Roll No. ☐☐☐☐☐☐☐☐

Q.P. Code 57/1/1

BIOLOGY (THEORY)

CBSE Class XII Board Examination 2024 — with answers

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

General Instructions:

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

SECTION A

Q1–16 are multiple-choice questions of 1 mark each.

1. Which of these plants bears both male and female flowers on the same plant, so that it can be pollinated by geitonogamy as well as xenogamy? **1**

(A) Papaya
(B) Date palm
(C) Maize
(D) Spinach

ANSWER
(C) Maize

Maize is monoecious – male (tassel) and female (cob) flowers are on the same plant. Pollen can reach a female flower of the same plant (geitonogamy) or of another plant (xenogamy); self-pollination within one flower (autogamy) is impossible because the flowers are unisexual.
Papaya, date palm and spinach are dioecious (male and female flowers on separate plants), so only xenogamy is possible in them.

2. Which hormone, secreted by the human placenta, helps to maintain pregnancy? **1**

(A) Relaxin
(B) Human chorionic gonadotropin
(C) Oxytocin
(D) Human placental lactogen

ANSWER
(B) Human chorionic gonadotropin (hCG)

hCG from the placenta keeps the corpus luteum alive in early pregnancy, so progesterone keeps being secreted and the endometrium is maintained.
Oxytocin is from the posterior pituitary (it causes uterine contractions at birth). hPL and relaxin are also produced during pregnancy, but the hormone whose key role is maintaining pregnancy is hCG (as accepted in the marking scheme).

3. In the periodic abstinence method of family planning, a couple should avoid coitus during which days of the menstrual cycle? **1**

(A) Day 5 to 10
(B) Day 13 to 15
(C) Day 10 to 17
(D) Day 16 to 20

ANSWER
(C) Day 10 to 17

Ovulation usually happens around day 14 of a 28-day cycle. The fertile period, when conception is most likely, is taken as day 10 to day 17. Avoiding coitus in this window is the periodic abstinence (natural) method.

4. Pick the INCORRECT pairing of human karyotype and feature: **1**

(A) 45 + XX – broad palm with a characteristic palm crease

(B) 44 + XXY – overall feminine development

(C) 44 + XO – sterile female with rudimentary ovaries

(D) 44 + XY – normal male

ANSWER

(B) 44 + XXY – overall feminine development

44 + XXY is Klinefelter's syndrome: the person is male with overall MASCULINE development, though some feminine features (gynaecomastia) appear, and is sterile. So pairing (B) is wrong.
45 + XX (trisomy 21 in a female) = Down's syndrome – broad palm with palm crease: correct.
44 + XO = Turner's syndrome – sterile female, rudimentary ovaries: correct.
44 + XY = normal male: correct.

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5. In nature there are 20 amino acids and 4 kinds of DNA bases, and a group of 3 bases codes for one amino acid. Suppose instead there were 96 amino acids and 12 kinds of bases. What would be the smallest number of bases needed in one codon? **1**

(A) 6

(B) 8

(C) 2

(D) 4

ANSWER

(C) 2

With n kinds of bases and codon length k, the number of different codons = n^k. We need $n^k \geq$ number of amino acids.
Real case: $4^2 = 16 < 20$, $4^3 = 64 \geq 20 \rightarrow$ triplet code.
Hypothetical case: $12^1 = 12 < 96$, $12^2 = 144 \geq 96 \rightarrow$ a codon of 2 bases is enough.
Common mistake: dividing 96 by 12 (= 8); the count of codons grows as a power, not a product.

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6. A schematic polynucleotide chain is drawn as a zig-zag backbone of alternating P (phosphate) and S (sugar) units, and each S is joined to a B (nitrogenous base) by a dotted line (S - - - - B). What bond does this dotted line stand for? **1**

(A) Hydrogen bond

(B) Peptide bond

(C) N-glycosidic linkage

(D) Phosphodiester bond

ANSWER

(C) N-glycosidic linkage

The nitrogenous base is joined to the 1′ carbon of the pentose sugar through an N-glycosidic linkage, forming a nucleoside.
The P–S links along the backbone are 3′–5′ phosphodiester bonds; hydrogen bonds join bases of opposite strands; peptide bonds occur in proteins.

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7. In which of these conditions is there a marked rise in the activity of mast cells in the human body? **1**

(A) Typhoid
(B) Allergy
(C) Ascariasis
(D) AIDS

ANSWER
(B) Allergy

In an allergy, IgE antibodies are produced against an allergen; the allergen then makes mast cells release histamine and serotonin, causing sneezing, watery eyes, running nose etc. So mast-cell activity rises sharply in allergy.

8. Lactobacillus, which turns milk into curd, belongs to which category? **1**

(A) Cyanobacteria
(B) Archaebacteria
(C) Chemosynthetic bacteria
(D) Heterotrophic bacteria

ANSWER
(D) Heterotrophic bacteria

Lactobacillus (a lactic acid bacterium) cannot make its own food; it uses the lactose of milk and converts it to lactic acid, which coagulates milk proteins into curd. It is therefore a heterotrophic bacterium (Eubacteria).

9. Which transgenic animal is used to test the safety of polio vaccine? **1**

(A) Sheep
(B) Goat
(C) Pig
(D) Mice

ANSWER
(D) Mice

Transgenic mice are being developed and used to test the safety of vaccines (e.g. polio vaccine) before they are used on humans; if successful this can replace the use of monkeys for such testing.

10. The restriction endonuclease Hind II cuts DNA at a fixed point after recognising a specific sequence of how many base pairs? **1**

(A) Six base pairs
(B) Four base pairs
(C) Seven base pairs
(D) Three base pairs

ANSWER
(A) Six base pairs

Hind II, the first restriction endonuclease isolated, always cuts DNA at a particular point by recognising a specific sequence of six base pairs – its recognition sequence.

11. What is the improved trait of the genetically modified crop 'Golden rice'? **1**

(A) High lysine content
(B) Insect resistance
(C) High protein content
(D) High vitamin-A content

ANSWER
(D) High vitamin-A content

Golden rice is engineered to make β-carotene (provitamin A) in the grain, giving it a golden colour; it is rich in vitamin A and is meant to fight vitamin-A deficiency.

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12. What are the following called, respectively: (1) the rate at which consumers form new organic matter, and (2) the biomass available for consumption by herbivores and decomposers? **1**

(A) Gross primary productivity and net primary productivity
(B) Net primary productivity and secondary productivity
(C) Secondary productivity and net primary productivity
(D) Secondary productivity and gross primary productivity

ANSWER
(C) Secondary productivity and net primary productivity

Rate of formation of new organic matter by consumers = secondary productivity.
NPP = GPP − respiration losses; this is the biomass available to herbivores and decomposers.

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13. Assertion (A): Indian law permits legal adoption, and it is one of the best ways for childless couples to become parents. **1**
Reason (R): Emotional, religious and social factors do not stand in the way of legal adoption of orphaned and destitute children in India.

(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

A is true – legal adoption is allowed and is a good option for childless couples.
R is false – in India, emotional, religious and social factors are in fact deterrents to adoption; that is why many couples do not choose it.

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14. Assertion (A): Linked genes do not give the dihybrid F_2 ratio of 9 : 3 : 3 : 1. **1**
Reason (R): Linked genes do not assort independently.

(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

The 9 : 3 : 3 : 1 ratio depends on independent assortment of two genes. Genes lying close together on the same chromosome tend to be inherited together (linkage), so parental combinations appear far more often than recombinants and the ratio deviates. R is the cause of A.

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15. Assertion (A): Agrobacterium tumefaciens is a pathogen of several monocot plants. **1**
Reason (R): It can transfer a piece of DNA called T-DNA that transforms normal plant cells into a tumour.

(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

A is false – Agrobacterium tumefaciens is a pathogen of several DICOT plants (causes crown gall). R is true – its Ti plasmid carries T-DNA, which it delivers into plant cells, turning them into tumour cells; a disarmed Ti plasmid is therefore used as a cloning vector.

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16. Assertion (A): The Government of India has set up an organisation called GEAC to decide on the validity of GM research. **1**

Reason (R): Genetically modified organisms have no effect when they are introduced into an ecosystem.

(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

A is true – GEAC (Genetic Engineering Appraisal Committee) judges the validity of GM research and the safety of introducing GM organisms for public services.

R is false – GM organisms CAN have unpredictable effects when released into an ecosystem; that is exactly why such a regulatory body is needed.

SECTION B

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

17. A table gives terms and the part of a plant each represents. Fill in A, B, C and D: **2**

(i) Pericarp → A

(ii) B → cotyledon in the seed of the grass family

(iii) Embryonal axis → C

(iv) D → remains of nucellus in a seed

ANSWER

A – wall of the ripened ovary (fruit wall); B – scutellum; C – radicle and plumule (embryonal axis); D – perisperm

A: Pericarp is the wall of the fruit, formed from the wall of the ripened ovary.

B: In grasses (monocots) the single cotyledon is called the scutellum.

C: The embryonal axis is the part that bears the radicle (root tip) and plumule (shoot tip) – epicotyl/hypocotyl portions.

D: Persistent remains of the nucellus in a seed are called perisperm (e.g. black pepper, beet).

18. A picture shows a series of giraffe-like animals: the first has a short neck and grazes on the ground, and each next one has a longer neck, reaching leaves higher up on trees. Name the naturalist who explained evolution using this example, and give his explanation. **2**

ANSWER

Lamarck – use and disuse of organs; inheritance of acquired characters (long neck of giraffe)

Naturalist: Jean-Baptiste Lamarck.

Explanation: evolution is driven by use and disuse of organs.

Ancestors of giraffes, trying to eat leaves on tall trees, kept stretching their necks, so the neck elongated a little in their lifetime.

This acquired character (longer neck) was passed on to the offspring; over many generations giraffes came to have very long necks (inheritance of acquired characters).

19. Write the basic steps of the Assisted Reproductive Technologies (ART) programme used to help childless couples. Why is it also called the 'test tube baby' programme? **2**

ANSWER

Collect ova and sperm → fertilise in vitro to form zygote/embryo → transfer embryo into female; called test-tube baby because fertilisation is done in the laboratory

Steps (IVF–ET):

1. Ova are collected from the wife or a female donor, and sperm from the husband or a male donor.
2. They are made to fuse under simulated conditions in the laboratory (in vitro) to form a zygote.
3. The zygote/early embryo is transferred into the female's fallopian tube or uterus (ZIFT/IUT) for further development.

Test tube baby: the first part – fertilisation and early development – takes place outside the body, in laboratory glassware, hence the name.

20. A farmer was bitten by a poisonous snake while working in his field. At the nearby health centre the doctor gave him an injection that saved his life. **2**

(i) What did the doctor inject and why? (1½)

(ii) What kind of immunity does this injection give? (½)

ANSWER

(i) Antivenom – preformed antibodies/antitoxin against snake venom, because a quick response is needed (ii) Passive immunity

(i) The doctor injected antivenom (anti-snake venom), i.e. ready-made antibodies/antitoxins against the venom. Snake venom acts fast; the body cannot make its own antibodies in time, so preformed antibodies are given to neutralise the toxin immediately.

(ii) Since the antibodies are supplied from outside and not made by the patient's own body, it is passive immunity (artificially acquired).

OR

Why do organic farmers not recommend wiping out insect pests completely? Explain with reason.

ANSWER

Beneficial predatory and parasitic insects depend on pests as food/hosts; biodiversity keeps the ecosystem healthy

1. Organic farmers believe complete eradication of pests is not only nearly impossible but also undesirable.
2. Many beneficial predatory and parasitic insects (biocontrol agents such as ladybirds, dragonflies) feed on or live in the pests; if all pests are destroyed, these useful organisms will not survive.
3. Their key belief is that biodiversity furthers health – a more diverse farm ecosystem is more stable and sustainable; pests are kept at manageable levels by natural checks.

21. A pyramid of biomass is drawn with two bars: the upper, wider bar 'A' is labelled PC (primary consumers) and the lower, narrower bar 'B' is labelled PP (primary producers). Name the standing crops likely to occupy levels A and B. Name this type of pyramid and the ecosystem in which it is found. **2**

ANSWER

A – zooplankton (small fish); B – phytoplankton; inverted pyramid of biomass; sea/aquatic ecosystem

A (primary consumers): zooplankton / small herbivorous fish.

B (producers): phytoplankton.

Type: inverted pyramid of biomass – the producer biomass at a given time is less than the consumer biomass.

Ecosystem: sea (aquatic). Phytoplankton have small standing crop but reproduce very fast, so they can support a larger biomass of consumers.

SECTION C

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

22. Explain how oral contraceptive pills taken by women act. What schedule must be followed for them to be effective? **3**

ANSWER

Progestogen or progestogen–estrogen pills inhibit ovulation and implantation and thicken cervical mucus; taken daily for 21 days from within the first 5 days of the cycle, then 7-day gap, repeated

Composition: progestogens alone or a progestogen–estrogen combination.
Mode of action:
1. Inhibit ovulation.
2. Inhibit implantation.
3. Alter the quality of cervical mucus so that entry of sperm is prevented or retarded.
Schedule:
1. One pill daily for 21 days, starting within the first five days of the menstrual cycle.
2. After a gap of 7 days (during which menstruation occurs), the course is repeated in the same way as long as the woman wishes to avoid conception.
(Saheli, a once-a-week non-steroidal pill, is another example.)

23. (a) Name the type of DNA on which DNA fingerprinting is based and write two of its features. (1 + 1) **3**
(b) Give any two applications of DNA fingerprinting. (½ + ½)

ANSWER

(a) Repetitive/satellite DNA (VNTRs) – non-coding, forms a large part of the genome, highly polymorphic (b) Forensics, paternity testing (also population/genetic diversity studies)

(a) Repetitive DNA – satellite DNA (e.g. VNTRs, variable number of tandem repeats).
Features (any two):
• It does not code for any protein.
• It forms a large portion of the human genome.
• It shows a high degree of polymorphism – the number of repeats differs from person to person, and this is inheritable.
(b) Applications (any two): forensic science (identifying criminals), paternity/maternity testing, finding population and genetic diversity, studying evolution, tracing hereditary diseases.

24. (a) Explain the significance of S.L. Miller's experiment. Name the scientists whose hypothesis led him to perform it. (2½) **3**

(b) How does the analysis of meteorites support this hypothesis? (½)

ANSWER

(a) Showed amino acids form from inorganic molecules (CH_4, NH_3, H_2, water vapour + electric discharge at 800 °C) – supports chemical evolution; Oparin and Haldane (b) Meteorites contain similar organic compounds, so such processes occur in space too

(a) In 1953 Miller sealed CH_4, H_2, NH_3 and water vapour in a closed flask, kept at about 800 °C and passed electric sparks through it (to mimic the early earth's atmosphere and lightning).
After some days amino acids were formed.
Significance: organic molecules can form from inorganic molecules under such conditions – experimental support for the theory of chemical evolution of life.
The hypothesis was proposed by Oparin (Russia) and Haldane (England).
(b) Analysis of meteorite content has revealed similar organic compounds, showing that similar processes are taking place elsewhere in space – this supports the idea.

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25. Fill in A to F in this table of human diseases (disease – causative organism – symptoms): **3**

- Pneumonia – Streptococcus – A
- Typhoid – B – high fever, weakness, headache, stomach pain
- Common cold – Rhinovirus – C
- Ringworm – D – dry scaly lesions on the body, redness, itching
- Ascariasis – Ascaris – E
- F – Entamoeba histolytica – constipation, cramps, stools with mucus and blood clots

ANSWER

A – fever, chills, cough, headache, bluish lips/nails; B – Salmonella typhi; C – nasal congestion and discharge, sore throat, cough; D – Microsporum/Trichophyton/Epidermophyton; E – internal bleeding, muscular pain, fever, anaemia, intestinal blockage; F – amoebiasis (amoebic dysentery)

A (pneumonia, Streptococcus pneumoniae/Haemophilus): fever, chills, cough, headache; in severe cases lips and finger nails turn grey to bluish (alveoli fill with fluid).
B: Salmonella typhi (confirmed by Widal test).
C (common cold): nasal congestion and discharge, sore throat, hoarseness, cough, headache, tiredness.
D (ringworm): fungi Microsporum, Trichophyton, Epidermophyton.
E (ascariasis): internal bleeding, muscular pain, fever, anaemia, blockage of the intestinal passage.
F: Amoebiasis (amoebic dysentery), caused by the protozoan Entamoeba histolytica.

26. In a family the father, the daughter and the son are colour blind, while the mother has normal vision. Did the son and the daughter both inherit the disorder from their father? Show a cross to justify your answer. **3**

ANSWER

No. Son got X^c from the carrier mother; daughter got one X^c from father and one from mother (mother X^cX × father X^cY)

Colour blindness is an X-linked recessive trait. Let X^c = allele for colour blindness, X = normal.
Father (colour blind): X^cY. Mother (normal vision) must be a carrier: XX^c – otherwise the son could not be colour blind.
Cross: XX^c (carrier mother) × X^cY (colour-blind father)
Gametes: mother – X, X^c; father – X^c, Y
Offspring: XX^c – carrier daughter; X^cX^c – colour-blind daughter; XY – normal son; X^cY – colour-blind son.
Conclusion: NO for the son – a son gets only the Y chromosome from his father, so his X^c came from his mother. The daughter (X^cX^c) received one X^c from the father and one from the mother.

27. (i) What are transgenic animals? (1) **3**

(ii) Name the first transgenic cow and state why it is important. (2)

ANSWER

(i) Animals whose DNA has been manipulated to carry and express a foreign gene (ii) Rosie (1997) – milk with human α-lactalbumin (2.4 g/L), nutritionally better for human babies

(i) Transgenic animals are animals whose DNA has been manipulated so that they possess and express an extra (foreign) gene.

(ii) The first transgenic cow was Rosie (1997).

Importance: she produced milk enriched with human protein – about 2.4 g of human alpha-lactalbumin per litre. Such milk is nutritionally more balanced for human babies than natural cow milk.

OR

(i) Explain how the restriction enzyme EcoRI is named. (2)

(ii) Using only an illustration, show how EcoRI acts on a DNA polynucleotide. (1)

ANSWER

(i) E – Escherichia (genus), co – coli (species), R – RY13 strain, I – first enzyme isolated from it

(ii) 5′-G↓AATTC-3′ / 3′-CTTAA↑G-5′ → sticky ends 5′-AATT overhangs

(i) EcoRI comes from Escherichia coli RY13:

• E – first letter of the genus Escherichia

• co – first two letters of the species coli

• R – the strain RY13

• I (Roman numeral) – the order in which the enzyme was isolated from that strain (first).

(ii) Illustration: EcoRI recognises the palindrome

5′ – G A A T T C – 3′

3′ – C T T A A G – 5′

It cuts each strand between G and A:

5′ – G A A T T C – 3′

3′ – C T T A A G – 5′

This leaves single-stranded overhangs (AATT) called sticky ends, which can pair with complementary ends of other DNA cut by the same enzyme.

28. (a) Explain how the orchid Ophrys makes sure it is pollinated by one particular species of bee. (2) **3**

(b) Using this example, describe co-evolution. (1)

ANSWER

(a) Sexual deceit – a petal looks like the female bee; the male pseudocopulates, gets pollen and carries it to the next flower (b) If the female bee's pattern changes, the flower must also change to stay pollinated – plant and pollinator evolve together

(a) Ophrys uses 'sexual deceit':

1. One petal of its flower resembles the female of a particular bee species in size, colour and markings.
2. The male bee is attracted to what it takes to be a female and 'pseudocopulates' with the flower; pollen is dusted on its body.
3. When the same bee pseudocopulates with another Ophrys flower, it transfers the pollen, causing pollination. Only that bee species is fooled, so pollination is species-specific.

(b) Co-evolution: if the colour pattern of the female bee changes even slightly during evolution, pollination success falls unless the orchid flower also evolves to keep the resemblance. Thus the plant and its pollinator evolve together – co-evolution (an example of mutualism-like interaction).

SECTION D

Q29 and Q30 are case-based questions of 4 marks each; each has 3 sub-questions with an internal choice in one of them.

29. India has only 2.4% of the world's land area but about 8.1% of global species diversity; prokaryotes are not included in such species estimates. A survey of species richness of mammal groups in three regions of the world is shown as a bar graph of taxonomic richness: Region I has the shortest bar, Region II a taller bar and Region III the tallest bar. **4**

(a) Why is species richness highest in Region III? (1)

(b) Plants and animals are not uniformly distributed over the world but show an uneven pattern. What is this kind of diversity pattern called? (1)

(c) Why are there no estimates of species numbers for prokaryotes like those for plants and animals? Explain. (2)

ANSWER

(a) Region III is tropical – undisturbed for millions of years, less seasonal and more predictable, more solar energy/productivity (b) Latitudinal gradient in diversity (c) Conventional taxonomic methods cannot identify microbial species, and many cannot be cultured in the lab

(a) Region III represents tropical latitudes, where diversity is highest because (any one):
• tropics remained relatively undisturbed for millions of years (no frequent glaciation), giving long evolutionary time for species diversification;
• the environment is less seasonal, more constant and predictable, favouring niche specialisation;
• more solar energy is available → higher productivity → greater diversity.
(b) Latitudinal gradient in diversity – species diversity decreases from the equator towards the poles.
(c) 1. Conventional taxonomic methods (based on morphology) are not suitable for identifying microbial species.
2. Many microbial species cannot be cultured under laboratory conditions, so they cannot be studied and counted. (Biochemical/molecular methods suggest their diversity may run into millions.)

OR

(a) Why is species richness lowest in Region I in the bar graph?

ANSWER

Region I is temperate/high latitude – frequent glaciation, more seasonal and less predictable environment, less solar energy

Region I represents temperate (high-latitude) regions. Diversity is low because (any one):
• they were subjected to frequent glaciations in the past, so there was less evolutionary time for species diversification;
• the environment is more seasonal, less constant and less predictable;
• less solar energy is available, so productivity – and hence diversity – is lower.

30. A diagram shows how transformed bacteria are selected. (i) A plasmid carries a gene for ampicillin resistance and a gene for tetracycline resistance. (ii) Foreign DNA is inserted into the plasmid to make recombinant DNA. (iii) Plate M shows five colonies (1–5), each derived from a single bacterium growing on agar. (iv) By replica plating, the colonies are transferred to Plate N containing agar with tetracycline and ampicillin; on Plate N colonies 1, 2, 3 and 5 grow but colony 4 does not appear. **4**

(a) Which colony has been transformed with recombinant DNA? Justify. (½ + ½)

(b) What are the sites in a plasmid where the ampicillin- and tetracycline-resistance genes lie (and into which foreign DNA is inserted) called? State their role in genetic engineering. (2)

(c) Name two enzymes that play an important role in genetic engineering. (1)

ANSWER

(a) Colony 4 – it fails to grow on tetracycline because the foreign DNA has inactivated the tetracycline-resistance gene (b) Selectable markers carrying restriction (recognition) sites – help select transformants and, by insertional inactivation, recombinants (c) Restriction endonuclease and DNA ligase (also Taq polymerase)

(a) Colony 4. It grows on Plate M but not on Plate N (which has tetracycline). The foreign DNA was ligated into the tetracycline-resistance gene, so that gene was inactivated; the bacteria still resist ampicillin but not tetracycline. Colonies that grow on both antibiotics carry the non-recombinant plasmid.

(b) The ampR and tetR genes are selectable markers, and the points within them where foreign DNA is joined are restriction (recognition) sites (e.g. BamHI/SalI in tetR, PstI/PvuI in ampR of pBR322). Role: selectable markers help to identify and select transformants and eliminate non-transformants; insertion of alien DNA at a site within one marker inactivates it (insertional inactivation), so recombinants can be told apart from non-recombinants.

(Note: the marking scheme awarded full marks for this part to all candidates.)

(c) Restriction endonuclease (molecular scissors) and DNA ligase (molecular glue); Taq DNA polymerase is also acceptable.

OR

(c) State the role of β-galactosidase in insertional inactivation.

ANSWER

Insertion of foreign DNA into the β-galactosidase gene inactivates it → recombinant colonies are colourless (white), non-recombinants blue on chromogenic substrate

A recombinant DNA is inserted within the coding sequence of the enzyme β-galactosidase, which inactivates the gene (insertional inactivation).

In the presence of a chromogenic substrate, colonies with an intact gene (non-recombinants) produce blue colour; recombinant colonies cannot make the enzyme and stay colourless/white. This makes selecting recombinants easy.

SECTION E

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

31. (i) Explain how the male gametophyte develops in an angiosperm. (2½) **5**

(ii) Draw a labelled diagram of a three-celled male gametophyte. (2½)

ANSWER

(i) Microspore mother cell → meiosis → microspore tetrad → microspores (pollen grains) → unequal mitosis → large vegetative cell + small generative cell; generative cell later divides into 2 male gametes (ii) Labels: exine, intine, germ pore, vegetative cell/nucleus, two male gametes

(i) 1. In the young anther, the sporogenous tissue forms microspore mother cells (2n).
2. Each microspore mother cell undergoes meiosis (microsporogenesis), producing a cluster of four haploid cells – the microspore tetrad.
3. As the anther matures and dries, the microspores separate and develop into pollen grains.
4. Each mature pollen grain divides by unequal (asymmetric) mitosis into a large vegetative cell (with food reserve and irregular nucleus) and a small spindle-shaped generative cell that floats in its cytoplasm – the 2-celled stage.
5. In some plants the generative cell divides mitotically to form two male gametes before shedding, giving the 3-celled stage (in others this happens in the pollen tube).
(ii) Diagram – a round pollen grain with a thick two-layered wall. Labels to show:
• Exine (outer, sporopollenin layer)
• Intine (inner, cellulose–pectin layer)
• Germ pore (gap in the exine)
• Vegetative cell with its nucleus
• Two male gametes (sperm cells)
• Cytoplasm.

OR

(i) Draw a diagrammatic sectional view of the human ovary and label: (1) blood vessels (2) primary follicle (3) tertiary follicle (4) ovum. (2)

(ii) At what stage of life are primary follicles formed in a human female? (½)

(iii) Explain the hormonal and structural events from ovulation up to the start of the next menstrual cycle. (2½)

ANSWER

(i) Labels: blood vessels, primary follicle, tertiary follicle (with antrum), ovum (ii) In the embryonic (foetal) stage (iii) LH surge → Graafian follicle ruptures (ovulation) → corpus luteum → progesterone maintains endometrium → no fertilisation: corpus luteum degenerates → endometrium breaks down → menstruation

(i) Diagram – an oval section of the ovary showing follicles at various stages in the stroma. Labels that must be shown: (1) blood vessels entering the stroma; (2) primary follicle – a primary oocyte surrounded by a single layer of granulosa cells; (3) tertiary follicle – larger follicle with a fluid-filled cavity (antrum) and theca layers; (4) ovum (secondary oocyte released/inside Graafian follicle). Other parts often shown: secondary follicle, Graafian follicle, corpus luteum.
(ii) Primary follicles are formed during the embryonic (foetal) stage; no new oogonia are formed after birth.
(iii) 1. LH and FSH reach a peak in the middle of the cycle (about day 14); the rapid rise of LH (LH surge) causes rupture of the Graafian follicle and release of the ovum – ovulation.

2. Luteal phase: the remaining parts of the Graafian follicle change into the corpus luteum.
3. The corpus luteum secretes large amounts of progesterone, which maintains the endometrium for implantation.
4. If fertilisation does not occur, the corpus luteum degenerates and progesterone level falls.
5. This causes disintegration of the endometrium, leading to menstruation – the start of the next cycle.

32. One of the earliest experiments in genetics clearly showed 'stability' as a property of the genetic material. Name the scientist, describe his experiment and state the conclusion he reached. **5**

ANSWER

Frederick Griffith (1928) – Streptococcus pneumoniae S and R strains in mice; heat-killed S + live R killed mice → transforming principle; genetic material survived heat (stable)

Scientist: Frederick Griffith (1928), working with Streptococcus pneumoniae.
Strains: S strain – smooth, shiny colonies, has a polysaccharide (mucous) coat, virulent; R strain – rough colonies, no coat, non-virulent.
Experiment:
1. Live S strain injected into mice → mice died.
2. Live R strain → mice lived.
3. Heat-killed S strain → mice lived.
4. Heat-killed S + live R → mice died, and live S bacteria were recovered from the dead mice.
Conclusion:
• The R-strain bacteria had been transformed by the heat-killed S strain.
• Some 'transforming principle' passed from heat-killed S to R bacteria and enabled them to make the smooth polysaccharide coat and become virulent – this must be due to transfer of genetic material.
• Heat that killed the bacteria did not destroy the properties of the genetic material – showing its stability.
(Later Avery, MacLeod and McCarty showed the transforming principle is DNA.)

OR

You are given a tall pea plant with violet flowers whose genotype is not known. Work out the plant's genotype using only self-crosses. Write the genotypic and phenotypic ratios of each cross you show.

ANSWER

Possible genotypes TTVV, TTVv, TtVV, TtVv. Selfing: TTVV → all tall violet; TTVv → 3 tall violet : 1 tall white (1:2:1); TtVV → 3 tall violet : 1 dwarf violet (1:2:1); TtVv → 9 : 3 : 3 : 1

Tall (T) and violet (V) are dominant, so the plant can be TTVV, TTVv, TtVV or TtVv. Self it and observe the progeny.
Case 1: TTVV × TTVV → gametes TV only → all TTVV.
Phenotype: all tall violet; genotype: all TTVV (pure for both traits).
Case 2: TTVv × TTVv → gametes TV, Tv → TTVV : TTVv : TTvv = 1 : 2 : 1.
Phenotype: tall violet : tall white = 3 : 1.
Case 3: TtVV × TtVV → gametes TV, tV → TTVV : TtVV : ttVV = 1 : 2 : 1.
Phenotype: tall violet : dwarf violet = 3 : 1.
Case 4: TtVv × TtVv → gametes TV, Tv, tV, tv (4 × 4 Punnett square).
Phenotype: tall violet : tall white : dwarf violet : dwarf white = 9 : 3 : 3 : 1.
Genotype: TTVV 1 : TTVv 2 : TtVV 2 : TtVv 4 : TTvv 1 : Ttvv 2 : ttVV 1 : ttVv 2 : ttvv 1.
Inference: no segregation → TTVV; only white appears → TTVv; only dwarf appears → TtVV; both appear in 9:3:3:1 → TtVv.
(Any three crosses with both ratios earn full marks.)

33. (i) Name and explain the property that normal cells have but cancer cells lose. (1½) **5**
(ii) All normal human cells carry genes that can turn cancerous under certain conditions. Name them and explain how. (1)
(iii) State the role of these techniques in detecting and diagnosing cancer: (1) biopsy and histopathology (1); (2) magnetic resonance imaging (1½).

ANSWER

(i) Contact inhibition (ii) Proto-oncogenes/cellular oncogenes – activated (by carcinogens, mutation etc.) they cause oncogenic transformation (iii) Biopsy: tissue sectioned, stained and examined under microscope; MRI: strong magnetic field + non-ionising radiation detects pathological/physiological changes in internal tissues

(i) Contact inhibition. In normal cells, contact with neighbouring cells stops their further growth and division. Cancer cells lose this property, so they keep dividing, forming masses of cells (tumours).
(ii) Proto-oncogenes (cellular oncogenes, c-onc). They are normal genes in all cells; when activated under certain conditions (mutation, carcinogens, viral oncogenes) they cause oncogenic transformation of cells, i.e. uncontrolled division.
(iii) (1) Biopsy and histopathology: a piece of suspected tissue is cut into thin sections, stained and examined under a microscope by a pathologist for abnormal/increased cell counts – confirms cancer.
(2) MRI: uses strong magnetic fields and non-ionising radiation to detect pathological and physiological changes in living tissue; useful for detecting cancers of internal organs without surgery and without harmful ionising radiation.

OR

Towns and cities produce huge amounts of sewage daily, which is treated in Sewage Treatment Plants (STPs). A flow diagram of two stages is given: 'Primary effluent passed into large aeration tanks' → 'Effluent passed into settling tanks to form a sediment'.
(i) (1) Why is the primary effluent passed into large aeration tanks? (1)
(2) What is the sediment called? Give its significance. (1)
(3) Explain the final step in the settling tank before the treated effluent is released into natural water bodies. (1)
(ii) Name two organisms from different kingdoms that are commonly used as biofertilisers, and explain how each acts as a biofertiliser. (2)

ANSWER

(i)(1) Aerobic microbes grow as flocs and consume organic matter, lowering BOD (2) Activated sludge – a small part is used as inoculum in aeration tanks (3) Bacterial flocs settle; rest of sludge goes to anaerobic digesters, effluent released (ii) Rhizobium (Monera) – fixes N_2 in root nodules of legumes; Glomus (fungi, mycorrhiza) – absorbs phosphorus for the plant

(i)(1) In the aeration tanks the effluent is constantly agitated and air is pumped in. This allows vigorous growth of useful aerobic bacteria, which with fungal filaments form mesh-like 'flocs'. They consume the major part of the organic matter, greatly reducing the BOD of the effluent.
(2) The sediment is called activated sludge. Its significance: a small part of it is pumped back into the aeration tank to serve as inoculum (supply of microbes); the rest is used in anaerobic sludge digesters.
(3) Once BOD is reduced sufficiently, the effluent is passed into the settling tank where the bacterial flocs are allowed to settle (forming activated sludge). The clear supernatant – the secondary/treated

effluent – is then released into rivers and streams. (The major part of sludge goes to anaerobic digesters, where anaerobic bacteria digest it and produce biogas – CH_4, H_2S, CO_2.)

(ii) Any two from different kingdoms:

• Rhizobium (bacterium, Monera) – lives symbiotically in root nodules of leguminous plants and fixes atmospheric nitrogen into organic form usable by the plant.

• Glomus (fungus) – forms mycorrhiza with roots; absorbs phosphorus from the soil and passes it to the plant (also gives resistance to root pathogens, drought tolerance).

• Cyanobacteria such as Anabaena, Nostoc, Oscillatoria (Monera) – fix atmospheric nitrogen and add organic matter, increasing soil fertility (e.g. paddy fields).

— END —

Questions restated from the CBSE Class XII Board Examination 2024 (set 57/1/1) for practice. Reading passages and map items are described, not reproduced.