

Name	Subject Class	Class	Candidate Number
	2BIX01		



ANGLO-CHINESE JUNIOR COLLEGE
Preliminary Examination 2015

BIOLOGY

HIGHER 1

Paper 2

8875/02
24 AUGUST 2015
2 hours

Additional Material: Writing Paper

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on this answer booklet.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.

Section A

Answer **all** questions.

Section B

Answer any **one** question.

At the end of the examination, circle the number of the Section B question you have answered in the grid opposite.
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 or 6	
Total	60

- 1 (a) Fig. 1.1 is a schematic diagram showing the transport pathways of extracellular and intracellular materials for digestion in a mammalian cell. Depending on the types of digested material, three possible pathways are initiated to deliver these materials for digestion within lysosomes, of which two are labelled as **A** and **B**.

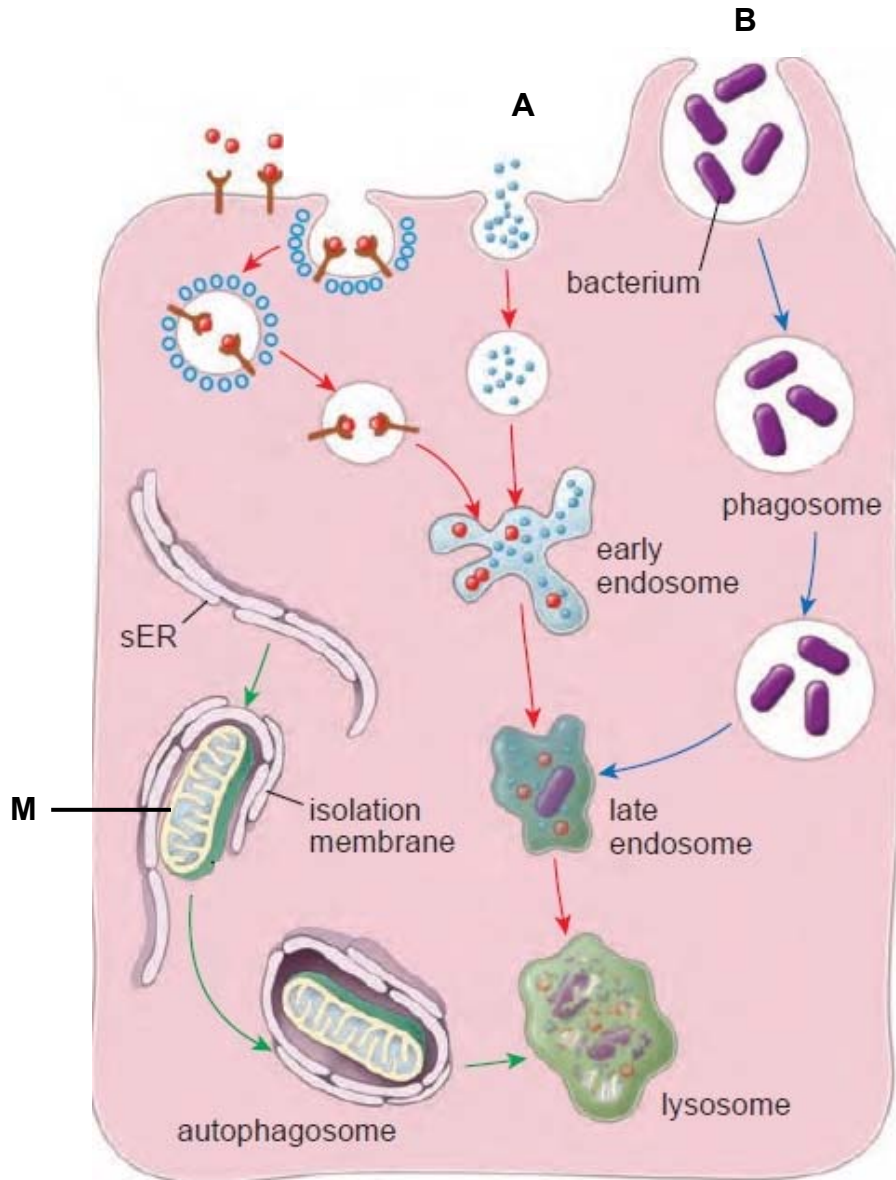


Fig. 1.1

- (i) State **one** property of the plasma membrane and explain how it enables process **A** to be carried out by a cell. [2]

1. **Membrane is fluid;**

2. **Ref. to invagination of plasma membrane in or fusion of two ends of plasma membrane to form endocytic vesicle;** @ 1m

- (ii) Organelle **M** is a mitochondrion with its inner membrane thrown into numerous folds. Explain the advantage of this feature to a cell undergoing aerobic respiration. [2]

1. **Increases the surface area for attachment of electron carriers and ATP synthase;**
2. **to increase the rate of ATP synthesis by chemiosmosis in oxidative phosphorylation;** @ 1m

- (iii) Degradation of worn out organelles such as mitochondria occurs inside most cells via autophagy. With reference to Fig. 1.1, describe the process of autophagy. [2]

1. **Isolation membrane (derived from SER) encloses mitochondria to form a (membrane bound) autophagosome;**
2. **Fusion of membrane of autophagosome with membrane of lysosome to release mitochondria into the lysosome;**
3. **Digestion of mitochondria by hydrolytic enzymes, which are activated by low pH within lysosome;** @ 1m, max 2

- (b) Lysosomes are rich in enzymes such as proteases and nucleases. The lysosomal membrane contains an unusually large amount of integral proteins, which are highly glycosylated with oligosaccharides on the surface of membrane facing the interior.

- (i) Briefly describe how an oligosaccharide is formed from glucose. [3]

1. **These glucose molecules are linked by glycosidic bonds R! covalent bonds**
2. **during condensation reaction (with removal of water molecules);**
3. **Ref. to catalysed by specific enzymes taking place;** @ 1m, max 2

- (ii) Suggest the role of these glycosylated proteins in lysosomes. [1]

1. **Ref. to large amounts of these glycoproteins acting as a molecular shield;**
2. **Hindering the access / contact of enzymes (e.g. proteases, phospholipases) with substrates (e.g. membrane protein, phospholipids) / preventing the binding of the substrates to the active sites of enzymes;**
3. **Ref. to prevent self - digestion of lysosome by hydrolytic enzymes/ OWTTE;** @ 1m, max 1

[Total: 10m]

- 2 (a) Cystic fibrosis (CF) in humans is caused by mutations of a gene coding for the transmembrane protein called the cystic fibrosis transmembrane conductance regulator (CFTR) which acts as an ion pump. A large number of different mutations of the gene have been found. Explain what is meant by a gene mutation. [3]

1. A change in the nucleotide sequence of a gene;

2. Which may give rise to a different amino acid sequence in the polypeptide;

3. Examples: insertion, deletion, substitution;

@1m

CFTR regulates the transport of chloride ions (Cl^-) across the plasma (cell surface) membrane. The transport of Cl^- by epithelial cells expressing the normal *CFTR* allele was compared with that by epithelial cells expressing two different types of mutant *CFTR* alleles. The results are shown in Table 2.1 where normal digestive function of the pancreas associated with a particular allele is indicated with a tick (✓) and the absence of normal functioning is indicated with a cross (✗).

Table 2.1

<i>CFTR</i> allele	Percentage of Cl^- transported in comparison with normal allele	Normal digestive function in pancreas
Normal	100	✓
Mutation 1	6	✗
Mutation 2	41	✓

- (b) With reference to the information given in Table 2.1, explain the different effects of mutations 1 and 2 on the digestive function of the pancreas. [4]

1. Mutation 1 results in a lower percentage of Cl^- transported across the plasma membrane as compared to mutation 2 e.g. 6% vs 41%;
2. Mutation 1 may be a insertion/deletion of one or two bases which results in a frameshift/substitution where the changed codon codes for a new amino acid with a different chemical property, causing a major change in the 3D conformation of the CFTR;
3. Mutation 2 may be substitution of a base which leads to a minor change in the 3D conformation of the CFTR;
4. When CFTR undergoes minor changes in 3D structure, transport of Cl^- can still occur but at a reduced rate (as compared to the normal allele);

@1m

- (c) About 80-90% of CF patients have pancreatic insufficiency, which means that the pancreas no longer functions at a level needed to digest food. Pancreatic tissues that express mutant *CFTR* alleles secrete acidic fluids into the lumen of the pancreatic duct, whereas secretions by tissues expressing the normal allele are alkaline. CF patients produce large amounts of thick, sticky mucus which can clog up the airways of the lungs, the pancreatic duct, the bile duct and the reproductive ducts.

Fig. 2.1 shows how the presence of thick, sticky mucus causes blockage in the pancreatic duct.

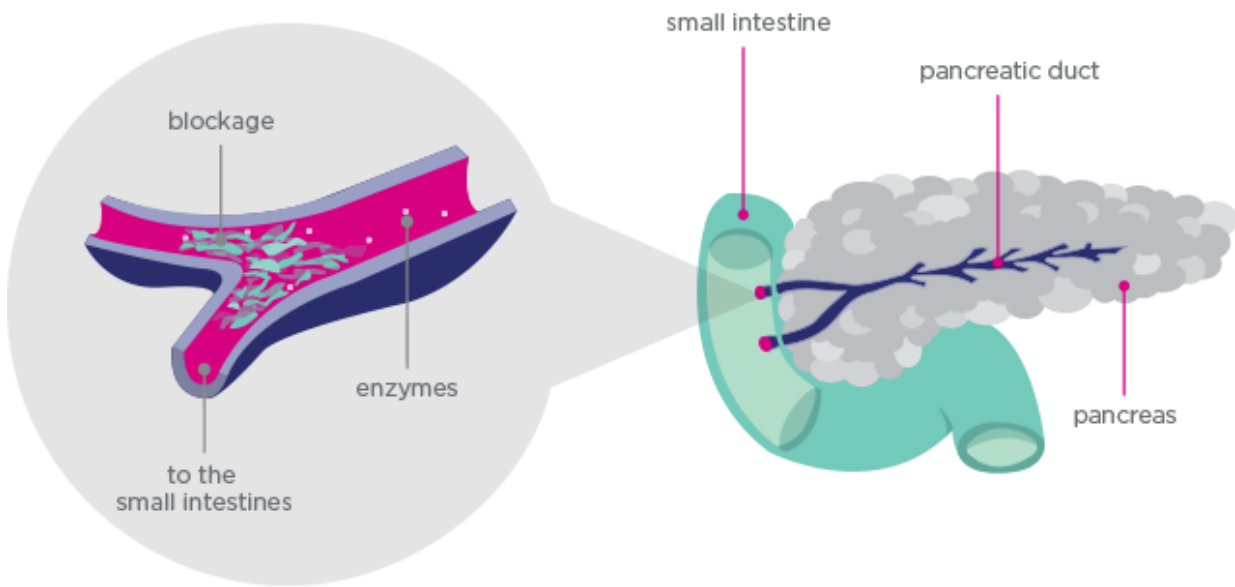


Fig. 2.1

Suggest how pancreatic tissues expressing mutant *CFTR* alleles may lead to maldigestion in CF patients. [2]

1. **Pancreatic enzyme released will be denatured by acidic conditions in the lumen of pancreatic duct;**
2. **The blockage also prevents the enzyme from entering the small intestine/gut;**
3. **Food substances in the small intestine is not digested by the pancreatic enzymes, leading to maldigestion;** @ 1m, max 2

- (d) CF patients undergo enzyme replacement therapy to help them digest food properly. The enzymes are provided in the form of a tablet, powder or a capsule. Explain why the therapy is **not** an effective permanent solution to treat pancreatic insufficiency. [1]

1. **Replacing the enzyme only increases the enzyme concentration in the small intestine/ enzyme being a protein may be digested in the digestive tract;**
2. **The mutated allele is still present (and not removed) in the patient, hence it will still code for a defective CFTR; @ 1m**

[Total: 10m]

- 3 (a) Fragile X Syndrome (FXS) is a sex-linked recessive genetic disease in human that causes intellectual disabilities ranging from mild to severe.

A woman who is a carrier of FXS with blood group AB married a man suffering from FXS with blood group O.

Using a genetic diagram, determine the probability of the couple having a normal boy with blood group B.

Key

Let X^F be the dominant allele coding for normal condition and X^f be the recessive allele coding for FXS condition

Let I^A be the allele coding for blood group A, I^B be the allele coding for blood group B and I^O be the allele coding for blood group O ;

Cross 1

Parental phenotypes Carrier of FXS, blood group AB Woman x FXS, blood group O man
Parental genotypes $I^A I^B X^F X^f$ x $I^O I^O X^f Y$;

Gametes $I^A X^F$ $I^A X^f$ $I^B X^F$ $I^B X^f$ $I^O X^f$ $I^O Y$;

	$I^A X^F$	$I^A X^f$	$I^B X^F$	$I^B X^f$
$I^O X^f$	$I^A I^O X^F X^f$ Blood group A, Normal female	$I^A I^O X^f X^f$ Blood group A, FXS female	$I^B I^O X^F X^f$ Blood group B, Normal female	$I^B I^O X^f X^f$ Blood group B, FXS female
$I^O Y$	$I^A I^O X^F Y$ Blood group A, Normal male	$I^A I^O X^f Y$ Blood group A, FXS male	$I^B I^O X^F Y$ Blood group B, Normal male	$I^B I^O X^f Y$ Blood group B, FXS male

@ 1m for genotypes & phenotypes/ phenotypic ratio (Punnett Square not necessary)

Probability = 1/8 ;

@ 1m
[5]

- (b) The disorder FXS is caused by insertion of multiple trinucleotide (CGG) repeats in the gene. In order to make a definitive diagnosis of FXS, genetic testing is conducted to determine the presence of trinucleotide repeats. Fig. 3.1 shows both the normal and mutant alleles.

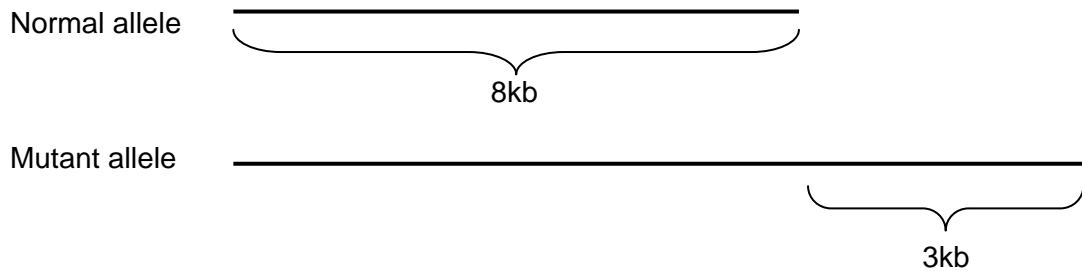


Fig. 3.1

In order to conduct a genetic test, two DNA samples were isolated from a carrier of FXS and a man suffering from FXS. The DNA samples are amplified using PCR followed by analysis using gel electrophoresis.

- (i) Describe the principles of gel electrophoresis. [2]

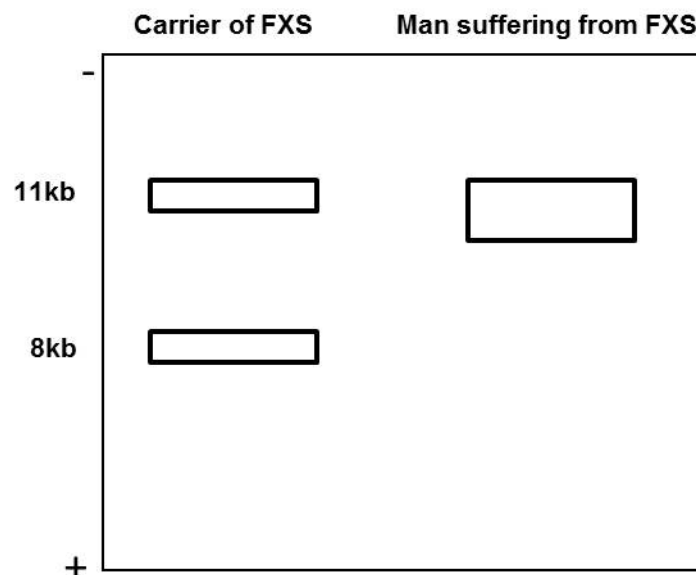
1. Electrical current applied across gel causes negatively charged DNA to move to positively charged terminals;

2. Polyacrylamide/ agarose gel act as molecular sieve for DNA fragment;

3. Smaller fragments move faster and hence further than larger fragments;

@ 1m, max 2

- (ii) In the gel electrophoregram below, draw and indicate the size of the bands you would expect to see from the two DNA samples isolated. [3]



2 equal sized bands for Carrier of FXS;

1 band (equal sized as carrier) for Man suffering from FXS;

Labeling fragment size;

@1m

[3]

[Total: 10m]

- 4 (a) BT corn is a genetically engineered corn that contains the gene for the toxin found in *Bacillus thuringiensis*. It has been planted extensively in various parts of the world. As the amount of BT corn plantation increases over the years, the number of species of corn borer that are resistant to BT toxin increases proportionally as well.

- (i) Explain the advantage of genetically engineering the BT corn. [2]

1. **BT toxin produced by the corn kills pest that destroy the crops;**

2. **Hence increases yearly crop yield for a growing population ;**

3. **Reducing the use of pesticides;**

@ 1m, max 2

- (ii) Explain the evolution of the resistant species of corn borers to BT corn. [4]

1. **There are genetic variation among the population of corn borers;**

2. **BT toxin exerts a selection pressure on the corn borer, corn borers with resistant alleles are selected for;**

3. **They have higher reproductive success and pass on their alleles to the next generation in greater proportion;**

4. **Leading to changes in the allele frequency of the gene pool over time;**

@1m

- (b) BT toxin has been found to bind to the transmembrane protein cadherin, found in the mid-gut of the European corn borer. Cadherin genes can also be found in a wide variety of organisms, from insects to mammals. They have roles in the central nervous system as well as in cell-cell adhesion. However BT toxin can only bind to cadherin proteins on the cells in insects like the European corn borer but not to those found in mammals.

With reference to the information above and your knowledge on molecular homology, explain how the presence of different cadherin genes between different organisms can support Darwin's theory of descent with modification. [4]

1. **Presence of cadherin gene with similar nucleotide sequence/ cadherin protein with similar a.a seq (in a variety of organism);**

2. **Indicates molecular homology;**

3. **Due to inheritance from a common ancestor;**

4. **Different binding between insects and mammals indicates slight changes in nucleotide sequence/ a.a seq;**

5. **Due to adaptation to different (physiological) environment;**

6. **Via natural selection;**

@1m

Pt 1-3 max 2

[Total: 10m]

Section BAnswer **EITHER 5 OR 6.**

Write your answers in the lined pages 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.

EITHER

- 5** (a) Outline the differences between facilitated diffusion and exocytosis. [6]
(b) Describe the roles of the different RNA molecules involved in translation. [8]
(c) Discuss the social implications of genetically modified organisms. [6]

OR

- 6** (a) Compare the structure of amylopectin and haemoglobin. [6]
(b) Discuss the importance of genetic variation in natural selection and evolution. [6]
(c) Outline the large scale production of insulin using genetic engineering. [8]

[Total: 20m]

5 (a) Outline the differences between facilitated diffusion and exocytosis.

[6]

Differences:

	Facilitated diffusion	Exocytosis
1.	Does not require ATP	Requires ATP;
2.	Transports polar or charged substances	Transports large macromolecules;
3.	Requires protein carrier / channel to transport substances	Encloses substances in membrane bound secretory vesicle to transport substances;
4.	Does not require microtubules in guiding the transport of substances	Requires microtubules in guiding the movement of vesicle;
5.	Does not involve the fusion of membranes	Involves the fusion of membranes;
6.	Bidirectional movement of substances	Uni-directional movement of substances;
7.	Requires concentration gradient to be established across a membrane	Concentration gradient is not required;

@1m per comparison, max 6

- 5 (b) Describe the roles of the different RNA molecules involved in translation. [8]
There are three types of RNA, namely messenger RNA (mRNA), ribosomal RNA (rRNA) and transfer RNA (tRNA).

mRNA (max 3)

1. The information carried by a gene on DNA is copied via a process called transcription onto messenger RNA (mRNA);
2. specific triplet base sequence on mRNA are called codons;
3. which code for specific amino acids of polypeptides;
4. Contains start codon AUG which initiates translation and location of start codon determines the correct reading frame for polypeptide synthesis;
5. Contains stop codons UAG, UAA and UGA, which terminate translation;

tRNA (max 3)

6. Amino acids are activated by combining with transfer RNA (tRNA);
7. The anticodon is made up of a specific triplet base sequence at a region of the folded tRNA molecule;
8. The triplet base sequence of the anticodon is complementary to the codon on mRNA;
9. At least 20 different tRNA molecules in a given cell, with at least one corresponding to each of the 20 amino acids required for protein synthesis;
10. The enzyme aminoacyl-tRNA synthetase causes a specific amino acid to attach itself to each tRNA molecule;
11. Specific amino acid binds to the 3' OH end of tRNA;

rRNA (max 3)

12. Together with ribosomal proteins, ribosomal RNA (rRNA) is a component of large and small subunits of ribosomes; which are the sites of translation;
13. The ribosomes interact with mRNA and tRNA molecules to translate the information in the mRNA into a polypeptide with the correct amino acid sequence;
14. rRNA of ribosome has peptidyl transferase activity OR serves as a ribozyme which catalyses formation of peptide bonds during translation;
15. rRNA undergoes complementary base pairing with tRNA/mRNA for anchorage of tRNA/mRNA to certain binding sites on the ribosome, ensuring that tRNA and mRNA are suitably positioned relative to each other for translation to occur;

@ 1m, max 8

5 (c) Discuss the social implications of genetically modified organisms.

[6]

Threat to human safety

1. Transgenic food causing allergies with named examples (e.g. Bt toxin in Bt corn/genes in Golden rice coming from several organisms);
2. Long term unexpected/negative effect of transgenic food on human health with named examples;
3. Use of antibiotic resistance genes as selectable markers in vectors used for transforming plants and concerns in making bacterial species in human gut more resistant;;

max 2

Threat to safety of the environment

4. Ref. to cross-pollination/unintended transfer of transgenes from GM crops/crop-to-weed hybridization with named example (e.g. soy crop plants with herbicide-resistance);;
5. Ref. to GM crops establishing as weeds/weeds becoming 'superweeds' and thus are invasive/reduces biodiversity/disrupts ecological balance;;
6. Ref. to GM crops being toxic to non-target organisms with named example (e.g. Bt toxin affecting larvae of monarch butterflies);;
7. Ref. to reduced numbers/extinction of non-target organism/disruption of food chain/disruption of ecological balance;;

max 2

Issues pertaining to Access and Intellectual Property

8. Companies seek patents and monopolize technology (e.g. make profits/protect results of research);;
9. Ref. to impact of patents (e.g. increase in price of seeds/ domination of world food production by few companies);;
10. Ref. to biopiracy and how developed countries exploit the resources of developing countries;;

max 2

Labelling is not mandatory in some countries

11. Ref. to need for labelling GM food (e.g. religious/medical/dietary concerns);;
12. Ref. to varying standards in labelling transgenic food with named examples (e.g. labelling threshold is 1% for Brazil and 5% for Japan/ labelling not mandatory in US);;
13. Ref. to difficulties in maintaining standard of labelling due to pollen drift with named example (e.g. unauthorized corn in Mexico)

max 2

Other social implications

14. Ref. to advances being skewed to interests of developed countries/benefiting only rich countries;;
15. Ref. to dominance of world food production by developed countries / increasing dependence of developing countries on industrialized nations;;
16. Ref. to impact on international trade with named example (e.g. Europe being more hesitant in accepting GM products compared to US);;

max 2

6a) Compare the structure of amylopectin and haemoglobin.

[6]

Similarities:

1. Both are polymers;
2. Both have hydrogen bonds;
3. Both have helical structures;

Differences:

	Basis	Amylopectin	Haemoglobin
1	Monomer	α -glucose	Amino acid
2	Bonds between monomers	α 1, 4 and 1,6 glycosidic bond	Peptide bonds
3	Other bonds	H bonds within molecule	Hydrogen bond, ionic bond, hydrophobic interactions
4	Branching	Branched	Unbranched
5	Subunits	No subunits	4 subunit, 2 α subunit and 2 β subunit
6	Orientation of hydroxyl groups	Point inwards	Ref. to the exterior
7	Crosslinks	No	Yes

@ 1m, max 6

6 (b) Discuss the importance of genetic variation in natural selection and evolution.

[6]

1. **Genetic variation results in phenotypic variation;**
2. **(Phenotypic) variation is needed for natural selection to act on;**
3. **Variations may be caused by spontaneous mutations;**
4. **Which creates new alleles and increases the gene pool for natural selection to operate;**
5. **Different environment have different selection pressures;**
6. **selects for individuals with phenotype more suited to the existing environment / individuals who are well-adapted to the environment have a selective advantage over those who are not;**
7. **Resulting in the individual able to survive till reproductive age and reproduce successfully / differential reproductive success;**
8. **This leads to certain alleles being passed to the next generation;**
9. **Results in change in allele frequency over time;**
10. **In the absence of variation, selection pressure acts equally on all individuals**

@1m, max 6

- (c) Outline the large scale production of insulin using genetic engineering. [8]
1. Isolate plasmid with 2 marker genes – resistance to ampicillin (or named antibiotic) and LacZ - from bacteria;
 2. A restriction site for named restriction enzyme (eg. EcoRI, BamHI) is located in LacZ;
 3. Digest the plasmid with the named restriction enzyme (eg. EcoRI/ BamHI);
 4. Obtain the cDNA for insulin gene by isolating insulin mRNA from pancreatic cells;
 5. and reverse transcribing it/reacting with reverse transcriptase;
 6. Attach EcoRI/BamHI (same restriction enzyme used to cut plasmid) linkers to cDNA and digest with EcoRI/BamHI to obtain cDNA with sticky ends;
 7. Mix the plasmid and cDNA together to allow the complementary sticky ends (of both fragments) to anneal by forming H bonds;
 8. Incubate with DNA ligase to form the phosphodiester bond that joins the fragments, forming the recombinant plasmid;
 9. Use electroporation to transform bacteria with recombinant plasmid;
 10. Plate the bacteria onto an agar plate with ampicillin (or named antibiotic) and X-gal, and incubate overnight at 37°C;
 11. Pick the white colonies, which have been transformed with recombinant plasmids where LacZ has been inactivated by insertion of insulin cDNA;
 12. These colonies are grown in large quantities in a suitable medium in a biofermentor
 13. Insulin produced by the bacteria will be extracted, purified and packaged for human use;

@1m, max 8