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CBSE Class 12 Biology Board Paper 2026 (57/4/1) with Solutions

PREVIOUS YEAR PAPER · CLASS XII · BIOLOGY (044) · BOARD EXAM 2026 · Q.P. CODE 57/4/1

TIME ALLOWED	MAXIMUM MARKS	QUESTIONS	NAME / ROLL NO.
3 hours	70	33 (A 16 · B 5 · C 7 · D 2 · E 3)	

GENERAL INSTRUCTIONS

Read the following instructions very carefully and strictly follow them:

1. This question paper contains 33 questions. All questions are compulsory.
2. Question paper is divided into five sections – Sections A, B, C, D and E.
3. Section A – questions number 1 to 16 are Multiple Choice Type Questions. Each question carries 1 mark.
4. Section B – questions number 17 to 21 are Very Short Answer Type Questions. Each question carries 2 marks.
5. Section C – questions number 22 to 28 are Short Answer Type Questions. Each question carries 3 marks.
6. Section D – questions number 29 and 30 are Case-Based questions. Each question carries 4 marks. Each question has subparts with internal choice in one of the subparts.
7. Section E – questions number 31 to 33 are Long Answer Type Questions. Each question carries 5 marks.
8. There is no overall choice. However, an internal choice has been provided in Sections B, C, D and E of the question paper. A candidate has to write answer for only one of the alternatives in such questions.
9. Wherever necessary, neat and properly labelled diagrams should be drawn.
10. This is the official 2026 board paper (Q.P. Code 57/4/1). The step marks shown in the solutions are our marking scheme in the CBSE style; CBSE's own marking scheme may award steps differently.
11. The answer key and the marking scheme are at the end of this booklet. Attempt the paper in 3 hours before you look at them.

Questions: CBSE board examination 2026, Q.P. Code 57/4/1, as published by CBSE at cbse.gov.in; diagrams redrawn. Answers, step marks and worked solutions © Master Testing Agency. Free for personal practice; not for resale. Master Testing Agency is an independent test-prep publisher, not affiliated with, endorsed by or connected to the Central Board of Secondary Education (CBSE) or any other exam-conducting body.

Chapters: Full syllabus · **Topics:** Sexual Reproduction in Flowering Plants · Human Reproduction · Reproductive Health · Principles of Inheritance and Variation · Molecular Basis of Inheritance · Evolution · Human Health and Disease · Microbes in Human Welfare · Biotechnology: Principles and Processes · Biotechnology and its Applications · Organisms and Populations · Ecosystem · Biodiversity and Conservation

SECTION A

Multiple choice questions of 1 mark each (Q13–16 assertion-reason).

1. Choose the option that gives the correct number of pollen grains that will be formed after 325 microspore mother cells undergo microsporogenesis. 1

(A) 325 (B) 650

(C) 1300 (D) 975

2. Select the phase of menstrual cycle in which the remaining parts of Graafian follicle transform into the corpus luteum. 1

(A) Secretory phase (B) Proliferative phase

(C) Menstrual phase (D) Ovulatory phase

3. A female undergoing IVF treatment has blocked fallopian tube. The technique by which the embryo with more than 8 blastomeres will be transferred into the female for further development is : 1

(A) ZIFT (B) GIFT

(C) IUT (D) AI

4. Select the correct statement. 1

All genes located on the same chromosome :

(A) form different groups depending upon their relative distance. (B) form one linkage group.

(C) will not form linkage groups. (D) form interactive groups that affect the phenotype.

5. Choose the correct statements : 1

(i) Polycistronic mRNA is generally found in eukaryotes.

(ii) The RNA polymerase II transcribes precursor of mRNA, the hnRNA.

(iii) The process of translation of mRNA begins when the mRNA encounters the large subunit of ribosomes.

(iv) Stop codons do not have any tRNAs.

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

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

6. Name the extinct ancestor of humans who ate only fruits and hunted with stone weapons. 1

(A) *Ramapithecus* (B) *Australopithecus*

(C) *Dryopithecus* (D) *Homo erectus*

7. Nicotine affects blood pressure and heart rate due to release of certain adrenal hormones. Following are some of the adrenal hormones : 1

(i) Adrenaline (ii) Cortisol (iii) Noradrenaline (iv) Aldosterone

Select the correct option :

(A) (i) and (ii) (B) (i) and (iv)

(C) (ii) and (iii) (D) (i) and (iii)

8. Microbes used for biocontrol of pest butterfly caterpillars is : 1

(A) *Saccharomyces cerevisiae* (B) *Bacillus thuringiensis*

(C) *Streptococcus* sp. (D) *Trichoderma*

9. The given diagram shows the skulls of two different mammals. (The photograph is described here in words.) 1

Skull	What the photograph shows
A	A long, sloping face with large protruding jaws and big teeth; a small, low braincase
B	A large, rounded braincase with a vertical forehead; a small, flat face and small jaws

Which of the following options accurately describes the differences between these skulls ?

(A) Skull B is the ancestor of skull A. (B) Skull A has more brain capacity than skull B.

(C) Skull A is of a human and skull B is of an adult chimpanzee. (D) Skull A is of an adult chimpanzee and skull B is of a human.

10. In RNAi, genes are silenced using which of the following biomolecules ? 1

(A) ssDNA (B) dsDNA

(C) dsRNA (D) ssRNA

11. Connell's elegant field experiments on the rocky seacoast of Scotland, found that larger barnacles *Balanus* dominated the intertidal area and removed the smaller barnacles *Chathamalus*. This happened due to : 1

(A) Parasitism (B) Predation

(C) Mutualism (D) Competition

12. Protein encoded by gene Cry-I Ab controls the infestation of which of the following ? 1

(A) Cotton bollworms (B) Mosquitoes

(C) Corn borer (D) Agrobacterium

13. **Assertion (A) :** Cleistogamous flowers have assured seed set. 1

Reason (R) : Cleistogamous flowers are invariably autogamous and do not depend on pollinating agents.

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation for Assertion (A).

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

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

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

14. **Assertion (A) :** The human blood group ‘AB’ exemplifies co-dominance. 1

Reason (R) : The gene for human blood group trait exists in three allelic forms I^A, I^B and i.

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation for Assertion (A).

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

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

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

15. **Assertion (A) :** *Nucleopolyhedrovirus* are useful as they are good biocontrol agents. 1

Reason (R) : They are species-specific, narrow spectrum bioinsecticides.

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation for Assertion (A).

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

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

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

16. **Assertion (A) :** The pyramid of biomass in a pond aquatic ecosystem is always inverted. 1

Reason (R) : The biomass of consumers like fishes far exceeds that of the producers like phytoplanktons.

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation for Assertion (A).

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

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

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

SECTION B

Very short answer questions of 2 marks each.

17. How do ‘implants’ act as an effective method of contraception in human females ? Mention one advantage of implants over contraceptive pills. 2

18. (a) Write one way by which apomictic seeds can be developed. 2

(b) Why do farmers prefer apomictic seeds over hybrid seeds ?

19. A laboratory assistant collected three water samples, namely river water, untreated sewage water and secondary effluent discharged from a sewage treatment plant. But the laboratory attendant did not note which was which. The samples were labelled A, B and C and subjected to a BOD test. The BOD values of the three samples A, B and C were recorded as 30 mg/L, 8 mg/L and 400 mg/L respectively. 2

(a) Which sample of the water is most polluted ?

(b) Can you assign the correct label to each, assuming the river water is relatively clean ?

20. Write the role of ‘ori’ and ‘restriction’ site in a cloning vector pBR322. 2

21. (a) Biodiversity must be conserved as it plays an important role in many ecosystem services that nature provides. Explain any two ecosystem services. 2

OR

(b) (i) State, what does 'standing crop' of a trophic level represent.
(ii) List any two ways of measuring the standing crop of a trophic level.

SECTION C

Short answer questions of 3 marks each.

22. Differentiate between wind-pollinated and insect-pollinated flowers. Give an example of each type. 3

23. (a) Construct a complete transcription unit with promoter and terminator on the basis of the hypothetical coding strand given below : 3



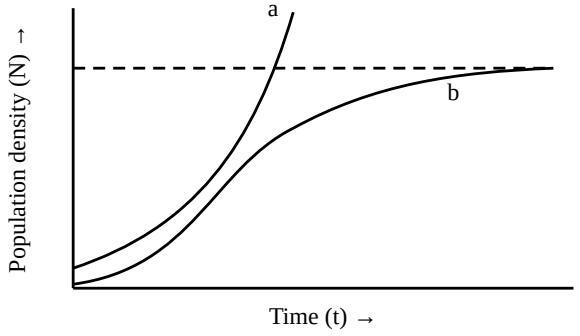
(b) Write the RNA strand transcribed from the above transcription unit along with its polarity.

24. Explain the three different ways in which natural selection operates. Explain with the help of graphs. 3

25. (a) How do some viruses cause cancer in humans ? 3
(b) How do benign tumours turn malignant ? How do malignant tumours harm the human body ?

26. (a) How is insulin different from proinsulin ? 3
(b) Explain all the stages of how human insulin is produced through rDNA technology.

27. (a) Study the graph given below and answer the questions that follow : 3



(i) Write the status of food and space in the curves a and b.
(ii) In the absence of predators, which one of the two curves would appropriately depict the prey population ?
(iii) 'Time' has been shown on x-axis and there is a parallel dotted line above it. Give the significance of this dotted line.

OR

(b) Answer the following questions :
(i) Define 'predation'.
(ii) Why is predation required in a community of different organisms ? Give any two points.
(iii) Why are predators 'prudent' in nature ?

28. There are many animals, which have become extinct in the wild, but continue to be maintained in zoological parks. Answer the questions that follow : 3

(a) What type of bio-diversity conservation is observed in this case ?

(b) Explain any other two ways which help in this type of conservation.

(c) Besides zoological parks, mention one place that serves this purpose.

SECTION D

Case-based questions of 4 marks each.

29. Gene expresses itself in a cell system as a protein/enzyme. How an expression of gene occurs in a cell system, when it needs to occur and how the gene expression is regulated in prokaryotic cell system was studied by the combined efforts of Francois Jacob, a geneticist and Jacques Monod, a biochemist. For their work on lactose metabolism in *E. coli* and introducing the concept of 'lac operon', they were awarded the Nobel Prize in 1965.

(a) It is said that 'lac operon' has to be operational at a very low level in the bacterial cell all the time. Justify. [1]

(b) How are the structural genes activated in the lac operon in *E. coli* ? [1]

OR

(b) Why is the regulation of operon called negative regulation ? [1]

(c) Why is lac operon said to be a transcriptionally regulated system ? [2]

30. Immunity in our body is of two types (i) Innate immunity, and (ii) Acquired immunity. Innate immunity is a non-specific defence mechanism, whereas Acquired immunity is pathogen specific. Acquired immunity is characterised by memory. Antibodies are specific to antigens and there are four types of antibodies produced in our body — IgA, IgE, IgG and IgM. It shows primary response where it encounters the pathogen for the first time and secondary response during the subsequent encounters with the same antigen/pathogen. These immune responses are carried out with the help of two special types of lymphocytes present in the blood.

(a) Name the two types of specialised cells which carry out the primary and secondary responses. [1]

(b) Name any two barriers present in our body that provide innate immunity. [1]

OR

(b) The organ transplants (grafts) are often rejected if not taken from suitable compatible persons. Mention the characteristic of our immune system that is responsible for the rejection. [1]

(c) How is active immunity different from passive immunity ? Write any two differences. [2]

SECTION E

Long answer questions of 5 marks each.

31. (a) Study the flow chart given below. Name the hormones involved at each stage and explain their functions. 5

Hypothalamus → Pituitary → Ovary → Pregnancy

OR

(b) (i) Draw a diagram of L.S. of maize grain and label its any six parts.

(ii) Differentiate between perisperm and endosperm giving one example of each.

32. (a) Write the types and locations of the genes causing thalassemia in humans. State the cause and symptoms of the disease. How is sickle-cell anemia different from this disease ? 5

OR

(b) (i) Enlist any four prime goals of the Human Genome Project (HGP).

(ii) List the two methodologies which were involved in the human genome project. Mention how they were used.

(iii) Expand 'YAC' and mention what it was used for.

33. (a) (i) EcoR I has played a very important role in rDNA technology. 5

(I) Explain the convention for naming EcoR I.

(II) Write the recognition site of this endonuclease restriction enzyme.

(ii) Name the overhanging stretches of DNA produced by these restriction enzymes. Describe their role in the formation of rDNA.

OR

(b) (i) Insertional inactivation is a method to detect the recombinant DNA. Explain this method.

(ii) Name the commonly used vector for transferring genes in plants from bacteria.

(iii) How is this able to transform a normal plant cell into a tumour ?

END OF THE QUESTION PAPER

ANSWER KEY — SECTION A

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16
(C)	(A)	(C)	(B)	(C)	(B)	(D)	(B)	(D)	(C)	(D)	(C)	(A)	(B)	(A)	(D)

MARKING SCHEME AND WORKED SOLUTIONS

Marks for each step are shown in brackets, as in the CBSE marking scheme. Any correct alternative method earns full marks.

Q1. Answer (C). Each microspore mother cell divides by meiosis into a tetrad of 4 microspores (pollen grains): 325 × 4 = 1300.

Q2. Answer (A). After ovulation, in the luteal (secretory) phase, the remaining parts of the Graafian follicle become the corpus luteum, which secretes progesterone.

Q3. Answer (C). Embryos with more than 8 blastomeres are transferred into the uterus: intra-uterine transfer (IUT). ZIFT uses the fallopian tube, which is blocked here.

Q4. Answer (B). Genes on one chromosome tend to be inherited together and form one linkage group; the number of linkage groups equals the haploid number of chromosomes.

Q5. Answer (C). Polycistronic mRNA is found in bacteria (eukaryotic mRNA is monocistronic), and translation begins when the small subunit binds the mRNA. (ii) and (iv) are correct: UAA, UAG and UGA have no tRNA.

Q6. Answer (B). NCERT: *Australopithecines* probably lived in East African grasslands, hunted with stone weapons but essentially ate fruit.

Q7. Answer (D). Nicotine stimulates the adrenal gland to release adrenaline and nor-adrenaline into the blood, raising blood pressure and heart rate.

Q8. Answer (B). *Bacillus thuringiensis* spores sprayed on plants are eaten by butterfly caterpillars, whose gut releases the toxin that kills them.

Q9. Answer (D). The skull with protruding jaws and a small braincase (A) is that of an adult chimpanzee; the large rounded braincase and flat face (B) is human. B has the larger brain capacity, and neither is the ancestor of the other.

Q10. Answer (C). RNA interference uses a complementary double-stranded RNA, which binds and prevents translation of the specific mRNA (silencing).

Q11. Answer (D). The superior competitor *Balanus* excluded *Chthamalus* from the intertidal area: interspecific competition (competitive exclusion).

Q12. Answer (C). NCERT: proteins encoded by cryIAc and cryIIAb control cotton bollworms; that of cryIAb controls the corn borer.

Q13. Answer (A). Cleistogamous flowers never open, so they can only self-pollinate and need no pollinator; this is exactly why seed set is assured. R explains A. Answer (A).

Q14. Answer (B). In AB persons both I^A and I^B express their own sugar: co-dominance (A true). Three alleles is multiple allelism (R true), but that is not why AB shows co-dominance. Answer (B).

Q15. Answer (A). Baculoviruses (genus *Nucleopolyhedrovirus*) are excellent biocontrol agents because they are species-specific, narrow-spectrum insecticides that do not harm plants, mammals, birds or non-target insects. R explains A. Answer (A).

Q16. Answer (D). NCERT: the pyramid of biomass in the sea is generally (not always) inverted, because the biomass of fishes far exceeds that of phytoplankton. 'Always' makes A false; R is true. Answer (D).

Q17. (2 marks) Answer: hormones under the skin stop ovulation; long-lasting.
Implants containing progestogens alone or with oestrogen are placed under the skin. They inhibit ovulation and implantation and change the quality of the cervical mucus so that sperms cannot enter. [1]
Advantage: they work for a much longer period, so there is no daily pill to remember. [1]

Q18. (2 marks) Answer: diploid egg without fertilisation; no need to buy seed every year.
(a) A diploid egg cell formed without reduction division develops into an embryo without fertilisation (or nucellar cells grow into embryos, as in *Citrus* and mango). [1]
(b) Hybrid seeds must be bought every year because the characters segregate in their progeny; apomictic hybrid seeds do not segregate, so farmers can keep using their own seed year after year, which is cheaper. [1]

Q19. (2 marks) Answer: C; A secondary effluent, B river water, C untreated sewage.
(a) C: the highest BOD (400 mg/L) means the most organic matter, i.e. the most polluted. [½]
(b) A (30 mg/L): secondary effluent (BOD reduced by treatment); B (8 mg/L): river water; C (400 mg/L): untreated sewage. [1½]

Q20. (2 marks) Answer: ori: start of replication, copy number; restriction site: cutting and inserting foreign DNA.
ori: the sequence where replication starts; any DNA linked to it can replicate in the host cell, and it also controls the copy number of the linked DNA. [1]
Restriction sites (e.g. for *Eco*RI, *Bam*HI, *Pst*I): recognition sites where the vector is cut and the foreign DNA is ligated; a single site for each enzyme is preferred. Sites inside the antibiotic resistance genes (*Bam*HI in tet^R, *Pst*I in amp^R) also allow recombinants to be selected by insertional inactivation. [1]

Q21. (2 marks) Answer: (a) oxygen, pollination; (b) biomass or number per unit area.
(a) Any two, 1 mark each: Oxygen: forests such as the Amazon produce a large share of the Earth's oxygen by photosynthesis. Pollination: bees, bumblebees, birds and bats pollinate plants, without which there would be no fruits or seeds. Others: flood and erosion control, purifying air and water, nutrient cycling, aesthetic and cultural value. [2]
OR (b) (i) The mass of living material at that trophic level at a particular time. [1]
(ii) As biomass (fresh or dry weight per unit area) or as the number of organisms per unit area. [1]

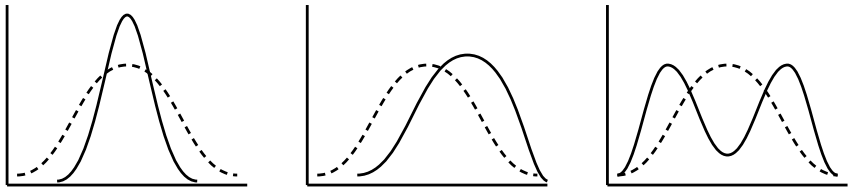
Q22. (3 marks) Answer: light pollen, feathery stigma vs colourful nectar-rich flowers; maize; Salvia.

Wind-pollinated	**Insect-pollinated**
Pollen light, non-sticky, produced in very large numbers	Pollen fewer, sticky or rough
Stamens and large, often feathery stigmas well exposed	Stamens and stigma enclosed in the flower
Flowers small, not colourful, no scent or nectar	Flowers large, colourful, fragrant, rich in nectar
Example: maize, grasses	Example: *Salvia*, sunflower, rose

Two differences [2]; one example of each [1].

Q23. (3 marks) Answer: template 3′-TACGTACGTATC-5′; RNA 5′-AUGCAUGCAUAG-3′.
(a) The coding strand begins with the start codon ATG and ends with the stop codon TAG, so it runs 5′→3′ as written: [2]
Promoter — 5′ ATGCATGCATAG 3′ (coding strand) — Terminator
Promoter — 3′ TACGTACGTATC 5′ (template strand) — Terminator
The promoter is at the 5′ end (upstream) of the coding strand, the terminator at its 3′ end; the template strand runs 3′→5′.
(b) 5′ AUGCAUGCAUAG 3′: the same as the coding strand with U in place of T. [1]

Q24. (3 marks) Answer: stabilising, directional, disruptive.



Stabilising Directional Disruptive

Dashed: before selection. Solid: after selection.
x-axis: value of the trait; y-axis: number of individuals.

Stabilising selection: more individuals acquire the mean character value; the peak becomes taller and narrower. [1]
Directional selection: more individuals acquire a value other than the mean, at one end; the peak shifts in one direction. [1]
Disruptive selection: more individuals acquire the values at both extremes; the curve splits into two peaks. [1]

Q25. (3 marks) Answer: viral oncogenes; loss of contact inhibition; starve normal cells, metastasis.
(a) Oncogenic viruses carry viral oncogenes; when they infect cells, these genes transform normal cells into cancerous cells. [1]
(b) When cells lose the property of contact inhibition (e.g. through activation of cellular oncogenes) they divide without control and invade the surrounding tissue, so a tumour that stayed in place (benign) becomes malignant. [1] Malignant cells grow rapidly, compete with normal cells for nutrients and starve them; cells sloughed from the tumour travel in the blood to distant sites and start new tumours (metastasis). [1]

Q26. (3 marks) Answer: C peptide; A and B chains made in E. coli and joined by disulphide bonds.
(a) Proinsulin has an extra stretch, the C peptide, besides chains A and B; mature insulin has only the A and B chains joined by disulphide bridges (the C peptide is removed). [1]
(b) In 1983 Eli Lilly prepared two DNA sequences coding for chains A and B of human insulin and put them into plasmids of *E. coli*. [1] The bacteria made the A and B chains separately; these were extracted and combined by forming disulphide bonds to give human insulin (humulin). [1]

Q27. (3 marks) Answer: (a) unlimited vs limited; curve a; carrying capacity; (b) energy transfer, prey control.
(a) (i) Curve a (exponential, J-shaped): food and space unlimited. Curve b (logistic, S-shaped): food and space limited. [1]
(ii) Curve a: without predators to check it, the prey population can grow almost unchecked (as the prickly pear cactus did when brought into Australia). [1]
(iii) It marks the carrying capacity (K), the largest population that the resources of the habitat can support; curve b levels off at it. [1]
OR (b) (i) An interaction in which one organism (predator) kills and eats another (prey) of a different species. [1]
(ii) Any two: it transfers energy to higher trophic levels; it keeps prey populations under control; it maintains species diversity by reducing competition among the prey species. [1]
(iii) A predator that over-exploits its prey would make the prey extinct and then die out itself, so predators in nature do not over-exploit their prey. [1]

Q28. (3 marks) Answer: ex situ; cryopreservation, IVF, tissue culture, seed banks; botanical gardens.
(a) *Ex situ* conservation. [½]
(b) Any two: cryopreservation, keeping gametes of threatened species viable and fertile for long periods; *in vitro* fertilisation; tissue culture propagation of plants; seed banks, storing seeds of commercially important plants for long periods. [2]
(c) Botanical gardens (or wildlife safari parks, seed banks). [½]

Q29. (4 marks) Answer: permease needed for lactose entry; inducer inactivates repressor; repressor control; control at transcription.
(a) Lactose can enter the cell only through the permease (product of the y gene). A very low level of expression keeps a little permease present all the time, so that lactose can get in when it is available and switch the operon on. [1]
(b) Lactose (the inducer) binds the repressor and inactivates it; the repressor can no longer bind the operator, so RNA polymerase reaches the promoter and transcribes the z, y and a genes. [1]
OR (b) Because it is controlled by a repressor protein that switches the operon off by binding the operator. [1]
(c) The control acts at the step of transcription initiation: the repressor bound to the operator stops RNA polymerase from transcribing the structural genes, and the inducer removes this block. [1] So the enzymes are made only when lactose is present: the amount of mRNA made decides the amount of gene product. [1]

Q30. (4 marks) Answer: B and T lymphocytes; skin, stomach acid; self/non-self; own vs ready-made antibodies.
(a) B-lymphocytes and T-lymphocytes. [1]
(b) Any two: physical barriers (skin, mucus lining of the respiratory and digestive tracts), physiological barriers (stomach acid, saliva, tears), cellular barriers (neutrophils, monocytes, NK cells, macrophages), cytokine barriers (interferons). [1]
OR (b) The immune system can distinguish 'self' from 'non-self'; the foreign graft is attacked by cell-mediated immunity (T-lymphocytes). [1]
(c) Active immunity: the body makes its own antibodies after meeting the antigen (infection or vaccine); it develops slowly and lasts long. Passive immunity: ready-made antibodies are given (e.g. IgA in colostrum, IgG through the placenta, antitoxins); it acts quickly but is short-lived. [2]

Q31. (5 marks) Answer: (a) GnRH; FSH, LH; oestrogen, progesterone; hCG, hPL; (b) perisperm = nucellus, endosperm = 3n.
(a) Hypothalamus: GnRH (gonadotropin releasing hormone), which stimulates the anterior pituitary to release the gonadotropins. [1]
Pituitary: FSH stimulates the growth of ovarian follicles and their secretion of oestrogen; LH: the mid-cycle LH surge causes ovulation and turns the follicle into the corpus luteum. [2]
Ovary: oestrogens (growth of follicles, regeneration of the endometrium); progesterone from the corpus luteum, which maintains the endometrium for implantation. [1]
Pregnancy: the placenta makes hCG, hPL, oestrogens and progestogens that maintain the pregnancy (and relaxin, from the ovary, in later pregnancy). [1]
OR (b) (i) L.S. of a maize grain:

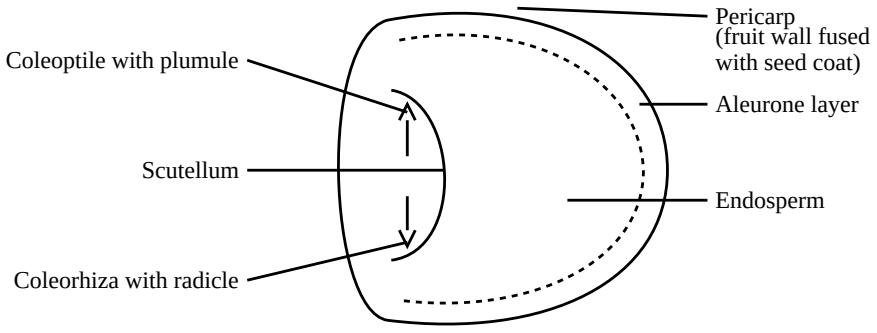


Diagram with six correct labels. [3]
(ii) Perisperm: the remains of the nucellus that persist in the seed; diploid; e.g. black pepper, beet. Endosperm: the triploid food tissue formed from the primary endosperm nucleus after triple fusion; e.g. wheat, castor, coconut. [2]

Q32. (5 marks) Answer: (a) HBA1/HBA2 on 16, HBB on 11; quantitative vs qualitative; (b) ESTs, sequence annotation; YAC.

(a) Types: α-thalassemia, controlled by two closely linked genes HBA1 and HBA2 on chromosome 16; β-thalassemia, controlled by a single gene HBB on chromosome 11. [2]

Cause: an autosome-linked recessive disorder; mutation or deletion of one or more of these genes reduces the rate of synthesis of one of the globin chains (α or β), so abnormal haemoglobin is formed. [1] Symptom: anaemia. [1]

Difference: thalassemia is a quantitative problem, too few globin molecules being made; sickle-cell anaemia is a qualitative problem, a wrongly functioning globin being made (glutamic acid replaced by valine at the 6th position of the β chain). [1]

OR (b) (i) Any four: identify all the approximately 20,000–25,000 genes in human DNA; determine the sequences of the 3 billion base pairs; store this information in databases; improve tools for data analysis; transfer related technologies to other sectors such as industry; address the ethical, legal and social issues (ELSI). [2]

(ii) Expressed Sequence Tags (ESTs): identifying all the genes that are expressed as RNA. Sequence annotation: sequencing the whole genome (coding and non-coding) and later assigning functions to the sequences. [1] For this the total DNA was broken into random fragments, cloned in hosts using vectors, and sequenced with automated DNA sequencers; overlapping regions were used to arrange the sequences with computer programs. [1]

(iii) Yeast Artificial Chromosome: a vector used to clone (and amplify) large DNA fragments for sequencing. [1]

Q33. (5 marks) Answer: (a) Escherichia coli RY13, first enzyme; GAATTC; sticky ends; (b) blue/white selection; Ti plasmid; T-DNA.

(a) (i) (I) E: genus *Escherichia*; co: species *coli*; R: the strain (RY13); I: the order in which the enzyme was isolated from that strain (Roman numeral). [2] (II) 5′–GAATTC–3′ / 3′–CTTAAG–5′ (a palindrome; it cuts between G and A). [1]

(ii) Sticky ends. [1] They form hydrogen bonds with their complementary cut counterparts, so a vector and foreign DNA cut with the same enzyme join together; DNA ligase then seals them, forming recombinant DNA. [1]

OR (b) (i) The foreign DNA is inserted into the coding sequence of the enzyme β-galactosidase, which is inactivated. On a medium with a chromogenic substrate, bacteria with a plasmid that has no insert give blue colonies; recombinants give colourless (white) colonies. (Similarly, insertion into tet^R of pBR322 makes recombinants lose tetracycline resistance.) [3]

(ii) The Ti plasmid of *Agrobacterium tumefaciens*. [1]

(iii) *Agrobacterium* delivers a piece of its DNA, the T-DNA, into the plant cell; it joins the plant genome and transforms normal cells into tumour cells that make the chemicals the pathogen needs. [1]

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