BIOLOGY

Code No. 044

SAMPLE QUESTION PAPER — SET 2 | 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.	Double fertilisation in flowering plants involves fusion of: (A) Two male gametes with one egg cell (B) One male gamete with the egg, and the second male gamete with the two polar nuclei (C) One male gamete with two synergids (D) Two male gametes with two polar nuclei only	1
2.	Which of the following best describes apomixis? (A) Formation of seeds without meiosis or fertilisation (B) Development of a fruit without fertilisation (C) Formation of more than one embryo in a seed (D) Union of two gametes from the same parent	1
3.	The process by which sperm undergo functional maturation inside the female reproductive tract before fertilisation is called: (A) Spermiogenesis (B) Spermiation (C) Capacitation (D) Acrosomal reaction	1
4.	Parturition (childbirth) in humans is primarily induced by signals arising from the: (A) Fully developed foetus and placenta (B) Mother's pituitary gland alone (C) Mother's ovaries alone (D) Umbilical cord only	1
5.	The classic blending vs particulate nature of hereditary factors was resolved in favour of 'particulate	1

	inheritance' primarily through the work of: (A) Darwin (B) Mendel (C) Watson and Crick (D) Morgan	
6.	A cross between a plant with genotype AaBb and one with genotype aabb (a test cross) is useful mainly because it: (A) Always produces only dominant phenotypes (B) Reveals the genotype of the AaBb parent through the phenotypic ratio of offspring (C) Eliminates the need for a Punnett square (D) Only works for linked genes	1
7.	Down's syndrome in humans arises due to: (A) Loss of one copy of chromosome 21 (B) An extra copy of chromosome 21 (trisomy 21) (C) Loss of an X chromosome (D) An extra Y chromosome	1
8.	The Hardy-Weinberg equation $p^2 + 2pq + q^2 = 1$ represents: (A) The binomial expansion of $(p - q)^2$ (B) The binomial expansion of $(p + q)^2$ (C) A ratio unrelated to allele frequency (D) The frequency of only heterozygotes in a population	1
9.	Which vaccine-preventable disease is caused by a virus (not a bacterium)? (A) Diphtheria (B) Whooping cough (C) Poliomyelitis (D) Tetanus	1
10.	The scientific name of the fungus commonly used to produce the immunosuppressive drug cyclosporin A is: (A) Trichoderma polysporum (B) Aspergillus niger (C) Saccharomyces cerevisiae (D) Penicillium notatum	1
11.	A key challenge in gene therapy for correcting a genetic disorder is: (A) Finding the disorder-causing gene, which is usually already well known (B) Introducing the functional gene into the target cells at the right time in a stable, functioning form (C) The complete absence of any suitable vector systems	1

	(D) Genetic disorders cannot be corrected even in principle	
12.	Which of the following statements about biofortification is/are correct? I. It aims to increase the nutritional value of crops through breeding. II. It can be achieved using conventional plant breeding as well as genetic engineering. III. It always requires the introduction of a foreign gene from another species. (A) Only I (B) I and II (C) I and III (D) I, II and III	1
13.	Questions 13 to 16 consist of an Assertion (A) and a Reason (R). Select the correct option: (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. Assertion (A): Identical twins arising from a single zygote are always of the same sex. Reason (R): Identical twins are formed by the mitotic splitting of a single fertilised egg, so they carry identical sex chromosomes.	1
14.	Assertion (A): All variations in a population arise only from new mutations. Reason (R): Recombination during sexual reproduction also generates new combinations of existing alleles, contributing to variation.	1
15.	Assertion (A): A person infected with HIV eventually shows a marked decline in the number of helper T-lymphocytes. Reason (R): HIV selectively infects and destroys helper T-lymphocytes, weakening the body's immune response.	1
16.	Assertion (A): Bt cotton plants are resistant to attack by certain lepidopteran insects. Reason (R): The Bt toxin protein remains in its active, toxic form throughout the plant tissue at all times, including before the insect ingests it.	1

SECTION B *Section B consists of 5 questions of 2 marks each.*		
17.	A. What is meant by 'self-incompatibility' in flowering plants, and how does it prevent self-pollination from resulting in seed formation, even though pollen may land on the stigma of the same flower? **OR** B. Distinguish between autogamy and geitonogamy, and explain why geitonogamy is genetically similar to self-pollination even though it involves transfer of pollen between two different flowers.	2

18.	Explain briefly how the discontinuous, lagging strand of DNA is synthesised during replication, and why this strand requires the enzyme DNA ligase while the leading strand does not.	2
19.	The table below shows a hypothetical urinalysis report of a patient: Parameter: Glucose — Result: Present — Normal: Absent Parameter: Protein (Albumin) — Result: Present — Normal: Absent Parameter: Ketone bodies — Result: Absent — Normal: Absent Parameter: Urea — Result: Normal range — Normal: Normal range A. Based on this report, which excretory system disorder is most likely indicated, and why? B. Name the structure in the nephron primarily responsible for preventing large proteins from entering the filtrate under normal conditions.	2
20.	A. Why are restriction enzymes sometimes called 'molecular scissors', and why must the DNA to be cloned and the vector be cut with the same restriction enzyme? **OR** B. What is meant by 'downstream processing' in the context of biotechnology-based production of a protein such as insulin?	2
21.	A. (i) A pond ecosystem shows a pyramid of biomass where producers (phytoplankton) have very low standing biomass at any instant, but primary consumers (zooplankton) have a comparatively higher biomass, giving an inverted pyramid shape. Explain how this is biologically possible, given that biomass pyramids are usually upright on land. (ii) If a forest ecosystem receives 800,000 joules of sunlight energy fixed by producers, construct an ideal pyramid of energy showing the energy available to primary, secondary and tertiary consumers, assuming standard 10% transfer efficiency.	2

SECTION C *Section C consists of 7 questions of 3 marks each.*		
22.	Suggest a suitable reproductive health intervention for each of the following cases, with justification: (i) A young couple wishes to know, before planning a pregnancy, whether either partner carries a genetic disorder that could be passed to their child. (ii) A woman who is 8 weeks pregnant wishes to terminate the pregnancy for medical reasons, within the legally permitted period. (iii) A couple has been unable to conceive due to a blockage in the woman's fallopian tubes and wishes to have a biological child.	3
23.	With reference to spermatogenesis in the human testis, answer the following: (i) What is the ploidy of a primary spermatocyte, and what type of division does it undergo to form secondary spermatocytes? (ii) Name the cells that provide nourishment to the developing sperm cells within the seminiferous tubules. (iii) A man has a mutation affecting only the cells lining the seminiferous tubules that nourish developing sperm, but not the sperm-producing germ cells themselves. Would you expect this mutation to be passed on to his children? Justify.	3

24.	In a species of flower, red flower colour (R) shows incomplete dominance over white (r), producing pink flowers in heterozygotes. In the same species, tall height (T) is completely dominant over short (t), and the two genes assort independently. If a pink, tall plant (RrTt) is crossed with a white, short plant (rrtt), find the proportion of offspring expected to be pink and tall. Show your working using a Punnett square.	3
25.	The fossil record shows that horses evolved over millions of years from a small, multi-toed ancestor (Eohippus) to the large, single-toed modern horse (Equus), passing through several intermediate forms. A. What kind of evidence for evolution does this fossil sequence represent? B. Explain briefly how natural selection, acting on variation within horse populations over long periods, could account for this gradual change in size and toe structure.	3
26.	Describe how microbes are used in the production of biogas in a biogas plant, including the role of methanogens and the type of environment they require.	3
27.	Explain the underlying immunological principle of the ELISA test used to diagnose HIV infection. Why is this test able to detect infection before symptoms of AIDS appear?	3
28.	A survey of a small lake recorded 40 individuals of a fish species in year 1, and this population grew to 200 individuals by year 4, after which growth slowed and the population stabilised around 480 individuals from year 8 onward, remaining roughly constant thereafter. A. Name and describe the type of population growth model this data best fits. B. What is the likely explanation for the population stabilising at around 480 individuals rather than continuing to grow indefinitely?	3

SECTION D *Section D consists of 2 case-based questions of 4 marks each.*		
29.	Given below is information about the inheritance of a trait in four hypothetical families: W: A trait appears only in male children; an affected father passes it to all of his sons, but never to any of his daughters. X: A trait shows a blending-like intermediate phenotype in heterozygotes, distinct from both homozygous phenotypes. Y: A trait is controlled by three or more allelic forms of a single gene, though any individual carries only two of these alleles. Z: A trait appears in both sons and daughters of an affected mother, but an affected father passes it only to his daughters (who become carriers), not his sons. A. Which family (W or Z) illustrates a Y-linked pattern of inheritance? Justify. [1] B. (i) Which family illustrates the phenomenon of multiple alleles? Name a well-known human trait that follows this pattern. [1] (ii) In family X, if two heterozygous (intermediate phenotype) individuals are crossed, what phenotypic ratio would you expect among their offspring? [1] C. Which family (Z) best illustrates X-linked recessive inheritance? Give a reason. [1] **OR**	4

	D. In family Z, if an affected (carrier) mother and a normal father have children, what proportion of their sons is expected to be affected? Justify. [1]	
30.	A study measured the blood glucose levels of a healthy volunteer over 4 hours after a meal. Blood glucose rose sharply within 30 minutes of eating, peaked at around 1 hour, and then declined steadily, returning close to baseline by 2.5-3 hours, remaining stable thereafter. A. Which hormone is primarily responsible for the decline in blood glucose seen after the peak, and which gland secretes it? [1] B. Explain the mechanism by which this hormone brings about a lowering of blood glucose levels in the body. [2] C. What trend would you expect in this hormone's secretion during the initial sharp rise in blood glucose, and why? [1] **OR** D. If this volunteer's pancreas were unable to respond adequately to rising blood glucose, what condition might eventually develop, and what would you expect the blood glucose graph to look like in this case? [1]	4

SECTION E *Section E consists of 3 questions of 5 marks each.*		
31.	A. Given a hypothetical DNA coding (sense) strand: 5'-ATGCTTGGACCA-3', write the mRNA sequence that would be transcribed from the corresponding template strand, and identify the anticodons of the tRNAs that would pair with each codon during translation. Also explain what is meant by the 'degeneracy' of the genetic code, with a suitable example. **OR** B. Describe the semi-conservative model of DNA replication, and explain how the Meselson-Stahl experiment using density-labelled nitrogen (^{15}N and ^{14}N) provided direct experimental support for this model.	5
32.	A. (i) Explain the role of a selectable marker gene in identifying bacterial cells that have taken up recombinant DNA during transformation. [2] (ii) Name one physical method and one chemical method used to introduce foreign DNA into a host cell. [1] (iii) A biotechnology company wants to mass-produce a human protein hormone using genetically engineered bacteria grown in large fermenters. Briefly describe the role of a bioreactor in this process, and name one such large-scale bioreactor design. [2] **OR** B. HindIII is a restriction enzyme that recognises the sequence 5'-AAGCTT-3'. (i) Write the complementary strand of this sequence and verify that it is a palindrome. [2] (ii) Explain what is meant by a restriction endonuclease being 'sequence-specific', and why this property makes such enzymes useful in genetic engineering. [1] (iii) If a gene of interest is cut out using HindIII and inserted into a vector cut with the same enzyme, explain why the sticky ends generated ensure the fragment can be joined into the vector in the correct orientation for ligation. [2]	5
33.	A. Justify each of the following statements about population interactions in nature, with a suitable	5

	example for each: (i) Predation can help maintain species diversity in a community rather than reducing it. (ii) Some interactions benefit one species while causing no measurable harm or benefit to the other (commensalism). (iii) Some interactions are obligatory and mutually beneficial to both species involved (mutualism). (iv) Parasitism generally has a negative effect on host fitness but does not usually kill the host outright. **OR** B. (i) Using a simple pond food chain, explain how it illustrates the Second Law of Thermodynamics (progressive loss of usable energy at each trophic transfer). (ii) The table below shows the number of recorded reptile species in different regions: Brazil: 650 species — Colombia: 520 species — Indonesia: 590 species — Sweden: 8 species — Finland: 5 species Identify the common geographical factor shared by the high-diversity regions, and suggest two reasons for this pattern.	

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Code No. 044 — Marking Scheme

MARKING SCHEME — SET 2 | CLASS XII

SECTION A		
1.	Double fertilisation involves one male gamete fusing with the egg (syngamy, forming the zygote) and the second male gamete fusing with the two polar nuclei (triple fusion, forming the primary endosperm nucleus). Answer: (B)	1
2.	Apomixis is a form of asexual reproduction that mimics sexual reproduction, producing seeds without the actual processes of meiosis and fertilisation. Answer: (A)	1
3.	Capacitation is the functional maturation of sperm inside the female reproductive tract, required before they can fertilise the egg. Answer: (C)	1
4.	Signals for parturition arise from the fully developed foetus and the placenta, which trigger mild uterine contractions (Ferguson's reflex) that intensify into labour. Answer: (A)	1
5.	Mendel's work established that hereditary factors (genes) are discrete, particulate units rather than blending fluids. Answer: (B)	1
6.	A test cross (with a homozygous recessive individual) reveals whether the parent in question is homozygous or heterozygous for the traits in question, based on the phenotypic ratio produced. Answer: (B)	1
7.	Down's syndrome results from trisomy of chromosome 21 (an extra copy), typically due to non-disjunction during gamete formation. Answer: (B)	1
8.	$p^2+2pq+q^2=1$ is the binomial expansion of $(p+q)^2$, representing the frequencies of the two homozygous genotypes and the heterozygote in a population at equilibrium. Answer: (B)	1
9.	Poliomyelitis is caused by the poliovirus; diphtheria, whooping cough (pertussis) and tetanus are all caused by bacteria. Answer: (C)	1
10.	Trichoderma polysporum is the fungus from which cyclosporin A, an immunosuppressive drug, is obtained. Answer: (A)	1
11.	The main challenge in gene therapy is delivering a normal, functional copy of the gene into the patient's target cells so that it is taken up, expressed appropriately, and functions correctly — ideally in a stable, long-term manner. Answer: (B)	1
12.	Biofortification increases nutrient content through breeding methods (I) and can use both conventional breeding and genetic engineering (II); it does not always require a foreign gene, since conventional selective breeding within the same species can also achieve it (III is incorrect). Answer: (B) I and II	1
13.	Both statements are true, and R correctly explains why identical twins are always the same sex — because they share identical genetic material, including sex chromosomes, from the same zygote. Answer: (a)	1

14.	A is false, since recombination (not only new mutation) is a major source of variation, as correctly stated in R. Answer: (d)	1
15.	Both statements are true, and R correctly explains the mechanism behind the decline in helper T-cell count in HIV infection. Answer: (a)	1
16.	A is true (Bt cotton does resist certain lepidopteran pests), but R is false: the Bt toxin is produced in an inactive protoxin form and is only converted to its active, toxic form in the alkaline gut of the insect after ingestion, not throughout the plant tissue at all times. Answer: (c)	1

SECTION B		
17.	A. Self-incompatibility is a genetic mechanism that prevents self-pollen (or pollen from a genetically similar plant) from developing normally, typically by inhibiting pollen germination on the stigma or preventing pollen tube growth down the style, so that fertilisation and seed formation do not occur even though pollination has physically taken place. [2] OR B. Autogamy is self-pollination within the same flower, while geitonogamy is transfer of pollen from one flower to another flower on the same plant. Genetically, geitonogamy behaves like self-pollination because both flowers belong to the same plant and carry the same genotype, so no new genetic combination is introduced despite pollen physically moving between two flowers. [2]	2
18.	The lagging strand is synthesised discontinuously in short fragments (Okazaki fragments) in the 5'→3' direction, opposite to the direction of replication fork movement, because DNA polymerase can only add nucleotides in the 5'→3' direction. Since these Okazaki fragments are synthesised as separate pieces, DNA ligase is required afterward to join (seal) them into a single continuous strand; the leading strand is synthesised continuously in one piece in the same direction as the fork moves, so it does not need ligase. [2]	2
19.	A. The presence of both glucose and protein in the urine, with normal urea, is most consistent with diabetic nephropathy/kidney involvement due to diabetes mellitus, where persistently high blood glucose damages the glomerular filtration mechanism, allowing glucose and protein to leak into the urine. B. The basement membrane (filtration membrane) of the glomerulus, along with the podocytes of Bowman's capsule, normally prevents large protein molecules from passing into the filtrate. [2]	2
20.	A. Restriction enzymes are called 'molecular scissors' because they cut DNA at specific recognition sequences, much like scissors cut paper at a chosen point. The DNA to be cloned and the vector must be cut with the same restriction enzyme so that both end up with identical, complementary sticky ends, allowing the foreign DNA fragment to base-pair and be ligated precisely into the cut vector. [2] OR B. Downstream processing refers to all the steps taken after the desired protein (e.g. insulin) has been produced by the genetically engineered organism, including separation and purification of the protein, formulation with suitable additives, and rigorous quality control testing, before it can be marketed as a finished product. [2]	2
21.	A. (i) This is possible because phytoplankton, although low in standing biomass at any given instant, have an extremely fast turnover/reproduction rate; they are consumed almost as fast as they are produced, so despite their high productivity, their standing crop (biomass present at any one time) is low, while the zooplankton that feed on them accumulate a comparatively larger biomass.	2

	(ii) Pyramid of energy: Producers = 800,000 J; Primary consumers = 80,000 J; Secondary consumers = 8,000 J; Tertiary consumers = 800 J. [2]	

SECTION C		
22.	(i) Genetic counselling (including carrier screening) is suitable, allowing the couple to understand the risk of passing on a genetic disorder before planning a pregnancy. (ii) Medical Termination of Pregnancy (MTP) is suitable and legally permissible, since 8 weeks falls within the legally allowed period for MTP. (iii) In vitro fertilisation (IVF, 'test-tube baby' technique), where eggs are fertilised outside the body and the resulting embryo/zygote is transferred into the uterus (or fallopian tube, as ZIFT), bypasses the blocked fallopian tube. [1 each]	3
23.	(i) A primary spermatocyte is diploid (2n); it undergoes the first meiotic division (meiosis I, a reductional division) to form two secondary spermatocytes. (ii) Sertoli cells (found within the seminiferous tubules) provide nourishment to the developing germ cells. (iii) No, this mutation would not be expected to pass to his children, since Sertoli cells are somatic supporting cells, not germ cells; only mutations in the germ cells (which give rise to the sperm themselves) can be transmitted to offspring. [1 each]	3
24.	Cross: RrTt (pink, tall) × rrtt (white, short). For flower colour (incomplete dominance): Rr × rr gives 1/2 Rr (pink) : 1/2 rr (white). For height (complete dominance): Tt × tt gives 1/2 Tt (tall) : 1/2 tt (short). Since the genes assort independently, probability of pink AND tall = 1/2 × 1/2 = 1/4. (A 2×2 Punnett square for each gene, combined, confirms 1 out of 4 offspring combinations is pink and tall.) [3]	3
25.	A. This is an example of palaeontological (fossil) evidence for evolution, showing a graded series of transitional forms connecting an ancestral species to a modern descendant. B. Within ancestral horse populations, natural variation in body size and toe number existed. As grasslands (rather than forests) became the dominant habitat, larger body size and a single, sturdy toe (better suited to running fast on open ground) were favoured by natural selection, since individuals with these traits survived and reproduced more successfully; over many generations, this shifted the population's characteristics toward the larger, single-toed form seen in modern Equus. [3]	3
26.	In a biogas plant, biological waste (such as cattle dung, forming 'gobar gas') is fed into a sealed digester tank called a biogas plant. In this oxygen-free environment, a consortium of anaerobic bacteria, particularly methanogens, break down the complex organic matter in the slurry. Methanogens specifically require strictly anaerobic conditions to survive and metabolise this waste, ultimately producing a mixture of gases, chiefly methane (biogas), along with CO2, hydrogen sulfide and other gases, which can be used as a fuel for lighting, heating or cooking. [3]	3
27.	The ELISA test for HIV works on the principle of antigen-antibody interaction. It is designed to detect antibodies produced by the patient's immune system against HIV antigens; an enzyme-linked secondary antibody produces a measurable colour reaction if the patient's antibodies against HIV are present in the sample. Because the body begins producing detectable antibodies against HIV relatively early after infection, well before the immune system is sufficiently weakened to cause	3

	visible symptoms of AIDS, ELISA can identify infection at an early, asymptomatic stage. [3]	
28.	A. This data fits the logistic (sigmoid, S-shaped) growth model, where a population grows slowly at first, then rapidly, and finally slows and stabilises as it approaches the carrying capacity of its environment. B. The population stabilises around 480 because this represents the carrying capacity (K) of the lake for this species — the maximum population size the available resources (food, space, oxygen etc.) in the lake can sustainably support; beyond this point, limited resources restrict further growth. [3]	3

SECTION D		
29.	A. Family W illustrates a Y-linked (holandric) pattern of inheritance: since the Y chromosome passes only from father to son, a trait carried on it appears only in males, and an affected father passes it to every one of his sons but to none of his daughters. [1] B. (i) Family Y illustrates multiple alleles; the human ABO blood group system (with alleles I^A, I^B and i) is a well-known example of multiple allelism in humans. [1] (ii) In family X (incomplete dominance), crossing two heterozygotes (intermediate phenotype) is expected to give a 1:2:1 ratio of the two homozygous phenotypes to the heterozygous (intermediate) phenotype. [1] C. Family Z best illustrates X-linked recessive inheritance, since the trait affects both sons and daughters of an affected (carrier) mother, while an affected father passes the recessive allele only to his daughters (who become carriers on their second X chromosome) and not to his sons (who receive his Y chromosome instead). [1] OR D. If the mother is a carrier (heterozygous) for an X-linked recessive trait and the father is normal, on average half of her sons are expected to be affected, since sons receive one of the mother's two X chromosomes at random, and only the X carrying the recessive allele would result in an affected son (sons have only one X chromosome, so there is no masking by a dominant allele). [1]	4
30.	A. Insulin is primarily responsible for lowering blood glucose after the peak, and it is secreted by the beta cells of the islets of Langerhans in the pancreas. [1] B. Insulin lowers blood glucose by stimulating the uptake of glucose from the blood into body cells (particularly muscle and liver cells), promoting the conversion of glucose into glycogen for storage in the liver and muscles (glycogenesis), and inhibiting the breakdown of glycogen and the production of new glucose (gluconeogenesis) by the liver — together lowering blood glucose concentration back toward baseline. [2] C. Insulin secretion would be expected to rise sharply during the initial increase in blood glucose, since rising blood glucose directly stimulates the beta cells of the pancreas to release more insulin in response. [1] OR D. If the pancreas cannot respond adequately (insufficient insulin secretion or inadequate insulin action), the person may develop diabetes mellitus; in this case, the blood glucose graph would show a much higher and more prolonged peak after the meal, with a slower return towards baseline (or failure to return to baseline at all) compared to a healthy individual. [1]	4

SECTION E		
31.	A. Coding (sense) strand (5'→3'): ATGCTTGGACCA. Since mRNA has the same sequence as the	5

	coding strand (with U instead of T), the mRNA (5'→3') is: AUGCUUGGACCA. Codons and their corresponding tRNA anticodons: AUG (anticodon 3'-UAC-5'), CUU (anticodon 3'-GAA-5'), GGA (anticodon 3'-CCU-5'), CCA (anticodon 3'-GGU-5'). Degeneracy of the genetic code refers to the fact that most amino acids are specified by more than one codon (i.e. the code is not one codon per amino acid). For example, leucine can be coded for by CUU, CUC, CUA, CUG, UUA or UUG — six different codons, all specifying the same amino acid. [5] OR B. In semi-conservative replication, the two strands of the parental DNA double helix separate, and each strand acts as a template for synthesis of a new complementary strand; each resulting daughter DNA molecule therefore contains one original (parental) strand and one newly synthesised strand. In the Meselson-Stahl experiment, E. coli were first grown in a medium containing heavy nitrogen (^{15}N) so that all their DNA became labelled as 'heavy'. They were then transferred to a normal (^{14}N, 'light') medium and allowed to replicate. After one round of replication, all the DNA was of intermediate ('hybrid') density (one heavy and one light strand) rather than being either fully heavy or a 50:50 mixture of fully heavy and fully light molecules — a result expected only under the semi-conservative model, and inconsistent with conservative or dispersive models of replication. After a second round, DNA of both intermediate and fully light density was observed, in proportions again consistent specifically with the semi-conservative model. [5]	
32.	A. (i) A selectable marker (e.g. an antibiotic-resistance gene) allows identification of transformed cells, since only cells that have taken up the vector (and therefore the marker gene) will survive when grown on a medium containing the corresponding antibiotic; untransformed cells lacking the vector will not survive and can be eliminated. [2] (ii) Physical method: micro-injection (direct injection of DNA into the nucleus of an animal cell) or the gene gun/biolistics method (for plant cells). Chemical method: use of calcium chloride to make bacterial cell walls permeable to foreign DNA (or use of liposomes to deliver DNA). [1] (iii) A bioreactor provides a large-volume, controlled environment (optimal temperature, pH, substrate, oxygen and agitation) in which large numbers of genetically engineered cells can be grown to produce the desired protein on a commercial scale, far beyond what is possible in small laboratory flasks. A commonly used large-scale bioreactor design is the stirred-tank bioreactor. [2] OR B. (i) HindIII site: 5'-AAGCTT-3' / complementary strand: 3'-TTCGAA-5'. Reading the complementary strand 5'→3' gives AAGCTT again, identical to the original — confirming it is a palindromic sequence. [2] (ii) 'Sequence-specific' means the enzyme recognises and cuts DNA only at one particular nucleotide sequence (its recognition site), rather than cutting DNA randomly at any point; this precision allows genetic engineers to cut DNA at predictable, chosen locations to isolate genes or open up vectors cleanly. [1] (iii) Because HindIII generates the same short, complementary single-stranded overhangs (sticky ends) on both the excised gene fragment and the cut vector, these overhangs can base-pair specifically with each other in only the correct orientation, and DNA ligase then seals the joins — ensuring the fragment is inserted correctly rather than randomly or backwards. [2]	5
33.	A. (i) Predation can maintain diversity by preventing a single competitively dominant prey species from monopolising resources, allowing other, weaker competitor prey species to persist — e.g. a predatory starfish keeping mussel populations in check on a rocky shore, allowing many other species to coexist in the space that would otherwise be dominated by mussels. (ii) In commensalism, one species benefits while the other is neither helped nor harmed; e.g. an orchid growing as an epiphyte on a large tree branch benefits from physical support and sunlight exposure, while the tree itself is unaffected.	5

	(iii) Mutualism involves an obligatory, mutually beneficial relationship; e.g. the fig tree and its specific pollinating wasp, where the wasp cannot reproduce without the fig, and the fig cannot be pollinated without the wasp. (iv) Parasitism generally harms host fitness (e.g. reducing growth, reproduction or health) but usually does not kill the host outright, since a parasite typically depends on the host remaining alive to continue obtaining nutrition; e.g. tapeworms living in the intestine of a host, absorbing nutrients but generally not immediately killing the host. [5, distributed across the four points] OR B. (i) In a pond food chain (phytoplankton → zooplankton → small fish → large fish), only a fraction of the energy present at each trophic level is transferred to the next, since a large proportion is lost as heat during metabolic processes (respiration) at every transfer; this progressive, unrecoverable loss of usable energy at each step illustrates the Second Law of Thermodynamics. (ii) All the high-diversity regions (Brazil, Colombia, Indonesia) lie within or close to the tropics. Two reasons for the greater reptile diversity there: tropical regions provide warmer, more stable temperatures year-round that favour ectothermic reptiles' metabolism and activity; and these regions have experienced longer, uninterrupted periods of evolutionary time (less affected by ice ages), allowing greater speciation and niche diversification to accumulate. [5]	