

JURONG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 1

CANDIDATE
NAME

CLASS

BIOLOGY

8875/02

Paper 2 Core Paper

2 September 2015

Additional Materials: Answer Paper

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A

Answer **all** questions.

Section B

Answer any **one** question.

Circle the question number of the question attempted.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [] at the end of each question or part question.

For Examiner's Use	
Section A	
1	
2	
3	
4	
Section B	
5 / 6	
Total	

This document consists of **13** printed pages and **1** blank page.

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Section A

Answer **all** the questions in this section.

- 1 The plasma membrane of beetroot cells contains protein and phospholipids and has a porous nature. As a result, the membrane is selectively permeable.

Cyanide is a poison that inhibits cytochrome c oxidase involved in aerobic respiration.

Fig. 1.1 shows how cyanide concentration affects the uptake of chloride ions by beetroot cells. The rates of chloride ion uptake are given as percentages of those obtained in a control experiment with no cyanide.

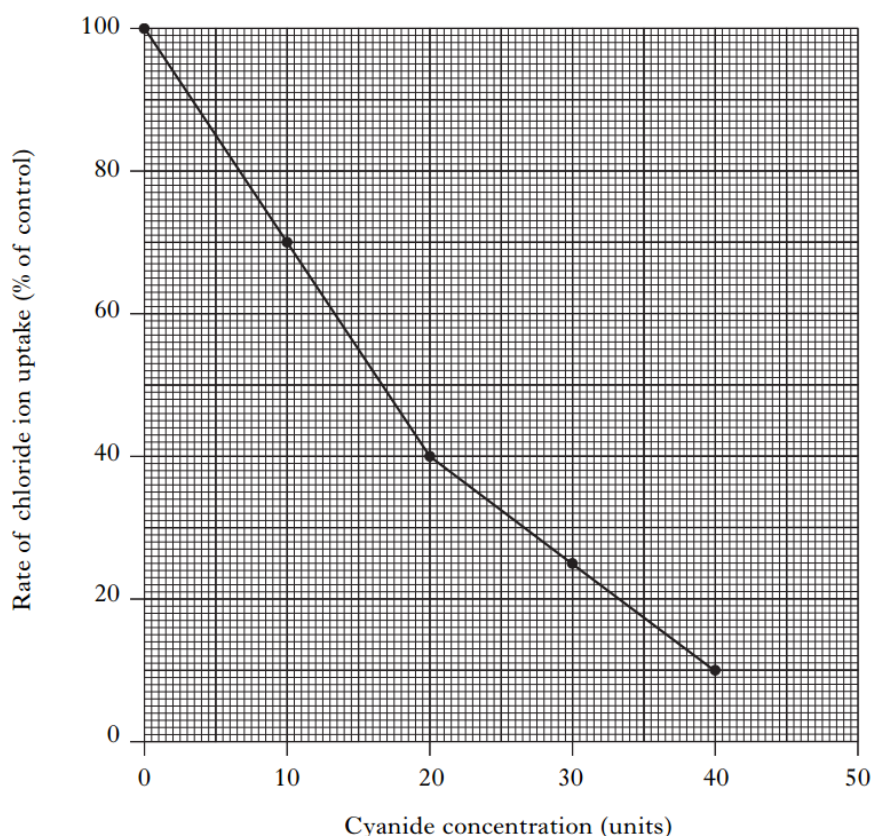


Fig. 1.1

- (a) It is known that the uptake of chloride ions requires the presence of transmembrane protein.

Describe how the membrane holds onto the transmembrane protein. [2]

1. The transmembrane protein is held in the membrane by weak hydrophobic interactions;;
2. Non-polar R groups of amino acid residues on protein form hydrophobic interactions with non-polar hydrocarbon tails of membrane phospholipid molecules;;

(b) With reference to Fig. 1.1,

(i) identify how chloride ions would be moved across the membrane, [1]

1. uptake occurs by active transport.

(ii) account for your answer in (b)(i). [3]

1. As cyanide concentration increases from 0 units to 40 units, rate of chloride ion uptake decreases from 100% of control to 10% of control;;
2. As cyanide concentration increases, rate of aerobic respiration decrease leading to decrease in (amount of) ATP synthesized;;
3. As ATP synthesis decreases, rate of chloride ion uptake decreases, indicating that ATP is required for the transport of Cl^- ;; (correlation)

Fig 1.2 shows the apparatus used in an investigation into the effects of varying substrate concentration on hexokinase, another enzyme of the aerobic respiration pathway, in the absence or presence of inhibitors.

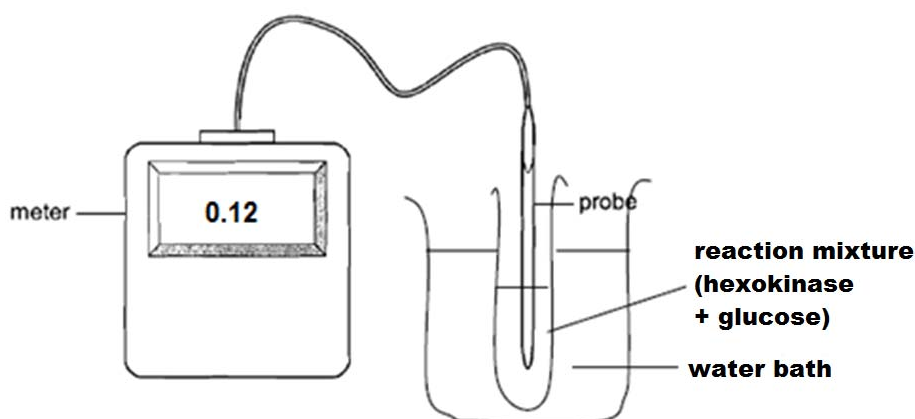


Fig. 1.2

Table 1.1 shows the results of the investigation; the greater the absorbance, the more active the enzyme.

Table 1.1

	absorbance / arbitrary units		
substrate concentration / %	absence of inhibitor	inhibitor X	inhibitor Y
0.1	0.12	0.03	0.06
0.25	0.17	0.06	0.06
0.5	0.21	0.14	0.06
1.0	0.36	0.30	0.06

(c) State a variable that must be kept constant for the investigation. [1]

1. Enzyme concentration / volume of substrate / temp / pH / any valid ans;;

(d) With reference to Table 1.1,

(i) describe the effect of substrate concentration on the activity of hexokinase, [1]

1. As substrate concentration increases from 0.1% to 1.0%, absorbance increases from 0.12 a.u to 0.36 a.u, activity of hexokinase increases;;

(ii) explain this effect. [2]

1. As substrate concentration increases (from 0.1% to 1.0%), more substrates are available for successful collision between enzymes and substrate;;

2. Increase in the frequency of successful collisions between the substrates and enzymes, increases the rate of formation of enzyme-substrate complexes and increases the activity of enzyme/rate of reaction/rate of formation of products;;

(e) (i) State the type of inhibition shown by inhibitor X. [1]

1. Competitive inhibition;;

(ii) Explain the results collected in the presence of inhibitor X. [3]

1. Inhibitor X is structurally similar to the substrate, inhibitor X competes with the substrate for binding at the active site of the enzyme;;

2. Competitive inhibition is reversible/not permanent and can be overcome by high substrate concentrations;;

3. At high substrate concentrations, substrates can out-compete the inhibitors for binding to the active site, and allow the maximum rate of reaction to be reached;;

4. substrate competes more successfully for active site, frequency of E-S collisions higher than E-I collisions, hence more E-S complexes than E-I complexes are formed, and this leads to a higher rate of reaction;;

(iii) Explain why the absorbance value remains at 0.06 au in the presence of inhibitor Y at all substrate concentrations. [1]

1. Binding of inhibitor Y/non-competitive inhibitor causes the cytochrome c oxidase to change shape such that its active site's conformation is altered and substrate can no longer bind to it. (Activity of enzymes remains low);;

[Total: 15]

- 2 Fig. 2.1 shows a normal mitochondrion and a mitochondrion with a structural defect due to lethal cell injury.

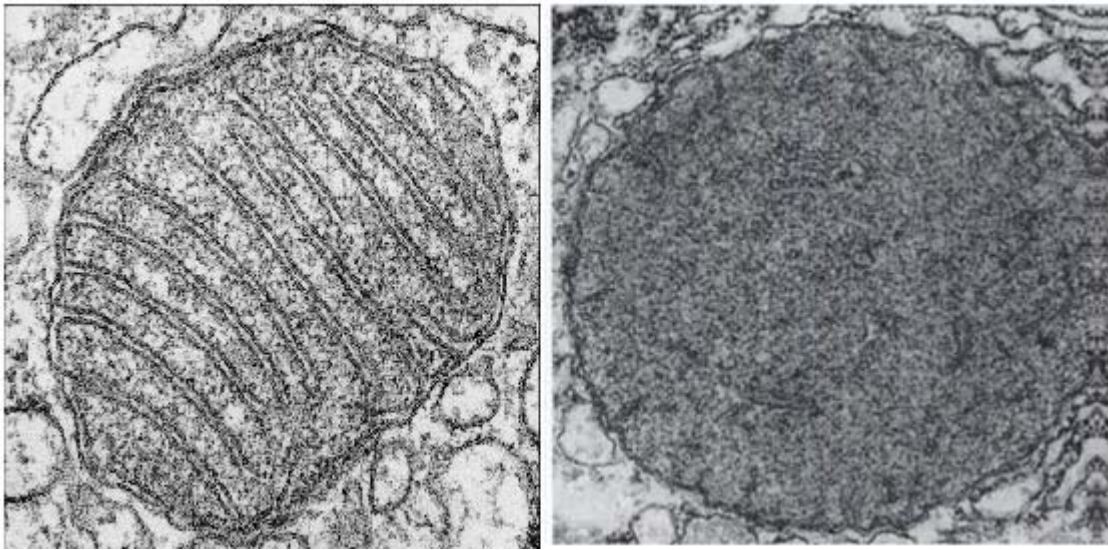


Fig. 2.1

(a) State the mitochondrial structural defect shown in Fig. 2.1. [1]

1. **Cristae loss/No inner membrane/No infolding of inner membrane;;**

(b) Explain the implications of this structural defect on

(i) glycolysis, [2]

1. **Presence of cytosol, glycolysis can still occur;;**
2. **glycolytic enzymes found in the cytosol are present;;**
3. **fermentation occurs to regenerate NAD for glycolysis;;**

(ii) oxidative phosphorylation. [2]

1. **Absence of cristae and therefore electron carriers of the electron transport chain (ETC) that are embedded on the cristae are absent;;**
 2. **There will be no electron flow along the ETC and no built up of proton gradient between the intermembrane space and mitochondrial matrix, oxidative phosphorylation cannot occur;;**
- Or**
3. **Stalked particles/ATP synthase that are embedded on the cristae are absent;;**
 4. **ATP synthesis by chemiosmosis / diffusion of H^+ down a concentration gradient from intermembrane space to matrix does not occur and oxidative phosphorylation cannot occur;;**

- (a) The metabolic pathway in which a hexose sugar, such as glucose, is broken down in respiration by cells starts with glycolysis. Fig. 2.2 outlines the key stages of glycolysis.

The enzymes responsible for catalyzing the first and last key steps, phosphofructokinase (PFK) and pyruvate kinase are the primary steps for allosteric enzyme regulation. PFK is allosterically inhibited by ATP, so glycolysis is slowed when cellular ATP concentrations are high.

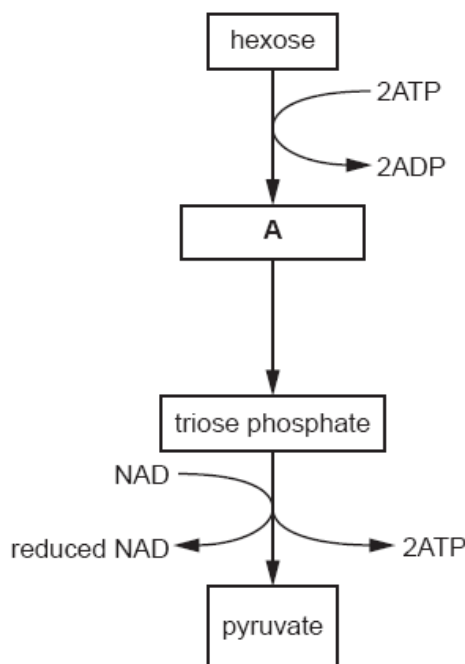


Fig. 2.2

- (i) Name substance A and suggest why hexose is converted to substance A. [2]

1. **Fructose-1,6-bisphosphate;;**
2. **This is a key step for regulation of glycolysis and determines the speed (rate) at which overall glycolysis proceeds;;**
3. **With 2 phosphate groups (on its opposite ends), the sugar is now ready to be split in half;;**

- (ii) Explain the role of NAD in aerobic respiration. [2]

1. **Act as a coenzyme (for dehydrogenase) and hydrogen atom / hydrogen ion and electron carrier and is reduced to NADH during glycolysis, link reaction and Krebs cycle in aerobic respiration;;**
2. **NADH carries electrons and protons / hydrogen atoms to electron transport chain at inner mitochondrial membrane to be used in oxidative phosphorylation;;**
3. **Leading to the regeneration of NAD for subsequent glycolysis, link reaction and Krebs cycle to proceed;;**

[Total: 9]

- 3 A type of pheasant occurs in a range of colours, especially when bred in captivity. It may, for example, have green or purple plumage.

Sometimes when a green male is crossed with a green female, all the male and female offspring are green. However, sometimes a green male crossed with a green female results in offspring in which the majority are green, but some of the females are purple, as shown in Table 3.1.

Table 3.1

phenotype	number of offspring
green male	7
green female	3
purple female	4

- (a) In birds, the sex chromosomes are referred to as W and Z. The W chromosome has no genes that affect plumage colour. The heterogametic sex is the female, **not** the male.

- (i) State which allele for colour of plumage is dominant. [1]

dominant allele: allele for green colour;;

- (ii) Use a genetic diagram to explain the results in Table 3.1. [3]

Parental phenotypes:	green	X	green	
Parental genotypes:	$Z^G Z^g$	X	$Z^G W$;;
Gametes	(Z^G)	(Z^g)	(Z^G)	(W) ;;
Offspring genotype :	$Z^G Z^G$:	$Z^G W$:
	$Z^G Z^g$;;
Offspring phenotype :	Green male	:	Green female	:
			Purple female	
Offspring phenotypic ratio :	2	:	1	:
			1	

In pheasant, another gene on the Z chromosome controls the rate of feather production. The allele for slow feather production, F, is dominant to the allele for rapid feather production, f.

(b) Explain why recessive, sex-linked characteristics are more common in female pheasant than in male pheasant. [1]

1. Sex-linked characteristics/features linked on the Z chromosome will only arise in the heterogametic (ZW) sex. When the recessive allele occurs in females, it expresses itself because the W chromosome does not/cannot carry any corresponding dominant allele;;
(females have one recessive allele)
2. males require the double recessive state for the condition to arise / need two recessive alleles / need to be homozygous recessive;;
3. males could be heterozygous / the effect of the recessive allele is masked by the dominant allele which occurs on the other Z chromosome;;

Note: Other answers must be in context of allele not chromosome or gene.

Fig. 3.1 shows the results produced from crosses carried out by a farmer.

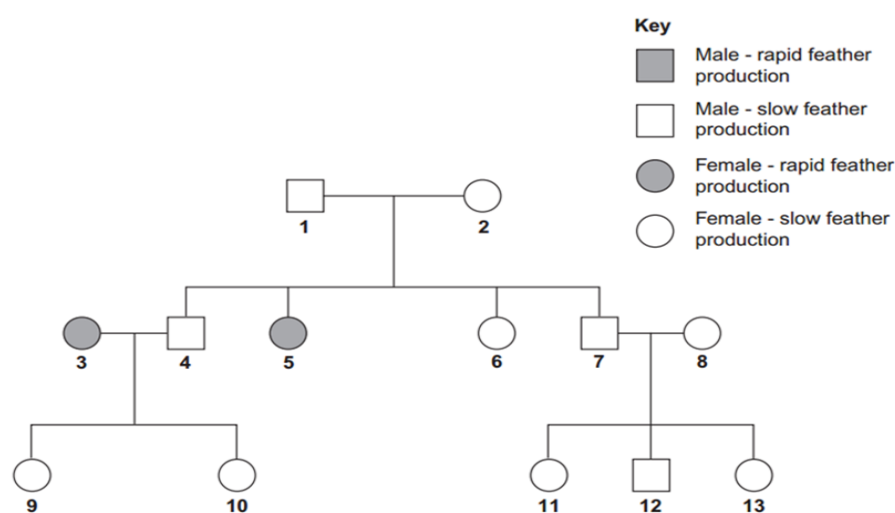


Fig. 3.1

(c) Explain one piece of evidence from Fig. 3.1 which shows that the allele for rapid feather production is recessive. [1]

1. 1 and 2 have slow feather production but produce one offspring (5) with rapid feather production;;
2. thus, 1 must be heterozygous (carrier) for the condition;;
3. (if slow feather production is recessive all offspring of (1 and 2) would be slow feather production / if rapid feather production was dominant 1 would have rapid feather production;;)

Reject: one of the parents (i.e. not specified) must be a carrier/heterozygous.

[Total: 6]

- 4 Fig. 4.1 shows the temperatures used at the different stages during part of the polymerase chain reaction (PCR), which is an automated process.

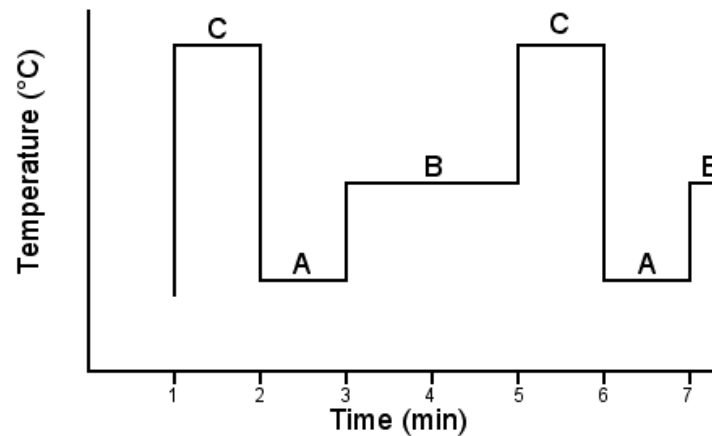


Fig. 4.1

(a) Describe what is happening at B and C. [4]

B:

1. primer extension by heating to 72°C;; (A) 60-75°C
2. Taq polymerase adds free nucleotides / dNTPs to 3' ends on both primers to synthesize rest of the fragment (new strands of DNA);;

C:

3. Denaturation by heating to 95°C;;
4. hydrogen bonds between double stranded DNA break, separating the double-stranded DNA into single stranded DNA;;

In Europe, the commonest mutation of the cystic fibrosis transmembrane conductance regulator (CFTR) gene is $\Delta F508$. Deletion of three base pairs results in the loss of one amino acid, phenylalanine, in the CFTR protein.

In genetic screening for this mutation, a fragment of DNA including the site of the deletion is cut out of the gene.

The fragment is 100 base pairs (bp) long when cut out of the normal allele and 97 bp long when cut from the mutant allele. The different fragments are separated by gel electrophoresis.

The results of genetic screening for $\Delta F508$ of three individuals, **A**, **B** and **C**, are shown in Fig. 4.2.

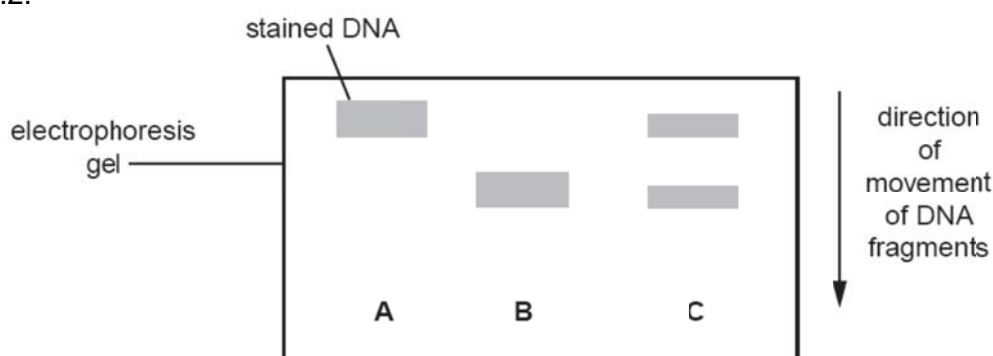


Fig. 4.2

(b) Describe how DNA fragments are separated in gel electrophoresis. [3]

1. **DNA is negatively charged and will migrate out of the well and travel through the gel towards the anode when the current is turned on / in an electric field;;**
2. **DNA fragments of different sizes in a given sample are separated based on their different rates of migration through the gel;;**
3. **Longer DNA fragments will have more difficulty (encounter more resistance) in moving through the pores in the gel and will therefore move slower at a lower rate and be found closest to the well (or vice versa);;**

(c) Identify the position of a 100 bp fragment on Fig. 4.2 by means of a labelled arrow. [1]

1. **band in A / top band in C;;**

(d) Explain the result obtained from individual **C**. [2]

1. **C is heterozygous for the CFTR gene as it contains the 100 bp fragment which is nearer the well and 97 bp fragments which is further away from the well;;**
2. **C possesses a normal allele (100 bp fragment) and a mutant allele (97 bp fragment) on homologous chromosomes;;**

[Total: 10]

Section B

Answer **one** question.

Write your answers on the separate answer paper provided.

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

- 5 (a)** Outline how the structure of cellulose is related to its specific function. [6]

Structure:

1. Cellulose molecule consists of a long (unbranched) chains of β -glucose residues joined by β -1, 4 glycosidic bond which make the chain straight;;
2. Successive β -glucose residues are rotated 180° with respect to its adjacent residues;;
3. which results in the $-OH$ groups projecting outwards from each chain in all directions;;
4. Many cellulose chains run parallel to each other, forming hydrogen bonds between $-OH$ groups of neighbouring chains;;
5. resulting in cross-linking that bind the chain rigidly together to form microfibrils and macrofibrils;;

Function:

6. Main structural component of all plants' cell wall
7. Microfibrils which confers high tensile strength, stability and support;;
8. The high tensile strength of microfibrils prevents the plant cells from bursting when water enters by osmosis;;
9. As a cell inflates with water, pressure develops inside it and the cell becomes turgid, which help support plants which lack wood;;
The arrangement of fibres around the cell helps to determine the shape of the cell as it grows

- (b) Explain how *E. coli* can be genetically engineered to produce insulin avoiding the problems associated with introns. [10]

Construction of ds DNA

1. mRNA coding for insulin is isolated from β -cells of the islets of Langerhans in the pancreas;;
2. Reverse transcriptase is used to make a copy of complementary DNA (cDNA) and DNA polymerase is then used to synthesize the second DNA strand, forming a dsDNA;;

R: insulating insulin gene from genomic DNA

Formation of recombinant plasmid

3. Vector/plasmid and insulin gene are digested by same restriction enzyme at specific restriction site;;
4. Production of complementary sticky ends on insulin gene and vector e.g. pBR322 or pVector;;
5. Complementary base pairing can form via hydrogen bonds between insulin gene fragment and vector;;
6. DNA ligase is added to seal the nicks via formation of phosphodiester bonds;;

Insertion of the vector into host cell

7. Introduction of recombinant DNA molecule into living host/bacteria/*E.coli* via transformation;;
8. Method of transformation through heat shock / CaCl_2 treatment to create permeability;;

Selection of the host cells with recombinant plasmids

pBR322

9. replica plating is carried out with master plate containing ampicillin and replica plate containing tetracycline;;
10. pBR322 ampicillin-resistance gene as first selectable marker and tetracycline resistance gene used as second selectable marker;;
11. Transformed bacterial cells containing a (recombinant or non-recombinant) plasmid are able to survive and grow on nutrient agar with ampicillin;;
12. If insulin gene is inserted into restriction site within the tetracycline resistance gene, the gene will be insertional inactivated and transformed bacteria will not be able to survive and grow on agar plate containing tetracycline;;

OR

pVector

13. Vector contains ampicillin-resistance gene as first selectable marker and lacZ gene as second selectable marker;;
14. Presence of ampicillin on the agar plate directly eliminates any bacterial cells that are not transformed;;
15. lacZ gene codes for the enzyme β -galactosidase which breaks down colourless X-gal to yield a blue coloured product;;
16. If foreign DNA is inserted at a restriction site in the lacZ gene, the gene will be insertional inactivated and β -galactosidase will not be synthesized;;
17. Bacterial colonies containing recombinant plasmids will appear white on the agar medium;;

(Screening for colonies containing gene of interest)

18. Southern blot can be carried out to screen for colonies containing the gene of interest;;)

Clone the recombinant host cell

19. Bacterial cells are grown in fermenters for multiplication of bacteria, giving rise to many copies of recombinant plasmids which can be expressed to give rise to many copies of the insulin protein which can be extracted and purified for use;;

(c) Explain how Bt corn produced through genetic engineering improve the yield of crops. [4]

- 1. Bt corn is a genetically engineered plant/corn containing a gene that codes for the *Bacillus thuringiensis* (Bt) toxin (resistance to insect pests);;**
- 2. larvae of *Lepidoptera* species that ingest corn may cause reduced yield for corn crops for farmers;;**
- 3. Bt toxin gene codes for insecticidal crystalized proteins (ICPs) that are lethal to *Lepidoptera* larvae / European corn borer larvae when they are ingested;;**
- 4. Larvae which ingest the toxin die because of damage caused to the gut;;**
- 5. Hence these larvae are unable to cause further damage to crops, farmers will have higher crop yield than before;;**
- 6. This allows farmers to concentrate resources on aspects like fertilizers, improved farming practices that result in further improved yield;;**

[Total: 20]

- 6 (a) Name each stage of mitosis. For each of the stage, describe the behaviour of chromosomes. [8]

Prophase:

1. Chromatin shorten and thicken/condense and become distinct structures called chromosomes;;

Metaphase:

2. Spindle fibres from each pole of the cell are attached to one of the two chromatids of each chromosome at the centromere region;;
3. Spindle fibres pull on the centromere, arranging the chromosomes in a single row on the metaphase plate (equator of the spindle);;

Anaphase:

4. Centromere divides and sister chromatids separate at centromere, forming daughter chromosomes;;
5. Shortening of microtubules occurs and spindle fibres attached to the centromeres pull the daughter chromosome to the opposite poles of the cell;;
6. with centromere leading the way;;

Telophase:

7. Daughter chromosomes reach the opposite poles;;
8. Chromosomes uncoil, lengthen and become indistinct to form chromatin again;;

2 correctly named stages – 1 mark

- (b) Explain how meiosis and random fertilisation may result in genetic variation in offspring. [7]

1. Independent assortment of homologous chromosomes in metaphase I of meiosis II;;
2. results in random assortment of paternal and maternal chromosomes between the nuclei of daughter cells producing new combinations of alleles;;
3. Independent assortment of chromatids in metaphase II of meiosis II;;
4. results in random assortment of chromatids between the nuclei of daughter cells;;
5. Independent segregation of homologous chromosomes during anaphase I of meiosis I and;;
6. independent segregation of chromatids during anaphase II of meiosis II leads to genetic variation;;
7. Crossing over between non-sister chromatids of homologous chromosomes;;
8. during prophase I of meiosis I;;
9. leads to the formation of new combinations of alleles on chromosomes of the gametes;;
10. Random fertilisation / random fusion of different types of gametes formed results in new combination of alleles in zygote and adds to genetic variation of the zygote formed;;

(c) Explain why genetic variation is important in natural selection. [5]

1. **Natural selection is a process where the environment selects for individuals who are better adapted and will be at a selective advantage/Individuals who are selectively disadvantaged will be selected against;;**
2. **For natural selection to occur, genetic variation must exist;;**
3. **Absence of genetic variation could result in no variation in phenotype;;**
4. **Environment unable to exert selection pressure on phenotypes / equal selection pressure on all phenotypes;;**
5. **Hence no differential reproductive success / no natural selection / no selection for or against of organisms;;**
6. **No change in allele frequencies and therefore evolution would not occur;;**

[Total: 20]