

ISC Class 12 Biology Specimen Paper 2

Written by the Future Topper subject team on the CISCE examination pattern. Not an official CISCE paper.
Found a mistake? Write to contactfuturetopper@gmail.com

Maximum Marks: 70 | Time Allowed: Three hours | Reading Time: 15 minutes

Paper 1 (Theory) carries 70 marks. Sections A and B are compulsory. Attempt any three questions from Section C.

General Instructions

Write your answers on the separate answer paper provided. The first 15 minutes are for reading the paper, and you may not write during that time. Section A and Section B are compulsory, and from Section C you must attempt any three of the four questions. Marks for each question, or part of a question, are shown in brackets. No diagrams are printed in this paper. Where a question asks you to draw and label a structure you are expected to draw it yourself in pencil, draw it large enough to be read, and label it with straight lines that do not cross one another. Scientific names must be written in the correct form, with the genus beginning with a capital letter. All working for numerical questions must be shown on the same sheet as the answer. This paper carries 70 of the 100 marks for the subject, the remaining 30 being for the practical work, the project and the practical file.

SECTION A (14 Marks)

Attempt all parts of Question 1.

Question 1 [14]

Each part carries 1 mark. For the parts that offer four choices, write only the option you choose. For the rest, answer in a single sentence or give the single word, name or value asked for.

- (i) The number of nuclei present in a mature embryo sac of the Polygonum type is:
(a) three (b) seven
(c) eight (d) sixteen
- (ii) Name the part of the seed of a grain of maize which stores the food, and give its ploidy.
- (iii) Spermatogenesis in the human testis is directly stimulated by:
(a) oxytocin (b) follicle stimulating hormone
(c) prolactin (d) relaxin
- (iv) Name the hormone which is detected in the urine in the common test for pregnancy.
- (v) A plant of the genotype TtRr is crossed with a plant of the genotype ttrr, the two genes assorting independently. The phenotypic ratio of the offspring is:
(a) 9 : 3 : 3 : 1 (b) 3 : 1
(c) 1 : 1 : 1 : 1 (d) 1 : 2 : 1
- (vi) Name the pattern of inheritance in which an allele is carried on the X chromosome, and give one human disorder inherited in this way.
- (vii) The fossil bird which carried both reptilian and avian characters is:
(a) Archaeopteryx (b) Dryopithecus
(c) Ichthyosaurus (d) Australopithecus
- (viii) Name the cells of the human immune system which the human immunodeficiency virus chiefly attacks.
- (ix) The clot busting drug obtained by recombinant DNA technology and used in the treatment of myocardial infarction is:
(a) interferon (b) streptokinase
(c) cyclosporin A (d) penicillin

- (x) Name the free floating aquatic fern which fixes nitrogen and is used as a biofertiliser in paddy fields.
- (xi) In the cloning of a gene, the enzyme used to seal the foreign DNA into the opened vector is:
(a) a restriction endonuclease (b) DNA ligase
(c) alkaline phosphatase (d) exonuclease III
- (xii) Name the technique used to separate fragments of DNA of different lengths in the laboratory.
- (xiii) The sequence in which the links of a grazing food chain are arranged, beginning at the producer, is:
(a) primary consumer, producer, secondary consumer (b) producer, secondary consumer, primary consumer
(c) secondary consumer, producer, primary consumer (d) producer, primary consumer, secondary consumer
- (xiv) Give the term for the richness of species found in a given area, and name the kind of biodiversity it measures.

SECTION B (26 Marks)

Attempt all parts of Question 2. Each part carries 2 marks.

Question 2 [26]

- (i) Draw and label a diagram of a mature pollen grain of a dicotyledonous plant, showing the exine, the intine, the germ pore, the generative cell and the vegetative cell. [2]
- (ii) Explain how a bisexual flower may avoid self pollination through dichogamy and through self incompatibility. [2]
- (iii) Explain what parthenocarpy is and name one fruit in which it is turned to commercial use. [2]
- (iv) Distinguish between the primary and the secondary oocyte in the human ovary, and state the stage at which the secondary oocyte completes its second meiotic division. [2]
- (v) In the snapdragon, *Antirrhinum*, the cross between a red flowered plant and a white flowered plant gives only pink flowered offspring. Name the kind of inheritance shown, and give the phenotypic ratio expected when two of these pink flowered plants are crossed together. [2]
- (vi) A woman who carries the allele for haemophilia, but does not suffer from the disease, marries a man who is not haemophilic. Work out the fraction of their sons expected to be haemophilic and state whether any of their daughters will suffer from the disease. [2]
- (vii) Explain what is meant by adaptive radiation, and give one example from the work of Darwin. [2]
- (viii) Distinguish between active and passive immunity, giving one example of each. [2]
- (ix) Name the two serious diseases caused by tobacco smoking and name the substance in tobacco which makes the habit addictive. [2]
- (x) Explain what single cell protein is and name one organism grown for this purpose. [2]
- (xi) Explain why the gene for beta galactosidase is used as a selectable marker in place of a second antibiotic resistance gene, and state what is seen on the plate when it is used. [2]
- (xii) A population of fish in a pond numbers 8000 at the beginning of a year. During that year 320 young fish are added and 160 fish die, and there is no migration. Calculate the birth rate, the death rate and the intrinsic rate of natural increase for the population. [2]
- (xiii) Distinguish between the alpha and the beta component of biodiversity, and state which of the two is measured by species richness within a single community. [2]

SECTION C (30 Marks)

Attempt any three questions from this Section. Each question carries 10 marks.

Question 3 [10]

- (a) Draw and label a diagram of a vertical section of a human seminiferous tubule as seen under the microscope, showing the spermatogonia, the Sertoli cells, the spermatids, the lumen and the interstitial cells outside the tubule. [3]
- (b) Trace the development of the human zygote from fertilisation to implantation, naming the stages formed and the two cell masses of the blastocyst with the fate of each. [3]
- (c) (1) Name the structure through which the foetus draws its nourishment from the mother and state two substances which pass across it to the foetus. (2) Name two hormones secreted by the placenta. (3) State the function of the amniotic fluid. (4) Explain what MTP is and state the period of pregnancy within which it is held to be relatively safe. [4]

Question 4 [10]

- (a) A couple who both have normal colour vision have a son who is colour blind. Work out the genotype of each parent, explain how the son came to be colour blind and state the probability that a daughter of theirs will be colour blind. [3]
- (b) A man of blood group A is married to a woman of blood group B, and their first child is of blood group O. Work out the genotype of each parent and give the blood groups possible among their further children with the ratio in which they are expected. [3]
- (c) (1) Name the disorder in which a man has the chromosome complement 47, XXY, and give two of its features. (2) Name the disorder in which a woman has the complement 45, X, and give two of its features. (3) Name the event in meiosis which gives rise to both complements. (4) Explain why sickle cell anaemia is described as a point mutation, naming the amino acid substituted and the amino acid which replaces it. [4]

Question 5 [10]

- (a) Explain what is meant by an antibiotic, name the first antibiotic discovered with the organism which yields it and the scientist who found it, and state why an antibiotic is of no use against a viral infection. [3]
- (b) Explain the three steps of plant tissue culture by which a large number of identical plants may be raised from a small piece of tissue, and give the term for a plant raised in this way. [3]
- (c) (1) Explain what is meant by a transgenic animal and give one example with the purpose it serves. (2) Explain what gene therapy sets out to do. (3) Name the enzyme used in the polymerase chain reaction and state the organism from which it is obtained. (4) Explain what the Bt toxin is and why it does no harm to the plant which makes it. [4]

Question 6 [10]

- (a) Define a population, a community and an ecosystem, and give one example of each from a pond. [3]
- (b) Explain what biomagnification is, naming one substance which shows it, and describe the effect it has had on fish eating birds. [3]
- (c) (1) Explain what a biodiversity hot spot is and name one such hot spot in India. (2) Distinguish between in situ and ex situ conservation, giving one example of each. (3) Explain what eutrophication is and state its effect on the fish of a lake. [4]

ANSWER KEY AND MARKING SCHEME

Full working is given for every numerical. Marks shown in italics are the step marks an examiner would award. Accept any correct alternative wording which carries the same biology, accept a correctly drawn and labelled diagram in any reasonable style, and accept a scientific name written without underlining provided the genus carries a capital letter.

Question 1 [14]

- (i) (c) eight. The three divisions of the functional megaspore give eight nuclei, which are arranged as the egg cell with two synergids at the micropylar end, three antipodal cells at the chalazal end and two polar nuclei in the central cell. The sac is seven celled but eight nucleate.

Correct option 1.

- (ii) The endosperm, and it is triploid, having been formed from the primary endosperm nucleus which arose by the fusion of one male gamete with the two polar nuclei.

Endosperm named as triploid 1.

- (iii) (b) follicle stimulating hormone. It acts on the Sertoli cells of the seminiferous tubules, which in turn support the developing sperm.

Correct option 1.

- (iv) Human chorionic gonadotropin, often written as hCG, which is secreted by the developing placenta and appears in the urine of a pregnant woman.

Correct answer 1.

- (v) (c) 1 : 1 : 1 : 1. The heterozygous parent gives four kinds of gamete in equal numbers while the double recessive parent gives only one, so the four classes of offspring are equal. This is the dihybrid test cross.

Correct option 1.

- (vi) X linked inheritance, also called sex linked inheritance. Haemophilia is a human disorder inherited in this way, and colour blindness and Duchenne muscular dystrophy are also accepted.

Pattern named with one correct disorder 1.

- (vii) (a) Archaeopteryx. It carried feathers and wings like a bird together with teeth in the jaws and a long bony tail like a reptile, so it is treated as a connecting link.

Correct option 1.

- (viii) The helper T lymphocytes, that is the CD4 bearing T cells. Macrophages are also invaded.

Correct answer 1.

- (ix) (b) streptokinase. It is obtained from Streptococcus and is modified by genetic engineering for use as a clot buster.

Correct option 1.

- (x) Azolla, which carries the nitrogen fixing cyanobacterium Anabaena azollae in its leaf cavities.

Correct answer 1.

- (xi) (b) DNA ligase. It seals the nicks in the sugar phosphate backbone and so joins the insert to the vector to give the recombinant molecule.

Correct option 1.

- (xii) Gel electrophoresis, usually carried out in agarose, in which the negatively charged fragments move towards the anode and the smaller ones travel further.

Correct answer 1.

- (xiii) (d) producer, primary consumer, secondary consumer. A grazing food chain begins with the living producer and energy passes from it to the herbivore and then to the carnivore.

Correct option 1.

- (xiv) Species richness, which measures species diversity, that is the diversity at the level of the species within a given area or community.

Term given with species diversity named 1.

Question 2 [26]

- (i) The drawing should show a rounded or oval grain with two coats. The outer coat, the exine, is thick and hard, made of sporopollenin and often sculptured, and it should be shown interrupted at one point by a thin circular region, the germ pore, through which the pollen tube later comes out. Inside it lies the intine, a thin delicate layer of cellulose and pectin. Within the intine are the two cells of the two celled grain, the larger vegetative cell, which is round with abundant food and a large irregular nucleus, and the small spindle shaped generative cell lying against it. All five labels asked for must be shown.

Exine with the germ pore, and the intine within it 1. Vegetative cell and generative cell correctly drawn and labelled 1.

- (ii) In dichogamy the anthers and the stigma of the same flower mature at different times, so that pollen is shed before the stigma of that flower is receptive, or the stigma becomes receptive and withers before the anthers of its own flower open. The two sexes are therefore never ready together in one flower and self pollination is avoided in time. In self incompatibility the flower is capable of being self pollinated, and the pollen may well land on its own stigma, but a genetic mechanism prevents the pollen of a plant from germinating on the stigma of that same plant, or stops the pollen tube from growing down the style to the ovule. Fertilisation therefore fails, and only pollen from another plant can succeed.

Dichogamy explained as a difference in the time of maturing 1. Self incompatibility explained as a genetic block to the pollen of the same plant 1.

- (iii) Parthenocarpy is the development of a fruit from the ovary without fertilisation, so that the fruit formed carries no seed. It may occur naturally or be induced by spraying the flower with a growth hormone such as a gibberellin or an auxin. The banana is the standard commercial example, and seedless grapes, pineapple and some varieties of orange are also accepted. The seedless fruit is valued because it is easier to eat and to process.

Parthenocarpy defined as fruit set without fertilisation, giving a seedless fruit 1. One correct commercial example 1.

- (iv) The primary oocyte is the cell formed in the foetal ovary from the oogonium. It enters the prophase of the first meiotic division and is then held there, so that it is still a diploid cell, arrested in meiosis I, and it waits in the primary follicle for years until the follicle is recruited. The secondary oocyte is the larger of the two unequal cells produced when the primary oocyte at last completes the first meiotic division just before ovulation. It is haploid, it holds almost all the cytoplasm, the other product being the small first polar body, and it at once enters the second meiotic division. The secondary oocyte completes that second division only when a sperm has entered it, that is at fertilisation, and the second polar body is given off at the same time.

Primary oocyte described as diploid and arrested in prophase I 1. Secondary oocyte as haploid, with the second division completed at fertilisation 1.

- (v) The inheritance is incomplete dominance. Neither allele is fully dominant over the other, so the heterozygote is intermediate in appearance between the two homozygotes, and the pink flower is the heterozygote. Writing the red allele as R and the white allele as r, the parents were RR and rr and every offspring was Rr, which is pink. When two pink plants are crossed, Rr x Rr, the gametes R and r meet at random to give RR, Rr, Rr and rr in equal numbers. RR is red, Rr is pink and rr is white, so the phenotypic ratio is 1 red : 2 pink : 1 white. The genotypic ratio is 1 : 2 : 1 as well, and here the two ratios are the same because each genotype has a phenotype of its own.

Incomplete dominance named, with the heterozygote as the intermediate 1. Phenotypic ratio 1 red : 2 pink : 1 white 1.

- (vi) The allele for haemophilia is recessive and is carried on the X chromosome. The woman is a carrier, so her genotype is $X^H X^h$, and the man is unaffected, so his genotype is $X^H Y$. The mother gives either X^H or X^h , and the father gives either X^H or Y. The children are therefore $X^H X^H$, a normal daughter, $X^H Y$, a normal son, $X^H X^h$, a carrier daughter, and $X^h Y$, a haemophilic son, all in equal numbers. Among the sons there is one normal and one haemophilic, so half of the sons are expected to be haemophilic, which is one quarter of all the children. No daughter will suffer from the disease. A daughter must receive X^h from both parents to be affected, and the father has no X^h to give, so every daughter receives his normal X^H and is at worst a carrier.

Parents written correctly as $X^H X^h$ and $X^H Y$, with half the sons affected 1. No daughter affected, because the father passes his normal X to every daughter 1.

- (vii) Adaptive radiation is the process in which a single ancestral species, having reached a new area with a range of unoccupied habitats, gives rise over time to a number of descendant species which differ in their structure and habits because each has been fitted to a different way of life in that area. The classic example is the finches of the Galapagos Islands, which Darwin studied. From one seed eating ground dwelling ancestor which reached the islands from the mainland there arose a whole set of species whose beaks differ widely, some suited to crushing seeds, some to taking insects and some to feeding on cactus, each beak matching the food available to it. The marsupials of Australia are a further example.

Adaptive radiation defined as divergence from one ancestor into different habitats 1. Darwin's finches named with the beaks as the character which diverged 1.

- (viii) In active immunity the body of the host is itself made to produce the antibodies, because it has been exposed to an antigen, either as a natural infection from which the person recovers or as a vaccine, which carries the inactivated or weakened pathogen or its antigen. Active immunity takes time to appear, since the antibodies must be made, but it is long lasting because memory cells are left behind. Immunity to measles after an attack of measles, or after vaccination against it, is an example. In passive immunity ready made antibodies are given to the host from outside, so the host's own immune system is not called upon. Protection is immediate, which is why this route is used in an emergency, but it is short lived and leaves no memory. The antibodies which pass from the mother to the foetus across the placenta, and those in the colostrum of the first milk, are the natural example, and the antitetanus serum given after a wound is the artificial one.

Active immunity defined with a correct example 1. Passive immunity defined with a correct example 1.

- (ix) Smoking causes lung cancer and emphysema, a condition in which the walls of the alveoli are destroyed so that the surface available for exchange of gases is greatly reduced and the person is left breathless. Cancer of the throat and of the urinary bladder, chronic bronchitis and coronary heart disease are also accepted. The substance which makes the habit addictive is nicotine, an alkaloid which stimulates the adrenal glands to release adrenaline and noradrenaline and so acts on the reward pathway of the brain.

Two correct diseases 1. Nicotine named as the addictive substance 1.

- (x) Single cell protein is protein obtained from the biomass of microorganisms, chiefly bacteria, yeasts, filamentous fungi and algae, which are grown in large quantity on a cheap substrate and then harvested, dried and used as food or as animal feed. The attraction is the speed with which microorganisms multiply and the very large yield of protein from a small mass of starting culture, so that far less land and water are needed than for the same protein from a crop or an animal. Organisms grown for this purpose include the blue green alga Spirulina, which is cultivated on waste water and on molasses, the filamentous fungus Methylophilus methylotrophus, and the yeast Saccharomyces cerevisiae.

Single cell protein defined as microbial biomass used as food or feed 1. One correct organism named 1.

- (xi) Both kinds of marker tell the worker which colonies carry the recombinant plasmid, but with a second antibiotic resistance gene the recombinants have to be found by insertional inactivation, which means the whole set of transformed colonies must first be grown on one plate and then transferred to a second plate carrying the antibiotic and compared colony by colony. That is slow and laborious. The beta galactosidase gene removes that step. The foreign DNA is inserted inside the gene, so in a recombinant the gene is broken and no enzyme is made, while in a plasmid which took up no insert the gene is intact and the enzyme is made. The cells are grown on a medium holding a chromogenic substrate of the enzyme. The colonies which carry no insert produce the enzyme, break the substrate down and turn blue, while the recombinant colonies cannot break it down and stay white. The white colonies are the ones wanted, and they are picked out from a single plate by eye.

The second antibiotic marker needs insertional inactivation on two plates, which is laborious 1. Blue colonies without the insert and white recombinant colonies on a single plate 1.

- (xii) Birth rate = number of births/number in the population at the start = $320/8000 = 0.04$ per individual per year.
Death rate = $160/8000 = 0.02$ per individual per year. Since no individual enters or leaves the pond, the intrinsic rate of natural increase $r = \text{birth rate} - \text{death rate} = 0.04 - 0.02 = 0.02$ per individual per year. The value is positive, so the population is growing, by 160 fish over the year.

Birth rate 0.04 and death rate 0.02 1. Intrinsic rate of natural increase 0.02 1.

- (xiii) Alpha diversity is the diversity found within a single community or habitat, counted as the number of species present there together with how evenly the individuals are spread among those species. Beta diversity is the diversity between communities, that is the extent to which the species present change as one passes from one community or habitat to the next along a gradient, so it measures the turnover of species rather than the number in any one place. Species richness within a single community measures alpha diversity.

Alpha and beta diversity correctly distinguished 1. Alpha named as the one measured by richness within a community 1.

Question 3 [10]

- (a) The section should be drawn as a thick walled tube cut across or lengthwise, with a clear central space, the lumen. The wall should be shown several cells deep. Resting on the basement membrane at the outside of the wall are the spermatogonia, drawn as rounded cells with large nuclei. Lying among them and running from the basement membrane towards the lumen are the tall Sertoli cells, which should be drawn as elongated cells whose inner ends reach the lumen and to which the developing cells are attached. Between the spermatogonia and the lumen the stages in order are the primary spermatocytes, the secondary spermatocytes and then the spermatids, the spermatids being drawn as small cells close to the lumen, with the tails of the maturing sperm shown projecting into it. Outside the tubule, in the angular spaces between neighbouring tubules, the interstitial cells, or Leydig cells, should be drawn in small groups along with a blood capillary. All five labels asked for must be shown.

Tube with the lumen and the spermatogonia on the basement membrane 1. Sertoli cells drawn running towards the lumen with the spermatids near it 1. Interstitial cells drawn outside the tubule, and all five labels given 1.

- (b) Fertilisation takes place in the ampullary region of the fallopian tube, where the sperm and the ovum fuse to give the diploid zygote. The zygote begins to divide by mitosis as it is moved down the tube towards the uterus, and these first divisions are the cleavage divisions, which add cells without adding to the total size. Two cells become four, then eight, then sixteen, and the solid ball of eight to sixteen cells is the morula. The morula continues to divide and a fluid filled cavity appears within it, so that it becomes the blastocyst. The blastocyst carries two distinct cell masses. The outer layer of cells is the trophoblast, which attaches to the lining of the uterus and goes on to form the embryonic membranes and the foetal part of the placenta. The inner group of cells attached to one side of the trophoblast is the inner cell mass, and it is this which becomes the embryo proper. The trophoblast then sinks into the endometrium, which grows over the blastocyst and encloses it, and this embedding of the blastocyst in the uterine wall is implantation. The embryo is now within the uterine lining and pregnancy has begun.

Zygote formed in the ampulla, cleaving to the morula 1. Blastocyst formed, with trophoblast and inner cell mass named 1. Fate of each mass given, and implantation described as the embedding of the blastocyst in the endometrium 1.

- (c) (1) The placenta, a structural and functional connection between the foetus and the uterine wall of the mother. Oxygen, glucose, amino acids, water, mineral ions and antibodies pass across it from the mother to the foetus, and carbon dioxide and the nitrogenous wastes of the foetus pass the other way. Any two of the substances passing to the foetus are accepted. (2) Human chorionic gonadotropin and human placental lactogen. Oestrogens, progesterones and relaxin are also accepted. (3) The amniotic fluid fills the amniotic cavity and surrounds the foetus. It acts as a shock absorber, so that a blow or a jolt to the mother is not carried to the foetus, it keeps the temperature around the foetus even, it stops the foetal membranes from sticking to the growing foetus and it allows the foetus to move freely, which is needed for the muscles and the joints to develop properly. (4) MTP stands for medical termination of pregnancy, the deliberate ending of a pregnancy before the foetus is able to survive outside the uterus. It is held to be relatively safe during the first trimester, that is up to twelve weeks of pregnancy, and the risk rises considerably once the second trimester has begun.

Placenta named with two substances passing to the foetus 1. Two placental hormones 1. Function of the amniotic fluid 1. Full form of MTP with the first trimester named 1.

Question 4 [10]

- (a) Colour blindness is due to a recessive allele on the X chromosome. Write the normal allele as X^C and the allele for colour blindness as X^c . The son is colour blind, so he is X^cY . A son receives his Y from his father and his single X from his mother, so the X^c must have come from the mother. The mother has normal vision, so she cannot be X^cX^c , and she must therefore be the heterozygous carrier X^CX^c . The father has normal vision and gave the Y, so he is X^CY . The son came to be colour blind because he received the X carrying the defective allele from his carrier mother, and having only one X he had no second normal allele to mask it, while his sisters who received the same X also received a normal X from the father and are not affected. The probability that a daughter of this couple will be colour blind is zero. A daughter must carry X^c on both her X chromosomes, and one of those must come from the father, who has only X^C to give. Half of the daughters are expected to be carriers.

Mother identified as the carrier X^CX^c and the father as X^CY 1. The son explained as having received X^c from the mother, with no second X to mask it 1. Probability of a colour blind daughter given as zero, with the reason 1.

- (b) The ABO blood groups are governed by three alleles of one gene, I^A , I^B and i . I^A and I^B are each dominant over i , and are codominant with one another. A child of group O is ii , so it must have received an i from each parent. The father is of group A and carries an i , so he is I^Ai , and the mother is of group B and carries an i , so she is I^Bi . The father gives either I^A or i and the mother gives either I^B or i , so the children are I^AI^B , I^Ai , I^Bi and ii in equal numbers. I^AI^B is group AB, because the two alleles are codominant and both antigens appear, I^Ai is group A, I^Bi is group B and ii is group O. All four groups are therefore possible among the further children, in the ratio 1 AB : 1 A : 1 B : 1 O, that is a one in four chance of each.

Father I^Ai and mother I^Bi , deduced from the group O child 1. The four offspring genotypes written out 1. All four blood groups possible in the ratio 1 : 1 : 1 : 1 1.

- (c) (1) Klinefelter's syndrome. The person is male in appearance but has an extra X, so there are 47 chromosomes with the sex complement XXY. The features are feminine development in the male, such as the growth of the breasts, together with sparse body hair, a tall build with long limbs, small testes and sterility. (2) Turner's syndrome. The person is female with only one X and no second sex chromosome, so there are 45 chromosomes in all. The features are a short stature, a webbed neck, ovaries which do not develop so that the person is sterile, and the absence of the secondary sexual characters at puberty. (3) Both arise from the failure of a pair of chromosomes, here the sex chromosomes, to separate at anaphase of meiosis, so that one gamete receives both members of the pair and the other receives neither. This failure is non disjunction. (4) Sickle cell anaemia is called a point mutation because the whole disorder follows from the change of a single base pair at one position in the gene for the beta chain of haemoglobin. The sixth codon of the chain is altered, so that the amino acid glutamic acid, which the normal gene puts at the sixth position, is replaced by valine. Valine is non polar where glutamic acid was charged, and this one substitution in a chain of 146 amino acids makes the haemoglobin molecules stack together when the oxygen tension falls, which pulls the red cell out of shape into the sickle form.

Klinefelter's syndrome named with two features 1. Turner's syndrome named with two features 1. Non disjunction named 1. Point mutation explained with glutamic acid replaced by valine 1.

Question 5 [10]

- (a) An antibiotic is a chemical substance produced by one microorganism, usually a fungus or a bacterium, which in low concentration kills or stops the growth of another microorganism, and which can be used in the body of a patient without serious harm to the patient. The first antibiotic discovered was penicillin, which is obtained from the mould *Penicillium notatum*, and it was found by Alexander Fleming, who noticed that a stray growth of the mould on one of his culture plates had cleared the bacteria from the area around it. Ernst Chain and Howard Florey afterwards established its value as a drug. An antibiotic is of no use against a viral infection because an antibiotic works by attacking a structure or a process which belongs to a cell, such as the building of the bacterial cell wall, bacterial protein synthesis on the bacterial ribosome, or the bacterial enzymes which copy DNA. A virus is not a cell. It has no wall, no ribosomes and no metabolism of its own, and it multiplies by using the machinery of the host cell, so there is nothing for the antibiotic to act upon.

*Antibiotic defined as a microbial product which inhibits or kills other microorganisms 1. Penicillin named with *Penicillium notatum* and Alexander Fleming 1. No effect on viruses, because a virus has no cellular machinery for the drug to attack 1.*

- (b) The first step is to take the explant, a small piece of tissue cut from any part of the plant, and to sterilise its surface so that no fungus or bacterium is carried in with it. The second step is to place the explant on a nutrient medium in sterile conditions. The medium holds a carbon source such as sucrose, inorganic salts, vitamins, amino acids and the growth regulators, and the proportion of auxin to cytokinin in it is what decides what the tissue does. The cells divide to give an undifferentiated mass, the callus. The third step is to transfer pieces of the callus to media whose hormone balance has been changed, first to one which makes the callus throw out shoots and then to one which makes those shoots strike roots, so that complete plantlets are formed. The plantlets are then hardened and moved to soil. Because every plantlet has come by mitosis from the cells of one parent plant, all of them are genetically identical with that plant and with one another. The whole method is micropropagation, and a plant raised in this way is called a somaclone.

Sterilised explant taken 1. Culture on a nutrient medium with growth regulators to give the callus 1. Shoots and roots induced by changing the hormone balance, and the product named as a somaclone 1.

- (c) (1) A transgenic animal is an animal into whose genome a gene from another species has been deliberately introduced, so that the gene is present in its cells and is passed to its offspring. The transgenic sheep Tracy, which was made to secrete the human protein alpha-1-antitrypsin in its milk, is an example, the purpose being to obtain a human therapeutic protein in quantity. Transgenic mice carrying a human gene, used to study a human disease and to test the safety of a vaccine, and transgenic cows giving milk richer in human lactalbumin are also accepted. (2) Gene therapy sets out to correct a disorder caused by a faulty or missing gene by putting a functional copy of that gene into the cells of the patient, so that the protein which the patient could not make is made and the cause of the disease is removed rather than its symptoms relieved. The first such attempt was made on a child suffering from adenosine deaminase deficiency. (3) The enzyme is Taq polymerase, a thermostable DNA polymerase obtained from the bacterium *Thermus aquaticus*, which lives in hot springs. Its value is that it survives the high temperature at which the two strands of the DNA are separated in each cycle, so fresh enzyme need not be added. (4) The Bt toxin is a protein coded for by the cry genes of the soil bacterium *Bacillus thuringiensis*, and the gene has been moved into crops such as cotton and maize. The bacterium stores the protein as an inactive crystal, which is why it is called a protoxin, and that is the form in which the plant holds it too. It does the plant no harm because it stays inactive. It becomes a toxin only in the gut of a susceptible insect, where the pH is strongly alkaline, and the alkali dissolves the crystal and converts it into the active form. The active toxin then binds to the lining of the midgut, makes pores in the cells, and the cells swell and burst, so the insect dies.

*Transgenic animal defined with one correct example and its purpose 1. Aim of gene therapy explained 1. Taq polymerase from *Thermus aquaticus* 1. Bt toxin as an inactive crystalline protoxin activated only by the alkaline insect gut 1.*

Question 6 [10]

- (a) A population is the group of individuals of one species which live together in a given area at a given time, share its resources and interbreed among themselves. All the Rohu fish of a pond form one population. A community is all the populations of all the different species, plants, animals and microorganisms together, which live in that same area and interact with one another. The fish, the frogs, the insects, the water plants, the plankton and the bacteria of the pond taken together form the community of the pond. An ecosystem is the community together with the non living surroundings with which it exchanges matter and energy, the two forming one working unit through which energy flows and nutrients are cycled. The whole pond, its water, its dissolved gases and salts, the mud of its bed and the sunlight falling on it, taken with every organism living in it, is the pond ecosystem.

Population defined with an example from the pond 1. Community defined with an example 1. Ecosystem defined as community plus the abiotic surroundings, with the pond as the example 1.

- (b) Biomagnification is the increase in the concentration of a substance at each successive trophic level of a food chain. It happens when the substance is not broken down by the body and is not excreted, but is instead stored in the tissues, commonly in the fat. Each organism takes in the substance held in the whole mass of food it eats over its lifetime and keeps nearly all of it, so the amount in its body comes to be far greater, in proportion to its own mass, than the amount in any single meal, and the organism at the top of the chain carries the heaviest load of all. The insecticide DDT is the standard example, and mercury is also accepted.

DDT washed into a lake may be present in the water at a very low concentration, yet it is taken up by the plankton, passed to the small fish which eat the plankton and on to the large fish, and the concentration rises at every step until in the fish eating birds it is thousands of times what it was in the water. In those birds the accumulated DDT disturbs the metabolism of calcium, so the shell laid down round the egg is too thin. The eggs break under the weight of the sitting bird before the chick can develop, breeding fails and the numbers of the bird fall steeply. The decline of fish eating birds of prey was traced to this cause.

Biomagnification defined as a rise in concentration along the food chain, with the reason that the substance is neither broken down nor excreted 1. DDT or mercury named with the rise along a named chain 1. Thinning of the egg shell through disturbed calcium metabolism, leading to breeding failure 1.

- (c) (1) A biodiversity hot spot is a region which holds a very large number of species, with a high proportion of them endemic, that is found nowhere else, and which is at the same time under serious threat of losing its habitat. Protecting such a region therefore saves a great many species for a comparatively small area conserved. The Western Ghats and Sri Lanka form one such hot spot in India, and the Eastern Himalayas, now treated with the Indo-Burma region, is another. (2) In situ conservation is the protection of a species where it lives, by setting aside and managing the whole habitat so that the species continues in its natural surroundings along with everything it depends on. National parks, wildlife sanctuaries, biosphere reserves and sacred groves are examples. Ex situ conservation is the protection of a species away from its natural home, the individuals, or their seeds, gametes or tissues, being kept and bred under human care. Zoological parks, botanical gardens, seed banks, gene banks and cryopreservation are examples, and the in vitro fertilisation and tissue culture of threatened species belong here too. (3) Eutrophication is the natural or accelerated enrichment of a body of water with nutrients, chiefly nitrates and phosphates, which reach it from sewage and from the fertiliser washed off farmland. The nutrients cause a heavy growth of algae at the surface, an algal bloom, which cuts off the light from the plants below. The algae then die in quantity and the decomposers which break them down use up the dissolved oxygen of the water. The fish, which need that oxygen, suffocate and die in large numbers, and the species which demand clean well oxygenated water are lost from the lake first.

Hot spot defined with endemism and threat, and one Indian hot spot named 1. In situ conservation with an example 1. Ex situ conservation with an example 1. Eutrophication explained through the algal bloom and the loss of dissolved oxygen, killing the fish 1.