogametic.

The chromosome make-up in R is the reason for the statement in A.

SECTION B

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

17. A diagram shows an early human embryo: a hollow ball of cells with an outer single layer of flattened cells (labelled X) and a cluster of cells attached to the inside of this layer at one side (labelled Y). **2**

(a) Name this embryonic stage.

(b) Where exactly is it found in a normal pregnancy?

(c) Give one function each of X and Y.

ANSWER

Blastocyst; in the endometrium of the uterus; X (trophoblast) – implantation, Y (inner cell mass) – forms the embryo

(a) Blastocyst.

(b) It gets embedded in the endometrium (inner lining) of the uterine wall – implantation.

(c) X = trophoblast: attaches the blastocyst to the endometrium and helps in implantation (later forms chorionic villi/placenta).

Y = inner cell mass: differentiates into the embryo (it contains stem cells).

18. (a) Through which end of the ovule does the pollen tube enter the embryo sac of a Hibiscus flower, and how is it guided in? **2**

(b) What happens to the two male nuclei carried by the pollen tube?

ANSWER

Micropylar end, guided by the filiform apparatus of a synergid; one male gamete fuses with the egg (syngamy), the other with the two polar nuclei (triple fusion)

(a) The pollen tube enters the ovule through the micropyle and then enters one of the synergids; the filiform apparatus at the micropylar end of the synergids guides the entry of the pollen tube.

(b) The two male gametes are released into the synergid's cytoplasm.

One fuses with the egg cell → diploid zygote (syngamy).

The other fuses with the two polar nuclei of the central cell → triploid primary endosperm nucleus (triple fusion).

Together these form double fertilisation.

19. Two structures are shown: A – a small circular double-stranded DNA ring; B – a virus with a polygonal head containing DNA, a tail sheath and tail fibres (the kind that infects bacteria). **2**

(i) Identify A and B.

(ii) Why are they important in biotechnology experiments?

ANSWER

A = plasmid, B = bacteriophage; both are used as cloning vectors

(i) A = plasmid (extra-chromosomal circular DNA of bacteria); B = bacteriophage (virus infecting bacteria).

(ii) Both are used as cloning vectors to carry a foreign gene into the host cell.

They replicate independently of the chromosomal DNA and have a high copy number, so the linked gene is multiplied.

Plasmids can carry selectable markers (e.g. antibiotic-resistance genes) to pick out transformants.

OR

Explain how a bacterial cell is made 'competent' to take up foreign DNA using divalent cations and a temperature treatment.

ANSWER

Treat with Ca^{2+}, incubate with rDNA on ice, heat shock at 42 °C, return to ice

DNA is hydrophilic and cannot pass through the cell membrane on its own.

Step 1: Treat bacterial cells with a specific concentration of a divalent cation such as calcium ($CaCl_2$); this increases the efficiency with which DNA enters through pores in the cell wall.

Step 2: Incubate the cells with recombinant DNA on ice.

Step 3: Give a brief heat shock at 42 °C.

Step 4: Put them back on ice. The cells now take up the recombinant DNA.

20. Ecological pyramids are useful but have limitations. State any two of them. **2**

ANSWER

Do not include a species that belongs to more than one trophic level; assume simple food chains (no food webs); saprophytes/decomposers are left out

Any two:

1. They do not take into account the same species belonging to two or more trophic levels.
2. They assume a simple food chain, which hardly ever exists in nature; they cannot show a food web.
3. Saprophytes (decomposers) are given no place in the pyramid although they play a vital role in the ecosystem.

21. India is the seventh largest country of the world by area. What percentage of the world's land area does India have? Then state what makes India one of the 12 mega-diversity countries. **2**

ANSWER

2.4% of world land area; it holds about 8.1% of global species diversity

India has only about 2.4% of the world's land area.
Yet its share of global species diversity is an impressive 8.1%.
This high species richness (and endemism) relative to its area makes India one of the 12 mega-diversity countries of the world.

SECTION C

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

22. Using a schematic diagram only, show in three steps how recombinant DNA is formed by the action of the restriction enzyme EcoRI and DNA ligase. **3**

ANSWER

EcoRI cuts GAATTC in vector and foreign DNA → sticky ends → ligase joins them

The diagram should show these three steps with labels:
Step 1: Vector DNA (plasmid) and foreign DNA, each carrying the palindromic sequence 5'-GAATTC-3' / 3'-CTTAAG-5'; EcoRI cuts each strand between G and A.
Step 2: Both DNAs now have complementary single-stranded overhangs (5'-AATT) – label them 'sticky ends'; the foreign DNA fragment is placed with its sticky ends facing those of the opened vector.
Step 3: The sticky ends pair by hydrogen bonds and DNA ligase seals the backbone – label 'DNA ligase' and 'recombinant DNA (plasmid with foreign DNA)'.
Marks are for each correctly drawn and labelled step (EcoRI site, sticky ends, ligase/recombinant DNA).

23. Pedigree: Generation I – a normal female and a normal male (parents). Generation II – their children: son 1 (normal), son 2 (affected), daughter 3 (normal). Son 1 marries an affected female and has a normal daughter (III-1). Daughter 3 marries a normal male and has an affected son (III-2) and two normal daughters (III-3, III-4). **3**

(a) Is the trait dominant or recessive? Give a reason.

(b) Is it autosomal or sex-linked? Give a reason.

(c) Write the possible genotypes of children 1 and 3 of generation II.

ANSWER

Recessive; autosomal (males and females both affected) – II-1: AA or Aa, II-3: Aa (CBSE also accepted X-linked: II-1 XY, II-3 XX^c)

(a) Recessive: both parents in generation I are normal but have an affected son (II-2), so they must carry a hidden allele.
(b) Autosomal: the trait appears in both a male (II-2, III-2) and a female (wife of II-1) and is passed through unaffected individuals; nothing restricts it to one sex.
(c) Using A (normal) and a (affected): II-1 is normal with carrier parents → AA or Aa. II-3 is normal but has an affected son → must be Aa.
Note: since more males are affected, the CBSE scheme also accepted an X-linked recessive answer: II-1 = XY, II-3 = XX^c (carrier).

24. (a) State the characteristics of stem cells. **3**

(b) Name sources of stem cells in humans.

(c) Give any two uses of stem cells in treating human diseases.

ANSWER

Self-renewal + ability to differentiate into many cell types; inner cell mass of blastocyst, umbilical cord blood, bone marrow; e.g. diabetes (islet cells), spinal-cord injury, vision restoration

(a) Stem cells can divide repeatedly to renew themselves (self-renewal) and can differentiate into different kinds of specialised cells/tissues.
(b) Sources: inner cell mass of the blastocyst (embryonic stem cells), umbilical cord blood, bone marrow (any one).
(c) Any two: forming insulin-producing islet cells for diabetes; repairing spinal-cord injury; restoring vision (retinal/corneal cells); treating heart disease; treating genetic disorders like cystic fibrosis; rheumatoid arthritis.

25. (a) Distinguish between malignant and benign tumours. **3**

(b) Name and explain the most dangerous property of malignant tumours.

ANSWER

Malignant – fast-growing, invasive, metastatic; benign – confined, no metastasis. Most feared property: metastasis

(a) Malignant tumour: cells divide rapidly, invade and damage surrounding normal tissue, and spread (metastasis).
Benign tumour: grows slowly, stays confined to its original location, does not spread to other parts of the body.
(b) Metastasis: cells slough off from the tumour, travel through the blood (or lymph) to distant sites, and wherever they lodge they start new tumours.

26. In a sewage treatment plant, explain: **3**

(a) Primary sludge

(b) Activated sludge

(c) Anaerobic sludge digesters

ANSWER

Primary sludge = solids settling in primary treatment; activated sludge = sedimented flocs of secondary treatment; digesters = tanks where anaerobic bacteria digest sludge producing biogas

(a) Primary sludge: in primary (physical) treatment, floating debris is removed by sequential filtration and grit/soil is removed by sedimentation; all the solids that settle form the primary sludge (the liquid above is primary effluent).

(b) Activated sludge: in secondary (biological) treatment the primary effluent is aerated, so aerobic microbes grow into flocs (bacteria + fungal filaments) that consume organic matter and lower BOD; the effluent is then passed to a settling tank where the flocs sediment – this is activated sludge. A small part is returned to the aeration tank as inoculum.

(c) Anaerobic sludge digesters: large tanks into which the remaining activated sludge is pumped; anaerobic bacteria digest the bacteria and fungi in it, producing biogas (CH_4, H_2S, CO_2).

27. (a) Name the two primate ancestors of modern humans that lived about 15 million years ago. **3**

(b) According to fossil records, when and where did Australopithecines live?

(c) Give two differences between Homo habilis and Homo erectus.

ANSWER

Dryopithecus and Ramapithecus; ~2 million years ago in East African grasslands; brain 650–800 cc vs 900 cc, did not eat meat vs probably ate meat

(a) Dryopithecus and Ramapithecus.

(b) About 2 million years ago, in the grasslands of East Africa.

(c) Homo habilis: brain capacity 650–800 cc; probably did not eat meat.

Homo erectus (about 1.5 mya): brain capacity about 900 cc; probably ate meat.

28. (i) Give the full forms of these assisted reproductive technologies: (1) ZIFT (2) ICSI (3) IUT (4) GIFT **3**

(ii) Which one of them cannot be called an IVF procedure? Give a reason.

ANSWER

Zygote Intra Fallopian Transfer, Intra Cytoplasmic Sperm Injection, Intra Uterine Transfer, Gamete Intra Fallopian Transfer; GIFT is not IVF

(i) ZIFT – Zygote Intra Fallopian Transfer; ICSI – Intra Cytoplasmic Sperm Injection; IUT – Intra Uterine Transfer; GIFT – Gamete Intra Fallopian Transfer.

(ii) GIFT. In GIFT the ovum (gamete) itself is placed in the fallopian tube and fertilisation happens inside the body (in vivo), whereas IVF methods fertilise the egg outside the body and transfer the zygote/embryo.

OR

Distinguish between:

(i) Perisperm and pericarp

(ii) Syncarpous and apocarpous pistil

(iii) Plumule and radicle

ANSWER

Perisperm = persistent nucellus in seed, pericarp = fruit wall from ovary wall; syncarpous = fused carpels, apocarpous = free carpels; plumule = future shoot, radicle = future root

(i) Perisperm: residual, persistent nucellus present in some seeds (black pepper, beet). Pericarp: the wall of the fruit, developed from the ovary wall.

(ii) Syncarpous pistil: two or more carpels fused together (Papaver). Apocarpous pistil: carpels free (Michelia).

(iii) Plumule: tip of the embryonal axis above the cotyledons (epicotyl end) – gives rise to the shoot. Radicle: tip at the lower (hypocotyl) end – gives rise to the root.

SECTION D

Q29–30 are case-based questions of 4 marks each.

29. Jacob (a geneticist) and Monod (a biochemist) explained how bacteria switch genes on and off, using lactose metabolism in E. coli; their 'lac operon' model earned the 1965 Nobel Prize. **4**

(a) Why is the lac operon called a transcriptionally regulated system? (1)

(b) The lac operon is said to work at a very low level in the cell all the time. Justify. (1/2)

(c) Why is the regulator gene of the lac operon called the 'i' gene? (1/2)

(d) Draw a schematic diagram of the lac operon when no inducer is present in the culture medium. (2)

ANSWER

Regulation occurs by the repressor allowing/blocking RNA polymerase at the operator; low expression needed for permease so lactose can enter; 'i' = inhibitor (codes repressor); diagram: repressor bound to operator, no transcription

(a) Whether the structural genes are expressed is decided at the level of transcription: without lactose the repressor binds the operator and stops RNA polymerase; with lactose the repressor is inactivated and RNA polymerase transcribes the operon.

(b) Lactose can enter the cell only through permease, coded by the y gene. A very low level of expression keeps some permease present, so that lactose can enter and switch the operon on.

(c) 'i' stands for inhibitor – this gene codes the repressor protein that binds the operator and switches the operon off.

(d) Diagram must show, in order: regulator gene i → its mRNA → repressor protein; promoter (p); operator (o) with the repressor bound to it; structural genes z, y, a; RNA polymerase unable to move past the operator; label 'no transcription / no lac mRNA'.

OR

(d) Draw a schematic diagram of the lac operon when the inducer is present in the culture medium of the bacteria.

ANSWER

Inducer (lactose/allolactose) binds repressor → repressor cannot bind operator → RNA polymerase transcribes z, y, a → β-galactosidase, permease, transacetylase

The labelled diagram must show:

1. Regulator gene i → mRNA → repressor protein.
2. Inducer (lactose/allolactose) bound to the repressor, making it inactive – it does not bind the operator.
3. Promoter p with RNA polymerase moving through the free operator o.
4. Structural genes z, y, a transcribed into one polycistronic lac mRNA.
5. Products: β-galactosidase (z), permease (y), transacetylase (a).

30. A diagram of the Earth shows latitude lines 0° (equator), 30°, 60° and 90° N and S. Region A is the band between about 30° N and 30° S around the equator; region B is the band from about 30° S towards the South Pole. **4**

(a) What happens to species diversity as you move from region A to region B? Give two reasons. (3)

(b) Giving the reason, state the approximate number of bird species recorded in India. (1)

ANSWER

Diversity decreases from A (tropics) to B (towards the pole); India has more than 1200 bird species because it lies largely in tropical latitudes

(a) Species diversity decreases as we move away from the equator (region A) towards the pole (region B) – the latitudinal gradient.

Reasons (any two): tropical regions have remained relatively undisturbed for millions of years (long evolutionary time for speciation); they have a less seasonal, more constant and predictable climate; they receive more solar energy, so productivity is higher; more habitable area/resources.

(b) India records more than 1200 species of birds, because the Indian landmass lies largely in the tropical latitudes (compare Greenland at 71° N with only 56 species).

OR

(b) Name the region of the world with the greatest biodiversity and say why.

ANSWER

Amazonian rainforest (South America) – it lies in the tropics

The Amazonian rain forest in South America has the greatest biodiversity on Earth (e.g. >40,000 plant species, >1,300 bird species).

Reason: it lies in the tropical region – stable climate, high solar energy and productivity, and a long undisturbed evolutionary history.

SECTION E

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

31. Recall the Meselson and Stahl experiment on the mode of DNA replication. **5**

(i) Which two kinds of nitrogen did they use, and why?

(ii) Why were E. coli samples taken at definite time intervals?

(iii) What was the role of the caesium chloride density gradient?

(iv) What did they conclude?

ANSWER

^{15}N (heavy) and ^{14}N (normal) to label DNA; samples every 20 min (one generation); CsCl separates DNA by density; replication is semi-conservative

(i) Heavy nitrogen ^{15}N (as $^{15}NH_4Cl$) and normal nitrogen ^{14}N. E. coli grown in ^{15}N for many generations gets heavy DNA; after transfer to ^{14}N the newly made strands are light – so old and new strands can be told apart by density.

(ii) E. coli divides about every 20 minutes, so sampling at 20-minute intervals gives DNA after each successive generation of replication in the ^{14}N medium.

(iii) Centrifugation in a CsCl density gradient separates heavy (^{15}N), hybrid ($^{15}N/^{14}N$) and light (^{14}N) DNA into different bands according to density.

(iv) After one generation (20 min) all DNA was hybrid (intermediate); after two generations (40 min) it was half hybrid and half light. Hence DNA replicates semi-conservatively – each daughter molecule has one parental and one new strand.

OR

(i) A true-breeding tall pea plant with round seeds is crossed with a dwarf pea plant with wrinkled seeds (recessive for both). Work out the cross up to F_2 and give the phenotypic ratios of F_1 and F_2.

(ii) Which Mendelian principle can be derived only from such a cross?

ANSWER

F_1 all tall round (TtRr); F_2 9 tall round : 3 tall wrinkled : 3 dwarf round : 1 dwarf wrinkled; Law of Independent Assortment

(i) Parents: TTRR (tall, round) × ttrr (dwarf, wrinkled).

Gametes: TR and tr.

F_1: TtRr – all tall with round seeds (ratio 1 : 0, i.e. 100%).

Selfing F_1: TtRr × TtRr; each parent forms four gametes TR, Tr, tR, tr in equal proportion.

A 4 × 4 Punnett square gives 16 combinations: T_R_ = 9 tall round, T_rr = 3 tall wrinkled, ttR_ = 3 dwarf round, ttrr = 1 dwarf wrinkled.

F_2 phenotypic ratio = 9 : 3 : 3 : 1.

(ii) Law of Independent Assortment: when two pairs of traits are combined in a hybrid, segregation of one pair of characters is independent of the other pair. It can be seen only in a dihybrid cross.

32. Children in India follow a fixed vaccination schedule from birth to ten years. A graph of antibody concentration in the blood against days after vaccination shows a small rise after the vaccine is given and a much faster, larger rise when the child is later re-infected by the same pathogen. **5**

(i) Why does giving a vaccine raise the antibody concentration?

(ii) If the child is infected by the same pathogen about four months later, the antibody level rises very quickly. Why?

(iii) In a table of immunity types, identify P, Q, R, S and T:

Natural active – antibodies produced: Yes; memory cells: P; mode: Q

Natural passive – antibodies produced: No; memory cells: R; mode: across the placenta in pregnancy / breast feeding

Acquired active – antibodies produced: S; memory cells: Yes; mode: getting a vaccine

Acquired passive – antibodies produced: T; memory cells: No; mode: injection of ready-made antibodies

ANSWER

Vaccine antigens trigger a primary response; memory cells give a quick secondary (anamnestic) response; P = Yes, Q = catching an infection, R = No, S = Yes, T = No

(i) A vaccine contains antigenic proteins of the pathogen or inactivated/weakened pathogen; these activate B-lymphocytes to produce antibodies – a primary (humoral) immune response, which is slow and of low intensity.

(ii) The primary response also produced memory B and T cells. On re-exposure they recognise the antigen quickly and mount a highly intensified secondary (anamnestic) response – antibody level rises fast.

(iii) P = Yes (natural active immunity forms memory cells); Q = getting infected by the pathogen naturally; R = No (no memory cells when antibodies are received ready-made); S = Yes (vaccine makes the body produce antibodies); T = No (in passive immunity the body does not produce antibodies itself).

OR

(i) What is the chemical name of 'smack'? Why is taking smack considered drug abuse?

(ii) Give the source plant and one effect on the body of: (1) Marijuana (2) Cocaine (3) Morphine

ANSWER

Diacetylmorphine (heroin) – highly addictive depressant; Cannabis sativa – affects cardiovascular system; Erythroxylum coca – interferes with dopamine transport, euphoria; Papaver somniferum – depressant/sedative, painkiller

(i) Smack is diacetylmorphine (heroin), obtained by acetylation of morphine. It is a depressant that slows down body functions and is highly addictive, so its non-medical use is abuse.

(ii) (1) Marijuana – from the inflorescence of Cannabis sativa; affects the cardiovascular system.

(2) Cocaine – from the coca plant Erythroxylum coca; interferes with the transport of the neurotransmitter dopamine, causing euphoria and increased energy (excess causes hallucinations).

> (3) Morphine – from the latex of the poppy, Papaver somniferum; a strong sedative and painkiller (depressant).

33. A diagram shows three modes of pollen transfer: arrow 1 – pollen goes from the anther to the stigma of the same flower; arrow 2 – pollen goes to another flower on the same plant; arrow 3 – pollen goes to a flower of a different plant. **5**

(i) Give the technical terms for methods 1, 2 and 3.

(ii) How are these plants pollinated? (1) Water lily (2) Vallisneria

(iii) Explain one hereditary (genetic) and one physiological device that flowering plants use to avoid inbreeding depression.

ANSWER

1 autogamy, 2 geitonogamy, 3 xenogamy; water lily – insects/wind; Vallisneria – water pollination at surface; self-incompatibility (genetic) and dichogamy/non-synchronous maturity (physiological)

(i) 1 – Autogamy; 2 – Geitonogamy; 3 – Xenogamy.

(ii) (1) Water lily: although an aquatic plant, its flowers rise above the water and are pollinated by insects or wind.

(2) Vallisneria: female flowers reach the water surface on long stalks; male flowers or pollen grains are released on the water surface and carried passively by water currents, eventually reaching the female flowers and stigma.

(iii) Genetic device – self-incompatibility: a genetic mechanism that prevents pollen from the same flower or other flowers of the same plant from fertilising the ovules by inhibiting pollen germination or pollen-tube growth in the pistil.

Physiological device – pollen release and stigma receptivity are not synchronised: either the pollen matures before the stigma is receptive or the stigma becomes receptive before pollen is released.

OR

A circular diagram of a 28-day human menstrual cycle is shown, with the days numbered 1 to 28.

(i) Give the technical terms for: (1) days 1–7 (2) days 8–12 (3) days 16–28 (4) days 13–15

(ii) Explain the role of ovarian and pituitary hormones during: (1) days 8–12 (2) days 13–15 (3) days 16–28

ANSWER

Menstrual phase; follicular/proliferative phase; luteal/secretory phase; ovulatory phase – FSH/estrogen drive follicle growth, LH surge causes ovulation, progesterone from corpus luteum maintains endometrium

(i) (1) Menstrual phase (menses); (2) Follicular or proliferative phase; (3) Luteal or secretory phase; (4) Ovulatory phase (ovulation ~day 14).

(ii) (1) Days 8–12: pituitary FSH (with LH) stimulates growth of ovarian follicles; growing follicles secrete estrogen, which causes proliferation (regeneration) of the endometrium.

(2) Days 13–15: rapid rise of LH (and FSH) – the LH surge – causes rupture of the mature Graafian follicle and release of the ovum (ovulation); estrogen is at its peak, endometrium thickened.

(3) Days 16–28: the ruptured follicle becomes the corpus luteum, which secretes large amounts of progesterone that maintains the endometrium for implantation; if no fertilisation occurs the corpus luteum degenerates and menstruation follows.

— END —

Questions restated from the CBSE Class XII Board Examination 2023 (set 57/1/1) for practice. Reading passages and map items are described, not reproduced.