

BIOLOGY

Code No. 044

SAMPLE QUESTION PAPER — SET 3 | CLASS XII

Time Allowed: 3 Hours

Maximum Marks: 70

General Instructions:

1. All questions are compulsory.
2. This question paper has five sections and 33 questions.
3. Section A has 16 questions of 1 mark each; Section B has 5 questions of 2 marks each; Section C has 7 questions of 3 marks each; Section D has 2 case-based questions of 4 marks each; and Section E has 3 questions of 5 marks each.
4. There is no overall choice. However, internal choices have been provided in some questions. Attempt only one of the alternatives in such questions.
5. Wherever necessary, neat and properly labelled diagrams should be drawn.

SECTION A

Q. No. 1 to 12 are multiple choice questions of 1 mark each. Q. No. 13 to 16 are Assertion-Reason questions.

1.	Pollination in which pollen from a flower on one plant is transferred to a flower on a genetically different plant of the same species is called: (A) Autogamy (B) Geitonogamy (C) Xenogamy (D) Cleistogamy	1
2.	The chalazal end of the embryo sac, opposite to the micropylar end, typically contains: (A) The egg apparatus (B) The antipodal cells (C) The two polar nuclei only (D) The synergids only	1
3.	In the human female, the corpus luteum secretes large amounts of which hormone, essential for maintaining the endometrium if pregnancy occurs? (A) FSH (B) LH (C) Progesterone (D) Oxytocin	1
4.	Amniocentesis, when misused to determine the sex of a foetus, is legally banned in India primarily to prevent: (A) Detection of genetic disorders (B) Sex-selective abortion (C) Testing for maternal health (D) Screening for twins	1

5.	<p>In a dihybrid cross between two heterozygous individuals (AaBb x AaBb) for two independently assorting genes, the expected phenotypic ratio of the offspring is:</p> <p>(A) 3:1 (B) 1:2:1 (C) 9:3:3:1 (D) 1:1:1:1</p>	1
6.	<p>Linkage between two genes on the same chromosome is indicated when:</p> <p>(A) The genes always assort independently (B) The genes tend to be inherited together more often than expected by independent assortment (C) Crossing over always separates them completely (D) The genes are located on different chromosomes</p>	1
7.	<p>Thalassemia, a Mendelian genetic disorder in humans, arises due to:</p> <p>(A) An extra copy of an autosome (B) A quantitative defect in globin chain synthesis (C) A translocation between two non-homologous chromosomes (D) Loss of an entire chromosome</p>	1
8.	<p>The theory that evolution proceeds mainly through the inheritance of characteristics acquired during an organism's lifetime was proposed by:</p> <p>(A) Darwin (B) Lamarck (C) Hugo de Vries (D) Wallace</p>	1
9.	<p>A common cold is caused by which type of pathogen?</p> <p>(A) Bacterium (B) Virus (C) Protozoan parasite (D) Fungus</p>	1
10.	<p>Statins, used to lower blood cholesterol levels, are obtained from which type of microorganism?</p> <p>(A) Bacteria only (B) Certain yeasts (C) Certain filamentous fungi (e.g. <i>Monascus purpureus</i>) (D) Protozoa</p>	1
11.	<p>A vector used to carry foreign DNA into a host cell must ideally have:</p> <p>(A) No origin of replication (B) An origin of replication, a selectable marker, and unique restriction sites (C) The ability to integrate randomly without any selection method</p>	1

	(D) Only a single restriction site for any enzyme	
12.	<p>Which of the following are considered concerns associated with the use of genetically modified (GM) crops?</p> <p>I. Possible unintended effects on non-target organisms</p> <p>II. Concerns around seed ownership and biopiracy</p> <p>III. Complete elimination of the need for any regulatory biosafety testing</p> <p>(A) Only I</p> <p>(B) I and II</p> <p>(C) II and III</p> <p>(D) I, II and III</p>	1
13.	<p>Questions 13 to 16 consist of an Assertion (A) and a Reason (R). Select the correct option:</p> <p>(a) Both A and R are true, and R is the correct explanation of A.</p> <p>(b) Both A and R are true, but R is not the correct explanation of A.</p> <p>(c) A is true but R is false.</p> <p>(d) A is false but R is true.</p> <p>Assertion (A): A test cross always distinguishes a homozygous dominant individual from a heterozygous individual.</p> <p>Reason (R): In a test cross, the heterozygous parent produces two types of gametes in equal proportion, giving a 1:1 phenotypic ratio, while a homozygous dominant parent produces offspring showing only the dominant phenotype.</p>	1
14.	<p>Assertion (A): Darwin's finches on the Galapagos Islands show a wide variety of beak shapes suited to different food sources.</p> <p>Reason (R): This diversity arose through adaptive radiation from a single ancestral finch species that colonised the islands.</p>	1
15.	<p>Assertion (A): Alcohol and drug abuse among adolescents is influenced only by curiosity and has no connection to peer pressure or family environment.</p> <p>Reason (R): Adolescence is a period of significant physical and psychological change, during which peer pressure and the desire for experimentation can strongly influence behaviour.</p>	1
16.	<p>Assertion (A): A gene coding for a desired protein, once cloned, will always be efficiently expressed as a functional protein in any host cell.</p> <p>Reason (R): Efficient expression of a cloned gene requires that it be placed under the control of sequences (such as a suitable promoter) that the chosen host cell's machinery can recognise and use.</p>	1

SECTION B

Section B consists of 5 questions of 2 marks each.

17.	<p>A. What is meant by 'outbreeding devices' in flowering plants? Name any two such mechanisms that promote cross-pollination.</p> <p>OR</p>	2
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	B. Explain briefly why unisexuality (presence of only male or only female flowers on a plant) is considered an effective outbreeding device.	
18.	Explain briefly why the Human Genome Project relied on identifying 'Expressed Sequence Tags' (ESTs), and what an EST represents.	2
19.	The table below shows a hypothetical lipid profile report of a patient: Parameter: Total cholesterol — Result: 265 mg/dL — Normal: <200 mg/dL Parameter: LDL cholesterol — Result: 172 mg/dL — Normal: <100 mg/dL Parameter: HDL cholesterol — Result: 32 mg/dL — Normal: >40 mg/dL A. Based on this profile, is this patient at increased or decreased risk of coronary artery disease? Justify your answer using the values given. B. Name the circulatory system disorder in which fatty deposits narrow the lumen of the coronary arteries, restricting blood flow to heart muscle.	2
20.	A. Explain briefly why a desired gene, once isolated, cannot simply be inserted directly into a host cell's chromosome, and what role a cloning vector plays in overcoming this. OR B. What is meant by 'molecular farming', and why are transgenic animals sometimes used for this purpose?	2
21.	A. (i) A grassland ecosystem shows a pyramid of numbers in which producers (grasses) are extremely high in number, primary consumers (grasshoppers) are somewhat fewer, and secondary consumers (birds) are fewer still, giving an upright pyramid shape at every level. Explain why pyramids of numbers, unlike pyramids of energy, do not always show this same upright shape in every ecosystem. (ii) If 300,000 joules of solar energy are fixed by producers in this grassland, construct an ideal pyramid of energy for producers through to tertiary consumers, assuming the standard 10% transfer efficiency.	2

SECTION C

Section C consists of 7 questions of 3 marks each.

22.	Suggest a suitable contraceptive or reproductive health method for each of the following cases, with justification: (i) Priya has just delivered a baby and is exclusively breastfeeding; she wants a natural, hormone-free method of temporary protection against pregnancy for the next few months. (ii) Kavita wants a long-acting reversible method that also reduces menstrual bleeding, without needing daily attention. (iii) A young couple wants emergency protection against pregnancy after a single instance of unprotected intercourse.	3
23.	With reference to oogenesis in the human ovary, answer the following: (i) At what stage of development is a female's total supply of primary oocytes typically established, and does this number increase after birth? (ii) Name the structure that remains in the ovary after ovulation and describe its main hormonal	3

	secretion. (iii) If the released oocyte is not fertilised within about 24 hours, what happens to this structure, and how does this affect hormone levels leading to menstruation?	
24.	In humans, a particular autosomal recessive disorder is expressed only in individuals homozygous for the recessive allele (aa); heterozygous individuals (Aa) are unaffected carriers. Two unaffected carrier parents (Aa × Aa) wish to know the probability that their next child will be an unaffected carrier (not homozygous either way). Show your working using a Punnett square and state the required probability.	3
25.	Antibiotic resistance in bacteria is known to increase rapidly in hospital environments where antibiotics are heavily used, even though no bacteria were originally exposed to that particular antibiotic before it was introduced. A. Explain how natural selection, rather than the antibiotic itself 'creating' resistance, accounts for this rapid increase in resistant bacteria. B. What term describes the phenomenon in which the frequency of a particular allele changes rapidly in a small population purely by chance, independent of natural selection?	3
26.	Describe the role of microbes in the industrial, large-scale production of citric acid, naming the organism commonly used and the substrate it is typically grown on.	3
27.	Explain the concept of 'herd immunity' and how the vaccination of a large proportion of a population can indirectly protect even unvaccinated individuals within that population.	3
28.	The table below shows recorded population data for a small town over four decades: Decade 1: Birth rate 38 per 1000, Death rate 30 per 1000 Decade 2: Birth rate 34 per 1000, Death rate 18 per 1000 Decade 3: Birth rate 22 per 1000, Death rate 9 per 1000 Decade 4: Birth rate 15 per 1000, Death rate 8 per 1000 A. Calculate the natural population growth rate (per 1000) for each decade, and describe the overall trend across the four decades. B. Suggest one plausible explanation for the changing gap between birth rate and death rate observed over this period.	3

SECTION D

Section D consists of 2 case-based questions of 4 marks each.

29.	Given below is information about the pollination mechanism in four flowering plant species: M: Flowers are large, brightly coloured, produce abundant nectar, and open during the day. N: Flowers are small, dull-coloured, produce large amounts of light, dry pollen, and lack nectar or strong scent. O: Flowers open only at night, are pale or white in colour, and emit a strong sweet fragrance. P: Flowers are tubular, red in colour, produce dilute nectar, and are odourless. A. Which species (N) is most likely pollinated by wind (anemophily)? Give one supporting feature from the description. [1]	4
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	<p>B. (i) Which species is most likely pollinated by moths active at night? Justify using features from the description. [1]</p> <p>(ii) Name the specific agent likely responsible for pollinating species P, based on the described features (tubular, red, odourless, dilute nectar). [1]</p> <p>C. Which of these species would you expect to have the least elaborate or showy floral structures overall, and why? [1]</p> <p>OR</p> <p>D. Suggest one reason why species pollinated by a specific, reliable animal vector (such as species P) can afford to invest less in producing excess pollen compared to wind-pollinated species. [1]</p>	
30.	<p>A study recorded the heart rate of a healthy adult at rest and then during and after a period of moderate exercise. Heart rate rose steadily during exercise, peaked shortly after exercise stopped, and then gradually declined back to the resting rate over the next several minutes.</p> <p>A. Which part of the human nervous system is primarily responsible for increasing heart rate during exercise? [1]</p> <p>B. Explain the role of the sinoatrial node (SA node) in initiating each heartbeat, and why it is referred to as the 'pacemaker' of the heart. [2]</p> <p>C. What trend would you expect in the person's cardiac output during the exercise period compared to rest, and why? [1]</p> <p>OR</p> <p>D. If this person had a disorder that damaged the SA node's ability to function normally, what effect might this have on their heart rate regulation? [1]</p>	4

SECTION E

Section E consists of 3 questions of 5 marks each.

31.	<p>A. With reference to the lac operon in <i>E. coli</i>, explain the roles of the regulatory gene (i), the promoter, the operator, and the structural genes (z, y, a). Describe what happens at each of these elements when lactose is absent from the medium.</p> <p>OR</p> <p>B. Describe the key steps involved in the Human Genome Project's approach to sequencing the entire human genome, including the significance of identifying Single Nucleotide Polymorphisms (SNPs).</p>	5
32.	<p>A. (i) Explain what is meant by a 'transgenic organism', and name one transgenic animal along with the purpose for which it was developed. [2]</p> <p>(ii) Briefly explain the role of gene therapy in correcting a genetic disorder, using the example of Adenosine Deaminase (ADA) deficiency. [2]</p> <p>(iii) Name one ethical or biosafety concern associated with the use of genetically modified organisms. [1]</p> <p>OR</p> <p>B. BglII is a restriction enzyme that recognises the sequence 5'-AGATCT-3'.</p> <p>(i) Write the complementary strand of this sequence and verify that it is a palindrome. [2]</p> <p>(ii) Explain the concept of a 'palindromic sequence' in the context of restriction enzyme recognition sites, and why most restriction sites have this property. [1]</p>	5

	<p>(iii) If a foreign gene cut with BglIII is inserted into a plasmid vector also cut with BglII, explain why the resulting recombinant plasmid can be introduced into and replicated within a bacterial host cell. [2]</p>	
<p>33.</p>	<p>A. Justify each of the following statements about biodiversity and its conservation, with a suitable example for each:</p> <p>(i) Loss of even a single keystone species can disproportionately affect an entire ecosystem.</p> <p>(ii) In-situ conservation is generally preferred over ex-situ conservation wherever feasible.</p> <p>(iii) Sacred groves have historically played a role in biodiversity conservation in India.</p> <p>(iv) The current rate of species extinction is considered unusually high compared to the background rate seen through most of Earth's history.</p> <p>OR</p> <p>B. (i) Using a simple forest food chain, explain why the number of trophic levels in a food chain is usually limited to four or five.</p> <p>(ii) The table below shows the number of recorded freshwater fish species in different river basins: Amazon basin: 3000 species — Congo basin: 700 species — Mekong basin: 850 species — Thames basin: 20 species — Rhine basin: 45 species</p> <p>Identify the common geographical factor shared by the high-diversity river basins, and suggest two reasons for this pattern.</p>	<p>5</p>

BIOLOGY

Code No. 044 — Marking Scheme

MARKING SCHEME — SET 3 | CLASS XII

SECTION A		
1.	Xenogamy is the transfer of pollen from a flower on one plant to a flower on a genetically different plant of the same species, ensuring true cross-pollination. Answer: (C)	1
2.	The chalazal end of a typical 7-celled, 8-nucleate embryo sac contains the three antipodal cells, opposite to the egg apparatus at the micropylar end. Answer: (B)	1
3.	The corpus luteum secretes large amounts of progesterone, which is essential for maintaining the endometrium to support pregnancy if implantation occurs. Answer: (C)	1
4.	Misuse of amniocentesis for sex determination has led to female foeticide, which is why the technique is legally restricted in India specifically to prevent sex-selective abortion. Answer: (B)	1
5.	A dihybrid cross between two double heterozygotes ($AaBb \times AaBb$) produces the classic 9:3:3:1 phenotypic ratio. Answer: (C)	1
6.	Linked genes on the same chromosome tend to be inherited together (deviating from independent assortment) more often than expected by chance. Answer: (B)	1
7.	Thalassemia results from a quantitative defect — reduced or absent synthesis of one or more globin chains of haemoglobin — rather than a chromosomal abnormality. Answer: (B)	1
8.	Lamarck proposed the theory of inheritance of acquired characteristics. Answer: (B)	1
9.	The common cold is caused by rhinoviruses, a group of viruses. Answer: (B)	1
10.	Statins used as blood cholesterol-lowering agents are obtained from certain filamentous fungi, such as <i>Monascus purpureus</i> . Answer: (C)	1
11.	A good cloning vector needs an origin of replication (<i>ori</i>) to multiply within the host, a selectable marker to identify transformants, and unique restriction sites to allow insertion of foreign DNA. Answer: (B)	1
12.	Concerns around GM crops include possible unintended ecological effects on non-target organisms (I) and issues of seed ownership/biopiracy (II); GM crops do not eliminate the need for biosafety testing — in fact, they require rigorous regulatory testing (III is incorrect). Answer: (B) I and II	1
13.	Both statements are true, and R correctly explains why a test cross reliably distinguishes homozygous dominant from heterozygous genotypes, based on the resulting phenotypic ratios. Answer: (a)	1
14.	Both statements are true, and R correctly explains the diversity of beak shapes as arising through adaptive radiation from a common ancestor. Answer: (a)	1
15.	A is false, since peer pressure and family/social environment are well-recognised, significant	1

	contributing factors to adolescent substance abuse, not merely curiosity alone; R is a true statement about adolescence. Answer: (d)	
16.	A is false, since a cloned gene is not always efficiently expressed in any host — expression depends on compatible regulatory sequences; R correctly explains this requirement. Answer: (d)	1

SECTION B		
17.	<p>A. Outbreeding devices are mechanisms in flowering plants that discourage or prevent self-pollination, thereby promoting cross-pollination and genetic variation. Two examples: (i) dicliny/unisexuality, where a plant bears only male or only female flowers; (ii) self-incompatibility, a genetic mechanism preventing self-pollen from fertilising the same flower even if it lands on the stigma. [2]</p> <p>OR B. When a plant produces only male flowers or only female flowers (unisexual/dicliny), self-pollination within the same flower is physically impossible, and pollination must occur between two different plants (or at least different flowers), effectively enforcing cross-pollination and preventing inbreeding. [2]</p>	2
18.	The Human Genome Project relied on identifying Expressed Sequence Tags (ESTs) because ESTs correspond to the portions of genes that are actually transcribed and expressed (i.e. found in mRNA/cDNA), helping researchers quickly identify and annotate functional genes within the vast amount of sequenced DNA, rather than having to characterise every stretch of the genome, including non-coding regions, from scratch. [2]	2
19.	<p>A. This patient is at increased risk of coronary artery disease, since total cholesterol and LDL ('bad') cholesterol are both well above the normal range, while HDL ('good') cholesterol is below the normal range — a combination strongly associated with fatty deposit build-up in arteries.</p> <p>B. This condition is called Coronary Artery Disease (atherosclerosis affecting the coronary arteries), where fatty deposits (plaques) narrow the coronary artery lumen and restrict blood flow to the heart muscle. [2]</p>	2
20.	<p>A. A desired gene cannot simply be inserted into a host chromosome because foreign DNA introduced alone is usually degraded or lost, and it needs a way to replicate independently within the host cell. A cloning vector (such as a plasmid) carries an origin of replication, allowing the foreign gene, once ligated into the vector, to be copied along with the vector each time the host cell divides, ensuring the gene is faithfully propagated (cloned). [2]</p> <p>OR B. Molecular farming refers to the use of genetically engineered organisms, often transgenic animals or plants, to produce large quantities of a useful protein (such as a pharmaceutical protein) in their milk, blood, eggs or tissues. Transgenic animals are sometimes preferred for this purpose because their mammary glands or other tissues can produce and correctly fold/modify complex proteins (such as human proteins) more efficiently and accurately than simpler organisms like bacteria. [2]</p>	2
21.	<p>A. (i) Pyramids of numbers can be irregular or even inverted in some ecosystems (e.g. a single large tree supporting numerous insects) because they depend on the size and reproductive rate of the organisms at each level, not just on energy transfer; pyramids of energy are always upright, however, because energy is inevitably lost as heat at each trophic transfer, regardless of organism size or numbers.</p> <p>(ii) Pyramid of energy: Producers = 300,000 J; Primary consumers = 30,000 J; Secondary consumers</p>	2

	= 3,000 J; Tertiary consumers = 300 J. [2]	
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SECTION C		
22.	<p>(i) The Lactational Amenorrhea Method (LAM) is suitable, as exclusive breastfeeding naturally suppresses ovulation for a limited period after childbirth, providing temporary, hormone-free contraceptive protection.</p> <p>(ii) A hormone-releasing IUD (e.g. LNG-IUS/Progestasert) is suitable, as it is long-acting, reversible, does not require daily attention, and is known to reduce menstrual bleeding.</p> <p>(iii) Emergency contraceptive pills are suitable, as they are specifically designed to prevent pregnancy when taken within a short window (typically up to 72 hours) after unprotected intercourse. [1 each]</p>	3
23.	<p>(i) A female's total supply of primary oocytes is established before birth (during foetal development); this number does not increase after birth — in fact, it progressively decreases through the woman's reproductive years.</p> <p>(ii) The corpus luteum remains in the ovary after ovulation and primarily secretes progesterone (along with some estrogen), which prepares and maintains the uterine lining.</p> <p>(iii) If the oocyte is not fertilised, the corpus luteum degenerates (into the corpus albicans), and progesterone (and estrogen) levels fall sharply; this drop in hormone levels causes the built-up endometrial lining to break down and be shed, resulting in menstruation. [1 each]</p>	3
24.	<p>Cross: Aa × Aa (both unaffected carriers).</p> <p>Punnett square gives offspring genotypes in the ratio 1 AA : 2 Aa : 1 aa.</p> <p>AA (1/4) is homozygous unaffected (not a carrier); Aa (2/4 = 1/2) is an unaffected carrier; aa (1/4) is affected.</p> <p>Probability that the next child is an unaffected carrier (Aa) = 1/2 (or 2/4). [3]</p>	3
25.	<p>A. Even before an antibiotic is introduced, a small number of bacteria in a population may already carry chance mutations that confer resistance to it. When the antibiotic is introduced, it does not create these mutations; rather, it acts as a selective pressure that kills susceptible (non-resistant) bacteria, allowing the pre-existing resistant variants to survive, reproduce, and rapidly increase in frequency — this is natural selection acting on existing variation, not the antibiotic 'creating' resistance.</p> <p>B. This phenomenon is called genetic drift, where allele frequencies change by random chance (especially significant in small populations), independent of natural selection. [3]</p>	3
26.	<p>Citric acid is industrially produced on a large scale using the fungus <i>Aspergillus niger</i>, grown under controlled fermentation conditions typically using a sugar-rich substrate (such as molasses, a by-product of sugar production) as the carbon source; the fungus metabolises the substrate and secretes large quantities of citric acid as a fermentation product, which is then extracted and purified for use in the food and other industries. [3]</p>	3
27.	<p>Herd immunity refers to the indirect protection of unvaccinated (or non-immune) individuals in a population when a sufficiently large proportion of that population is immune (through vaccination or prior infection). Because most people around them are immune, the pathogen has very few susceptible hosts available to infect and spread between, breaking chains of transmission; this reduces the overall circulation of the pathogen, thereby indirectly protecting even those individuals</p>	3

	who are not themselves immune. [3]	
28.	<p>A. Natural growth rate (birth rate – death rate) per 1000: Decade 1 = 38–30 = 8; Decade 2 = 34–18 = 16; Decade 3 = 22–9 = 13; Decade 4 = 15–8 = 7. The overall trend shows the growth rate first rising sharply (Decade 1 to 2) and then gradually declining over the subsequent decades (Decade 2 to 4).</p> <p>B. This pattern is consistent with a classic demographic transition: death rates decline first (due to improvements in healthcare, sanitation and nutrition), initially causing the growth rate to rise sharply since birth rates remain high; birth rates then decline later (due to factors like improved education, family planning and economic development), causing the growth rate to fall again in later decades. [3]</p>	3

SECTION D

29.	<p>A. Species N is most likely wind-pollinated (anemophilous); its small, dull-coloured flowers with abundant light, dry pollen and no nectar or scent are classic adaptations for wind pollination, since there is no need to attract animal visitors. [1]</p> <p>B. (i) Species O is most likely moth-pollinated; its features — flowers opening at night, pale/white colour (visible in low light) and strong sweet fragrance (to attract pollinators in the dark when vision is less useful) — are typical adaptations for pollination by night-active moths. [1]</p> <p>(ii) Species P (tubular, red, odourless, dilute nectar) is most likely pollinated by birds (ornithophily), since birds are attracted to red colour, have little sense of smell (explaining the lack of scent), and the tubular shape suits a bird's beak while dilute nectar suits their higher energy/fluid needs. [1]</p> <p>C. Species N (wind-pollinated) would be expected to have the least elaborate or showy floral structures, since it does not need to attract any animal pollinator and can rely entirely on producing abundant light pollen dispersed by air currents. [1]</p> <p>OR D. A plant relying on a specific, reliable animal pollinator (like species P) can produce fewer pollen grains because most of the pollen delivered by a targeted animal visitor is likely to reach a compatible flower's stigma efficiently, unlike wind pollination, where the vast majority of pollen is lost to random air currents and never reaches a stigma, requiring wind-pollinated plants to produce pollen in much greater excess to ensure successful pollination. [1]</p>	4
30.	<p>A. The sympathetic nervous system is primarily responsible for increasing heart rate during exercise. [1]</p> <p>B. The SA node is a specialised patch of tissue in the wall of the right atrium that generates rhythmic electrical impulses spontaneously, without requiring any external nervous stimulus, at a faster intrinsic rate than any other part of the heart's conducting tissue. Because it initiates each heartbeat and sets the overall rhythm and rate of the heart, it is referred to as the heart's natural 'pacemaker'. [2]</p> <p>C. Cardiac output would be expected to increase substantially during exercise compared to rest, since both heart rate and stroke volume typically rise to meet the increased oxygen and nutrient demand of the actively working muscles. [1]</p> <p>OR D. If the SA node were damaged and unable to function normally, the heart's rhythm might become irregular or excessively slow, since the heart would then have to rely on a secondary, slower pacemaker (such as the AV node) to initiate heartbeats, potentially requiring an artificial pacemaker to maintain a normal heart rate. [1]</p>	4

SECTION E

31.	<p>A. The regulatory gene (i) continuously produces a repressor protein. The promoter is the site where RNA polymerase binds to begin transcription of the structural genes. The operator is the region adjacent to the promoter where the repressor protein binds; when bound, it physically blocks RNA polymerase from transcribing the structural genes (z, y and a, which code for beta-galactosidase, permease and transacetylase respectively).</p> <p>In the absence of lactose: the repressor protein (produced continuously by gene i) is active and binds tightly to the operator region, preventing RNA polymerase from transcribing the structural genes, so the enzymes needed to metabolise lactose are not produced (since there is no lactose to metabolise, this is efficient for the cell). [5]</p> <p>OR B. The Human Genome Project used a combination of two main sequencing strategies: identifying Expressed Sequence Tags (ESTs) to locate functional, expressed genes, and Sequence Annotation to determine the sequences of the entire genome (including non-coding regions), often using automated, high-throughput DNA sequencers and computational assembly of overlapping sequenced fragments into complete chromosome sequences.</p> <p>Identifying Single Nucleotide Polymorphisms (SNPs) — single base-pair variations between individuals — is significant because SNPs can help explain differences between individuals in disease susceptibility and drug response, and serve as useful genetic markers for locating disease-associated genes and for studies in personalised medicine and forensic science. [5]</p>	5
32.	<p>A. (i) A transgenic organism is one whose genome has been deliberately altered by the introduction, deletion or modification of a gene using genetic engineering techniques, resulting in a permanent genetic change that can typically be passed on to offspring. Example: 'Rosie', a transgenic cow, was developed to produce protein-enriched (human alpha-lactalbumin-containing) milk more suitable for human infants. [2]</p> <p>(ii) Gene therapy involves correcting a genetic defect by introducing a normal, functional copy of the defective gene into a patient's cells. In ADA deficiency (a condition impairing immune function), lymphocytes are extracted from the patient's blood, a functional ADA gene is introduced into these cells using a suitable vector, and the genetically corrected cells are returned to the patient's body, where they (temporarily) provide the missing enzyme function; periodic repetition may be required since these cells are not permanent. [2]</p> <p>(iii) One key concern is biosafety/ecological risk, such as the possibility that genes from a GM organism could spread to wild relatives (gene flow) with unpredictable ecological consequences; alternatively, concerns about corporate control over seeds and biopiracy of indigenous genetic resources are also commonly raised. [1]</p> <p>OR B. (i) BglII site: 5'-AGATCT-3' / complementary strand: 3'-TCTAGA-5'. Reading the complementary strand 5' → 3' gives AGATCT again, identical to the original — confirming the sequence is palindromic. [2]</p> <p>(ii) A palindromic sequence in this context reads the same on both strands when each is read in the 5' → 3' direction. Most restriction sites are palindromic because this allows the restriction enzyme (which typically functions as a symmetric dimer) to recognise and cut both strands of the DNA at corresponding, symmetric positions, generating complementary sticky or blunt ends efficiently. [1]</p> <p>(iii) Since both the foreign gene and the vector are cut with the same enzyme (BglII), they are left with identical, complementary single-stranded sticky ends; these ends can base-pair with each other, and DNA ligase then seals the nicks, forming a stable recombinant plasmid that retains the vector's origin of replication and can therefore be taken up by, and replicated within, a bacterial host cell. [2]</p>	5
33.	<p>A. (i) A keystone species has an ecological influence disproportionately larger than its abundance would suggest; its loss can trigger a cascade of changes throughout the ecosystem, e.g. removal of sea otters (a keystone predator) allows sea urchin populations to explode, which then overgraze and destroy kelp forests, collapsing the wider ecosystem.</p> <p>(ii) In-situ conservation (protecting species within their natural habitat, e.g. national parks and</p>	5

wildlife sanctuaries) is generally preferred because it conserves the whole ecosystem and the natural interactions/evolutionary processes within it, not just the target species in isolation, as would occur with ex-situ methods like zoos or seed banks.

(iii) Sacred groves — patches of forest traditionally protected by local communities for religious or cultural reasons — have preserved several rare and endemic species and habitats in India (e.g. sacred groves in parts of Meghalaya and the Western Ghats) that might otherwise have been cleared.

(iv) The current rate of species extinction (often estimated at many times the natural 'background' extinction rate seen in the fossil record) is considered unusually high because it is driven largely by human activities such as habitat destruction, overexploitation, pollution and climate change, occurring over a very short timescale compared to natural extinction processes. [5, distributed across the four points]

OR B. (i) In a food chain, only about 10% of the energy at one trophic level is typically transferred to the next (the rest being lost as heat during respiration and other metabolic processes); this progressive energy loss means that after 4 to 5 trophic transfers, too little usable energy remains to support a viable further trophic level, which is why food chains are usually limited to four or five levels.

(ii) All the high-diversity river basins (Amazon, Congo, Mekong) lie within or near the tropics. Two reasons for their greater freshwater fish diversity: tropical river basins have larger areas of stable, warm aquatic habitat with high primary productivity supporting more niches; and they have experienced longer, less disrupted evolutionary history (less affected by glaciation cycles), allowing more speciation and diversification of fish lineages to accumulate over time. [5]