

CATHOLIC JUNIOR COLLEGE
JC2 Preliminary Examinations
in preparation for General Certificate of Education Advanced Level
Higher 1

ANSWER

CANDIDATE
NAME

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CLASS

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INDEX
NUMBER

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BIOLOGY

8875/02

Paper 2 Core Paper

28 August 2015

2 hours

Additional Materials: Answer Paper

READ THESE INSTRUCTIONS FIRST

Write your index number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A

Answer **all** questions in the spaces provided on the question paper.

Section B

Answer any **one** question on the answer paper provided.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units

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

For Examiner's Use	
1	
2	
3	
4	
5 or 6	
Total	

This document consists of **15** printed pages and **1** blank page.

[Turn over

Section A

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

1 Meiosis is an important event which is required) prior to fertilisation in sexual reproduction.

(a) Explain the need for reduction division (meiosis) prior to fertilisation in sexual reproduction. [2]

- Meiosis halves the number of chromosomes going into gametes ;
 - so that the diploid number in the zygote can be conserved when the gametes fused together during fertilisation ;
- OR
- During fertilisation, the number of chromosomes doubles in the zygote ;
 - In order to conserve the diploid number in the organism, there has to be an equivalent reduction in the chromosome number in the gametes that fused together ;

Fig. 1.1 below shows 8 different micrographs taken at the different timing during the meiosis of a cell.

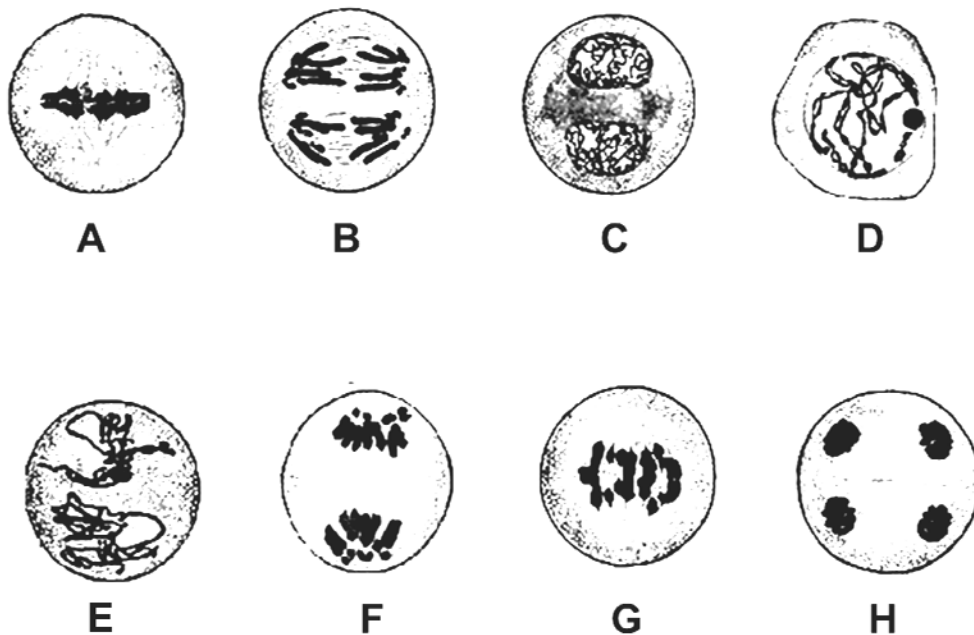


Fig. 1.1

(b) Arrange the 8 stages (A - H) in chronological order.

D, A, G, F, C, E, B, H

[1]

(c) With reference to Fig. 1.1,

(i) identify **one** stage (A - H) that will result in genetic variation. [1]

(ii) explain how this stage results in genetic variation. [2]

- Micrograph B ;

- chiasmata formation and crossing over during prophase I resulting in the exchange of alleles ;
- This results in new combinations of alleles on chromosomes of the gametes, causing genetic variation ;

OR

- Micrograph A ;

- independent assortment of homologous chromosomes at metaphase I ;
- Subsequent separation of the homologous chromosomes during anaphase I will produce different combinations of chromosomes in the daughter cells at the end of meiosis I.

OR

- Micrograph G;

- independent assortment of chromatids at metaphase II ;
- Subsequent separation of chromatids during anaphase II will produce different combinations of chromosomes in the daughter cells at the end of meiosis II ;

Bone marrow contains stem cells that divide by mitosis to form blood cells. Each time a stem cell divides it forms a replacement stem cell and a cell that develops into a blood cell.

Fig. 1.2 shows changes in the mass of DNA in a human stem cell from the bone marrow during three cell cycles.

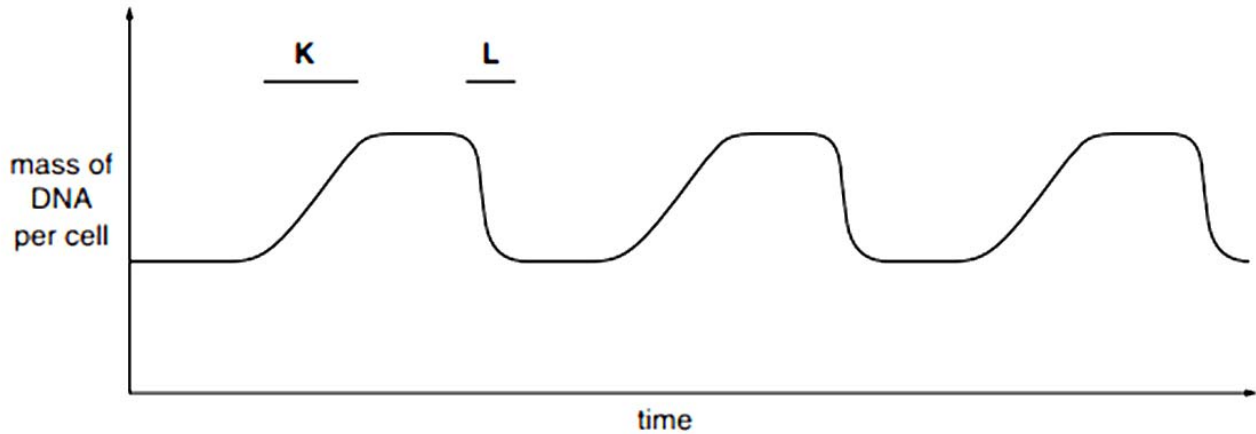


Fig. 1.2

(d) With reference to Fig. 1.2, state:

- (i)** what happens to bring about the changes in the mass of DNA per cell at **K** and at **L**. [2]
 K – (DNA) replication/ synthesis / described ;
 L – cytokinesis / cytoplasmic division / cell division ;
- (ii)** how many blood cells are formed from the stem cell in the time shown. [1]
 3
- (iii)** what happens to the number of chromosomes in the stem cell. [1]
 remain the same / stays constant / stay at 46 / AW ; *Reject: description of events occurring before and during mitosis*

[Total: 10]

- 2 In mice, fur colour is controlled by a gene with multiple alleles. These alleles are listed below in no particular order.

yellow = C^y

agouti = C^a

black = C^b

(a) Suggest explanations for the results of the following crosses between mice.

- (i) Mice with agouti fur crossed with mice with black fur may produce all agouti offspring or some agouti and some black offspring. [2]

accept answers in a genetic diagram where genotypes are linked to phenotypes

- agouti allele / C^a , dominant to black allele / C^b ; (or reverse argument)
- black parents homozygous recessive;
- agouti parents heterozygous or homozygous;

[max 2 marks]

- (ii) Crosses between heterozygous parents with the genotype $C^y C^b$ always produce a ratio of two yellow mice to one black mouse. [2]

accept answers in a genetic diagram where genotypes are linked to phenotypes

- yellow allele / C^y , dominant to, black allele / C^b ;
- ref. to modified 3:1;
- (homozygous) genotype $C^y C^y$, lethal / does not survive;

[max 2 marks]

- (b) The budgerigar, *Melopsittacus undulatus*, is a small type of parrot that is native to Australia.

Fig. 2.1 shows a budgerigar.



Fig. 2.1

A budgerigar can have blue, green, yellow or white feathers.

Two genes, **A/a** and **D/d**, are involved in the inheritance of feather colour in budgerigars.

- A bird which has at least one dominant allele **A** but is homozygous for **d** has blue feathers.
- A bird which has at least one dominant allele **D** but is homozygous for **a** has yellow feathers.
- A bird with at least one dominant **A** allele and one dominant **D** allele has green feathers.
- A bird that is homozygous for **a** and **d** has white feathers.

Two green-feathered budgerigars, heterozygous at both gene loci, were crossed. Draw a genetic diagram of this cross to show the probability of producing offspring with yellow feathers. [6]

- parental genotypes $AaDd \times AaDd$;
- gametes $AD\ Ad\ aD\ ad \times AD\ Ad\ aD\ ad$;
- two marks for correct Punnett square ;; deduct one mark for each mistake
- two marks for correct Punnett square ;; deduct one mark for each mistake
- (all 4) phenotypes linked correctly to genotypes ;
- (probability of yellow offspring) 3 out of 16 or 0.19 or 19% ;

[Total: 10]

- 3 MRSA is a variety of *Staphylococcus aureus*. It is difficult to treat infections caused by this bacterium because it is resistant to methicillin and to some other antibiotics. As a result, some patients who are already very ill may die if they become infected with MRSA.

(a) The antibiotic methicillin inhibits the enzyme transpeptidase. This enzyme is used by some bacteria to join monomers together during cell wall formation. Methicillin has a similar structure to these monomers. [2]

- Attaches to active site (of enzyme)/Competes for active site of enzyme ;
- (Methicillin) is a competitive inhibitor / prevents monomers/substrate attaching (to enzyme) ;

(b) Fig. 3.1 shows the number of deaths in England and Wales between 1994 and 2008 caused by MRSA.

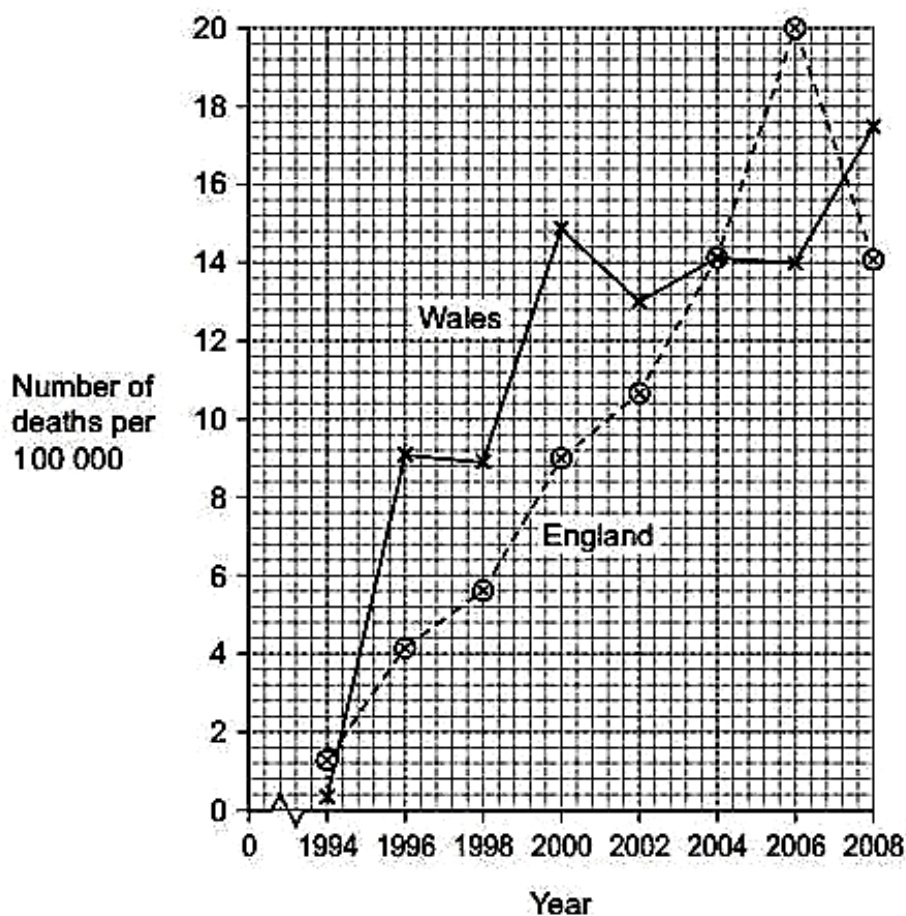


Fig. 3.1

Describe the change in the number of deaths caused by MRSA in England in the period shown in the graph. [1]

- Increase up to 2006/20 (per 100 000) then decreases till 2008/14 (per 100 000) ;

(c) Describe how natural selection has increased the difficulty of treating bacterial infections with antibiotics. [4]

- Antibiotic resistant gene / allele already existing in gene pool of bacterial population;
- Selection pressure of antibiotic being exerted on bacterial population;
- Resistant bacteria are at the selective advantages and are able to survive and reproduce pass down the allele for antibiotic resistance to their offspring;
- Over time, the allele frequency of antibiotic resistance allele in the bacterial population increases. As a result, the population of resistant bacteria increases. Thus, increases the difficulty of treating bacterial infections with antibiotics.

[Total: 7]

4 The artificial plasmid, pBR322, was constructed to act as a vector. It has often been used to insert human genes, such as the human insulin gene, into the bacterium, *Escherichia coli*.

The plasmid was constructed to include two genes, each giving resistance to a different antibiotic: an ampicillin resistance gene and a tetracycline resistance gene. The plasmid also has a target site for the restriction enzyme, *Bam*HI, in the middle of the tetracycline resistance gene.

A pBR322 plasmid was cut using *Bam*HI and the cDNA gene for human insulin inserted into it. Fig. 4.1 shows pBR322 and the recombinant plasmid.

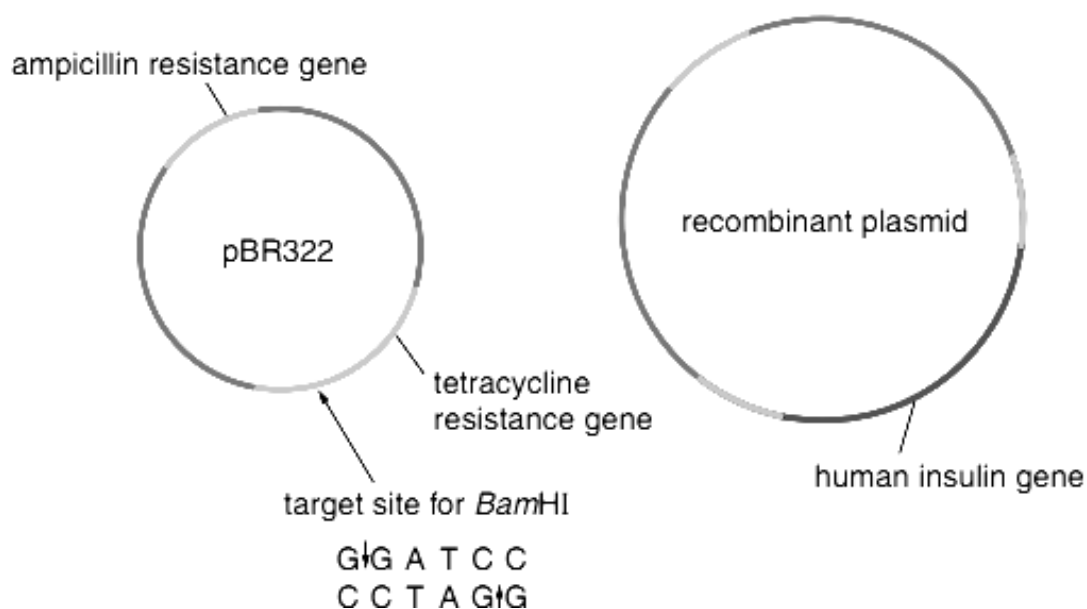


Fig. 4.1

(a) With reference to Fig. 4.1, describe how a cDNA human insulin gene can be inserted into pBR322 that has been cut by *Bam*HI. [4]

- ref. sticky ends ;
- GATC and CTAG ;
- complementary bases (pairing) ;

- A to T and C to G ;
- H-bonds (to sticky ends of plasmid) ;
- (gaps in) sugar-phosphate backbones sealed by (DNA) ligase ;
- AVP ; e.g. formation of phosphodiester bonds / ref. terminal transferase ;

[max 4 marks]

(b) Bacteria were then mixed with the recombinant plasmids. Those bacteria which had successfully taken up recombinant plasmids were identified using the following steps:

- step 1 – the bacteria were spread onto culture plates containing nutrient agar and ampicillin and incubated to allow colonies to form
- step 2 – some bacteria from each of the colonies growing on these plates were transferred to plates containing nutrient agar and tetracycline, as shown in Fig. 4.2.

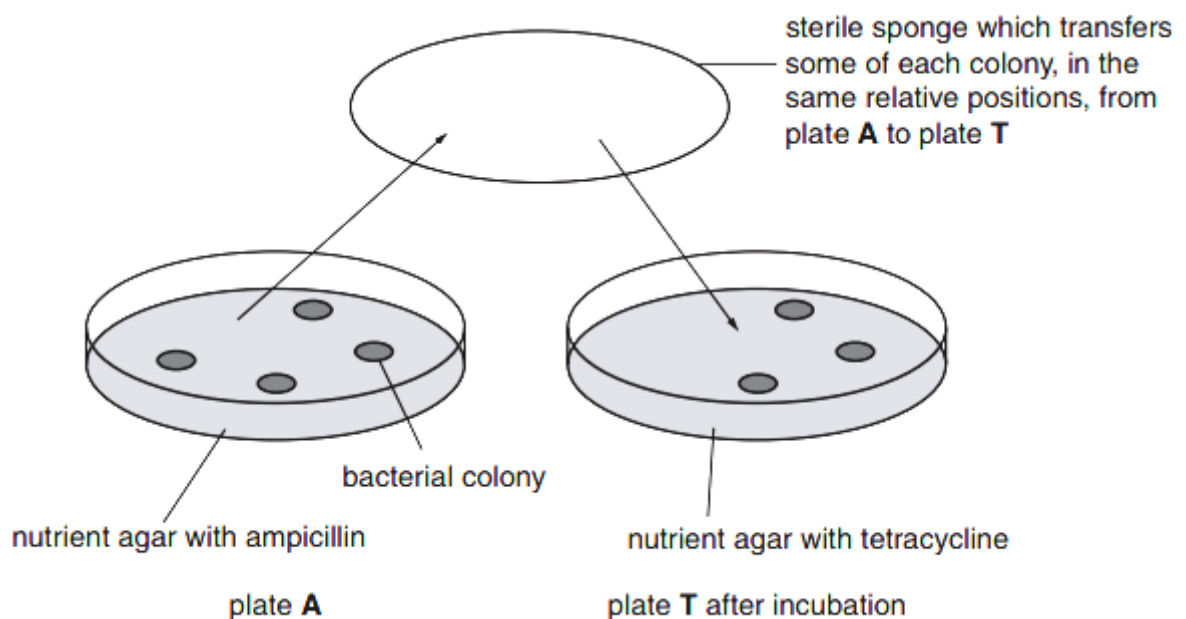


Fig. 4.2

(i) Explain why the bacteria were first spread onto plates containing ampicillin. [3]

- idea of identifying bacteria that, are transformed / have taken up plasmid / have taken up ampicillin resistance gene ;
- these bacteria have survived ;
- these bacteria may contain pBR322 or recombinant plasmid / plasmids taken up may not contain human insulin gene ;
- other bacteria have been killed ;

[max 3 marks]

(ii) Explain why it is important, for identifying bacteria that have successfully taken up the recombinant plasmid, that on pBR322 the target site for *Bam*HI is in the middle of the tetracycline resistance gene. [3]

- (BamHI) breaks the tetracycline resistance gene ;
- (inserting human insulin gene) makes tetracycline resistance gene inactive ;
- colonies that are ampicillin-resistant but not tetracycline-resistant have taken up recombinant plasmid / insulin gene ;

- colonies that survive on, tetracycline / both ampicillin and tetracycline / plate T, have not taken up the recombinant plasmid / insulin gene ;

[max 3 marks]

(iii) Use a label line and the letter **C** to identify, on Fig. 4.2, a colony of bacteria that contain the recombinant plasmid.

Put your answer onto Fig. 4.2 on **page 12**.

[1]

Answer on Fig. 4.2 left hand colony on plate A;

(c) Plasmid vectors carrying antibiotic resistance genes are now rarely used in gene technology.

Suggest one type of gene that has replaced antibiotic resistance genes in plasmid vectors and indicate how its presence can be detected.

[2]

mark for gene and mark for how product detected:

- gene for β galactosidase ; blue colour from X-gal medium ;
- gene for β glucuronidase (GUS) ; produces product that is easily stained blue ;
- gene for, GFP / other fluorescent product ;
- R fluorescent / fluorescence gene, fluorescence detected when present ;
- other gene ; & how detected ;

[max 2 marks]

[Total: 13]

Section B

Answer EITHER 5 OR 6.

Write your answers on separate answer paper provided.

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

Your answer must be in **continuous prose**, where appropriate.Your answer must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

5 (a) Compare the structures and roles of DNA and RNA.

[8]

Feature	DNA	RNA
Similarities:	<ul style="list-style-type: none"> Both contain nucleotide monomers that is made up of nitrogenous base, pentose sugar and a phosphate group Both are polynucleotides and can form complementary base pairing between C-G and A-T(DNA) or A-U (RNA) In complementary base-pairing for both DNA and RNA, the number of H-bonds form between C-G is 3 and A-T / A-U is 2 	
Differences:		
Nucleotide monomer	Deoxyribonucleotide	Ribonucleotide
Pentose sugar	Deoxyribose	Ribose
Nitrogenous bases	Adenine, guanine, cytosine and thymine Ratio of adenine to thymine is 1:1 for all molecules. Ratio of cytosine to guanine is 1:1 for all molecules.	Adenine, guanine, cytosine and uracil Ratio of adenine to uracil varies from one molecule to another. Ratio of cytosine to guanine varies from one molecule to another.
Structure	With the exception of the DNA in some viruses, DNA is always double-stranded (2 polynucleotide chains). There is only one form of DNA.	With the exception of the RNA in some viruses, RNA is always single-stranded (1 polynucleotide chain). There are three types of RNA, namely mRNA, rRNA and tRNA.
Size	Large molecule	Relatively small molecule
ROLE:	A template for DNA replication and transcription	mRNA: A template for protein synthesis tRNA: to bring activated amino acids to mRNA for translation elongation rRNA: complex with protein to become ribosome

(b) Describe the process of translation.

[6]

Translation process occurs on ribosomes and can be summarized as:

- Amino acid activation and function of tRNA in translation

Keywords:

- amino-acyl tRNA synthetase
- tRNA
- 20 different common amino acids

- Binding of mRNA to ribosome and translation initiation

Keywords:

- Small subunit of ribosome for binding of mRNA
- Large subunit of ribosome for binding of charged-tRNA (E, P, A sites)
- Formation of translation initiation complex

- Elongation

Keywords:

- Peptidyl transferase
- 3-step cycle: Codon recognition, Peptide bond formation, Translocation

- Termination

Keywords:

- Stop mRNA codons (UAA, UGA, UAG)
- Release factor
- Addition of water

- (c) Explain how competitive and non-competitive inhibitors affect a reaction catalyzed by an enzyme. [6]

[Max 4 marks]

- Competitive inhibitors has a close structural resemblance to substrates, therefore, they bind to active sites of the enzyme,
- Idea of: competitive inhibitors excluding the substrate from the active site, thus reducing rate of reaction.
- Effect of competitive inhibitor can be reduced by increasing substrate concentration, increasing rate of reaction / V_{max} remains unchanged because there will be a greater chance for the substrate to bind to the active sites, leaving fewer to be occupied by the inhibitor but products take a longer time to be formed
- With increased substrate concentration, less inhibition will occur K_m increases since the affinity of the enzyme for the substrate decreases due to the competition with the inhibitor for the active site of the enzyme

[Max 4 marks]

- Non-competitive inhibitors has no structural resemblance to substrate and binds to a site other than active site of enzyme (allosteric sites)
- Resulting in a change of configuration of active site, again preventing substrate from binding, thus reducing the rate of reaction.
- Effects of non-competitive inhibitors cannot be reduced by increasing substrate concentration, rate of reaction not increased / V_{max} is lowered since a proportion of enzymes have been denatured by the inhibitor, leaving lower concentration of functional enzyme to catalyse the reaction
- K_m remains unchanged since the affinity of the enzyme for the substrate remain the same as the inhibitors bind to the site other than the active site of the enzyme.

[Total: 20]

- 6 (a) Describe the pathway taken by cell-membrane bound proteins following their synthesis. [7]

- Proteins enter lumen of rough endoplasmic reticulum ;
- Embedded into phospholipid membrane of transport vesicles ;
- Transport vesicles bud from the rough endoplasmic reticulum ;
- Transport vesicles move to the Golgi apparatus along microtubules ;
- Transport vesicles fuse with the *cis* face of the Golgi apparatus ;
- Travel through cisternae of Golgi apparatus ;
- Secretory vesicles bud from the *trans* face of the Golgi apparatus ;
- Secretory vesicles travel to the cell-membrane ;
- Secretory vesicles fuse with the cell-membrane ;
- Proteins become incorporated into the cell-membrane ;

[max 7 marks]

(b) Describe the roles of NAD and NADP in cells.

[8]

- Both NAD^+ and NADP^+ are coenzymes and electron acceptors/carriers. In reduced form, NADH and NADPH respectively, temporarily store energized electrons and protons which transfer them to electron transport chain (ETC) ;

[max 4 marks]

- NAD which is found in the mitochondrial matrix and cytoplasm of cells, is reduced to NADH during glycolysis, link reaction and Krebs cycle by dehydrogenation reactions
- NADH donates its electrons to the electron transport chain (ETC) embedded in the inner mitochondrial membrane during oxidative phosphorylation ;
- The transfer of the electrons through ETC down the energy gradient results in the establishment of a proton concentration gradient and eventually ATP synthesis ;
- Each NADH produces 3 ATP. The regeneration of NAD^+ ensures that glycolysis, link reaction and Krebs cycle of cellular respiration can continue to proceed for the synthesis of ATP via substrate level phosphorylation or oxidative phosphorylation ;

[max 4 marks]

- NADP, found in the stroma of chloroplast in plant cells, is the final electron acceptor of the ETC embedded at the thylakoid membrane. The reduced form, NADPH, is produced during the light dependent reaction of photosynthesis. They are needed for the light independent / Calvin cycle ;
- NADPH reduces glycerate-3-phosphate to form triose phosphate/glyceraldehyde-3-phosphate. Some of the triose phosphates will combine to form other sugar phosphates and eventually produce starch, fats and proteins in plants ;
- By donating its hydrogen to glycerate-3-phosphate, NADP^+ is regenerated and continues to accept the electrons and protons from the light dependent reaction for the synthesis of different bio-molecules in plants ;
- The rest of triose phosphates are used for regeneration of ribulose biphosphates (RuBP) needed for carbon dioxide fixation ;

[max 8 marks]

(c) Discuss the ethical implications of genetically modifying plants.

[5]

- Bt corn, Golden Rice and GM Salmon have the capability of producing more yield with a given number of resources, as compared to traditional methods. Allow for more people to be fed with a given amount of resources.
- Bt corn, Golden Rice and GM Salmon have the capability of producing more yield with a given number of resources, as compared to traditional methods. Helps to cut down cost of production.
- Bt corn has the capability of producing better quality crops as the crystallized protein has an insecticidal effect.
- Mixing genes among species may be argued to be creating a new 'species' through artificial means.
- There is a risk of the genetically modified organism escaping and its effect on the environment and biodiversity is unknown.
- The effects of GM products on human health are still not fully known The effects may only be known after a long period of exposure.
- There is no law making it mandatory for GM food to be labelled.
Allergic reactions may occur if people unknowingly consume products containing introduced genes.

[max 8 marks]

[Total: 20]