H1 ANDERSON JUNIOR COLLEGE
HIGHER 1

NAME

PDG | | | | | INDEX NUMBER | | |

BIOLOGY
8875/02

Paper 2 Core Paper

13 September 2016
Tuesday
2 hours

Additional Materials: Answer Paper

READ THESE INSTRUCTIONS FIRST

Write your name and PD group on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graph or rough working.
Do not use paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer **all** questions

All working for numerical answers must be shown.

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.

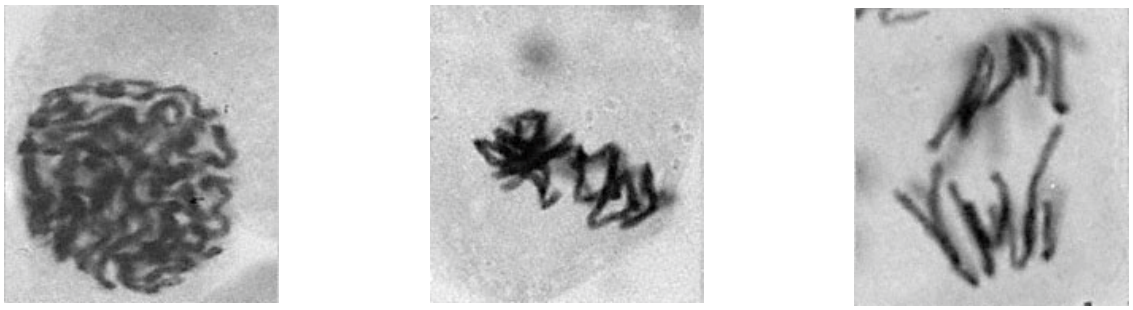
Calculators may be used

For Examiner's Use	
PAPER 1	
1-30	
	30 marks
PAPER 2	
Section A	*40 marks*
1	
2	
3	
4	
Section B	*20 marks*
5	
PAPER 2	
	60 marks
TOTAL	
	90 marks

Section A

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

1 Fig. 1.1 shows an electron micrograph of an actively dividing cell from *Bellevalia romana*, a flowering herbaceous plant.



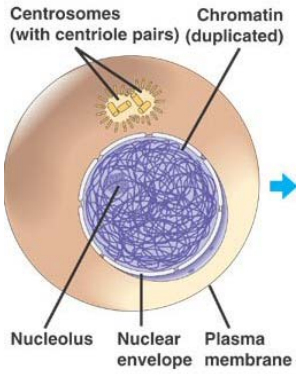
A **B** **C**

Fig. 1.1

(a) Identify stages A and B, and state the visible features that enabled your identification.

- Stage A → chromatin fibres coil and condense to become (discrete) chromosomes → (early) prophase

  Some students indicated A incorrectly as interphase - DNA is in the **uncondensed** form (i.e. chromatin fibres).



- Stage B → chromosomes (starting to) align at metaphase plate → (early) metaphase [2]

(b) Explain the change in distance between centromeres of a chromosome in stage C.

- Distance between centromeres of sister chromatids increase in stage C;
- Because (during anaphase), centromere divide *(reject: split)*;
- Chromosomes *(reject: chromatids)* pulled to opposite poles *(reject: ends)* by kinetochore microtubules/spindle fibres (with centromeres leading);

Well done :) [3]

(c) Explain why it is important that replication occurs before mitosis.

- So that each chromosome consists of 2 genetically identical sister chromatids (joined at centromere during prophase and metaphase);
- Each (of the two) daughter cells receive a copy of exact/same DNA molecule/chromosome → genetically identical;

Many scored only 1 mark as first point was not mentioned. [2]

	(d)	Explain how homologous chromosomes in stage A are genetically different from those in prophase II of the same plant.	
		• Homologous chromosomes in prophase II have different alleles of the same gene as compared to those in stage A, prophase; • This is because in prophase I, (chiasmata formation and) crossing over between non-sister chromatids of homologous chromosomes occurred; • Exchange of DNA segments with different alleles of the same gene/formation of new linkage groups/formation of new combinations of alleles; Well done :)	[3]
			[Total: 10]

2 Tomatoes, when ripened will get soft and are more susceptible to damage in the process of being transported to the markets to be sold. Softening of the fruit is due to the production of an enzyme polygalacturonase (**PG**) which breaks down the cell wall. Scientists have come up with an antisense technology to block the synthesis of this enzyme so that the fruits can remain firm. This involves the insertion of a promoter region into the non-template strand of the DNA shown in **Fig. 2.1**.

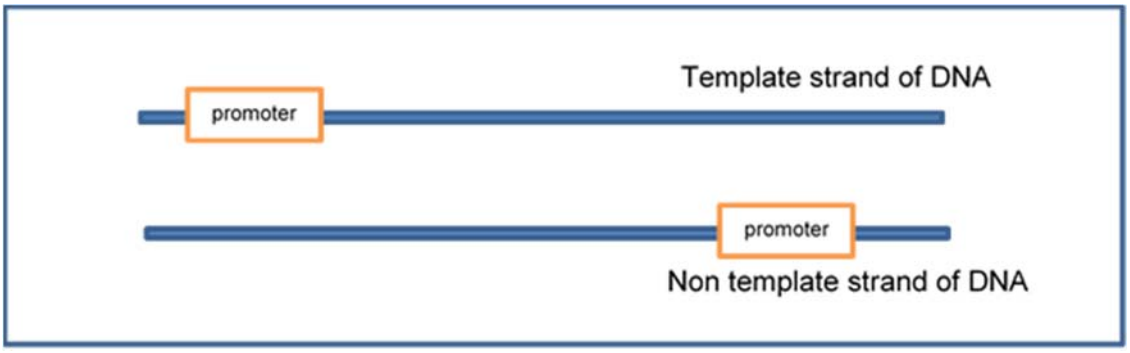


Fig. 2.1

(a) (i) On **Fig 2.1,** label clearly the 5' and 3' ends of both strands of DNA.

[1]

(ii) Explain what is meant by the term "template".

- Strand of DNA used for the synthesis of the mRNA by complementary base pairing;

Comments:

- Some students thought that the term template was used to describe the DNA strand that is used for DNA replication. This cannot be so as Fig. 4.1 has both a template as well as a non-template DNA.
- Students are still missing up DNA replication with transcription. The former deals with making another copy of DNA ('replica") whereas the latter deals with formation of a single stranded mRNA.

[1]

(b) Explain why the insertion of a promoter in the non-template DNA strand can block the synthesis of the PG enzyme.

- Presence of the promoter will be recognised by the RNA polymerase;
- Transcription will result in the production of an mRNA;
- that is <u>complementary to the mRNA</u> produced by transcription of the template strand or the two mRNA are complementary to each other;;
- Hybridised/ form double stranded RNA;
- Bases or codons on mRNA not exposed for translation;
- Therefore no functional enzyme produced;

Comments:

- Most students realise that the insertion of a promoter region in the non-template strand will allow the RNA polymerase to bind to it to initiate transcription. But many went on to explain that this will result in the production of mRNA which when translated, results in a non-functional protein. Even if this is true, there will still be production of functional enzyme from the transcription of the template DNA and so it cannot explain for the non-production of the enzyme.

[3]

(c) Describe how the promoter sequence can be isolated and then inserted into the non-template DNA.

- Remove promoter from source with appropriate restriction enzyme;
- Cut the non-template DNA with the same restriction enzyme;
- Producing complementary sticky ends;
- Mix the promoter with the promoter together in the presence of ATP and DNA ligase;
- Hydrogen bonds form between complementary sticky ends;
- And (DNA ligase will catalyse the formation of) of phosphodiester bonds between the 2 DNA;

Comments:

- Well done too :)
- Students have to be more careful with the singular and plural form of the term restriction enzyme. It does not make sense to isolate the promoter using restriction enzymes and use the same restriction enzymes on the non-template strands as this means that the ends produced from both DNA may not be complementary as it depends on which restriction enzyme happens to cut them.

[3]

(d) Explain how uncontrolled cell division can result in cancer.

- When a cell undergoes uncontrolled cell division, there is dysregulation of the cell cycle checkpoints where the cell proceeds to the next stage of the cell cycle even when proper conditions are not met.
- State the checkpoint and explain at least **2** factors not met:
  Eg. **G_1 checkpoint:** If cell size is not adequate, there is insufficient nutrients available to support daughter cells, growth factors (Extracellular signal proteins that stimulate a cell to grow or divide) are not present/
  G_2 checkpoint: If cell size is not adequate, DNA replication is not complete and not successful, there is DNA damage/
  Metaphase (M) checkpoint: If chromosomes are not under bipolar tension (not properly attached to kinetochore microtubules from the two different poles of the cell), chromosomes are not aligned at the metaphase plate.
- Cells continue to divide excessively and form tumours.
- Metastasis occurs when cancer cells from a tumour penetrates the blood or lymphatic system, travels through the bloodstream and invade normal tissues elsewhere in the body.
- Cancers can also spread through the body by the process of invasion. This occurs when cancer cells directly migrate to and penetrate into neighbouring tissues.

Pls remember to substantiate answers. For example, mention of metastasis must be elaborated with when cancer cells from a tumour penetrates the blood or lymphatic system, travels through the bloodstream and invade normal tissues elsewhere.

Must also remember to relate uncontrolled cell division to “dysregulation of the cell cycle checkpoints”.

[2]

				[Total: 10]

3	In Drosophila, the characteristics of wing length and body colour are controlled by one gene locus each. For each gene locus, there may be two or more alleles.		
	(a)	Explain the meaning of the terms	
	(i)	locus	
		• Locus is the fixed position of gene on a chromosome; Some failed to indicate “on a chromosome”.	[1]
	(ii)	allele	
		• Alternative form of a gene; • Occurs at the same position (locus) on homologous chromosomes; • Alleles have slightly different DNA sequences from each other; [max 2m] Well done too :)	[2]
	(b)	A cross was made between two fruit flies. One parent had an unknown genotype since it had the wild phenotype (normal [long] wings and normal body colour). The other parent had vestigial [undeveloped] wings and ebony body colour, so it was known to be homozygous recessive for both characteristics. The resulting offspring were as follows: normal wings and normal body colour — 89 normal wings and ebony body colour — 93 vestigial wings and normal body colour — 99 vestigial wings and ebony body colour — 84 Using the following symbols: **N** normal wings **n** vestigial wings **E** normal body **e** ebony body Draw a genetic diagram in the space below showing the cross described.	
		• Correct parental genotypes linked to phenotypes; • Correct gametes;	[4]

- Correct F1 genotypes;
- Correct F1 phenotypes linked to genotypes;

Well done too :)

(c) The wing length of fruit flies with normal wings varies between 70 to 85 µm.

Suggest a reason for the variation in wing length within fruit flies with normal wings.

- environmental factors such as nutrition affected the expression of allele coding for normal wings / environmental factors such as nutrition has a small effect on wing length;

This Q was challenging for many students. Those who were able to state envt factors must substantiate with example – nutrition. [1]

(d) Alleles coding for mutant phenotypes in fruit flies are caused by artificially induced mutations in laboratory bred flies. Suggest why such mutants are unlikely to be found in natural populations.

- Mutation rate is low;
- Mutant alleles may confer selective disadvantage,
- resulting in alleles being removed by natural selection; [2]

[Total: 10]

4 Giant anteaters, armadillos and Australian numbats (*Myrmecobius fasciatus*) have many similar traits. This led some to believe that they were closely related.

Table 4.1 shows the comparison of four characteristics between the three mammals

Mammal	Characteristics			
	Diet	Body	Snout	Tongue
Armadillo	Feed on insects	Covered by bony keratinised plates	Pointy snout	Long tongues
Giant Anteater	Feed on ants and termites	Covered by hair	Elongated narrow snout	Long tongues
Numbats	Feed on termites	Covered by hair	Narrow snout	Long tongues

Table 4.1

DNA sequences of selected genes such as 18s rRNA are subsequently compared between some organisms, including the three mammals, when molecular experimental techniques advanced and the results helped clarified the evolutionary relationships of the mammals.

(a) Using Table 4.1, explain why comparison of anatomical structures led to the incorrect conclusion about the evolutionary relationships of the three mammals.

- Structures were **analogous structures** arising from **convergent evolution**;
- Both are subjected to **similar selection pressures**, e.g. same type of food (insects);
- Similar **structures** were **inherited** from **different ancestors** but selected for;
- E.g. of selective advantage: strong digging limbs to dig for insects / long tongue probe into insect nest;

About half of the 6 students were able to answer correctly. Some incorrectly stated divergent evolution which does not lead to homology. [4]

(b) Explain why the 18s rRNA gene was chosen to compare DNA sequences between organisms.

- 18s rRNA gene is **ubiquitous** / will be present in all organisms which serves as a good basis of comparison between organisms
- **Essential gene** which changes very **slowly,** useful for estimating time of divergence that occurred long time ago

Well done too :) [2]

(c) Explain how the evolution of long tongues in numbats supports Darwin's theory of natural selection.

- **Genetic variation** give rise to different tongue lengths in (ancestral) numbats
- Under a **selection pressure of** limited food/ big termite nests/ deep termite nests/AVP
- Numbats with longer tongues have a **selective advantage**/ will be **selected for** because they can probe deeper into termite nests / AVP
- Numbats with longer tongues will **survive, reproduce** and **pass down alleles** encoding for longer tongues to the **next generation**
- Over time, the **frequency of alleles** coding for long tongues will increase

Must remember to relate to the context eg "different tongue lengths". Otherwise, Well done too :) [4]

[Total: 10]

Section B

Answer **all** questions.

Write your answers on the separate answer paper provided.
Your answer should be illustrated by large, clearly labeled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in section (a), (b) etc., as indicated in the question.

5 (a) With reference to the levels of protein structure, explain how the specificity of an enzyme is determined by its structure. [8]

1. A protein has a specific primary structure which refers to the **number and unique sequence of amino acids held by peptide bonds**,
2. which is dictated by the **unique DNA base sequence of the gene**.
3. The specific primary structure is determined by the specific secondary structure (**α-helix, β-pleated sheet** or **triple helix)** formed by coiling and pleating of polypeptide chain maintained by **hydrogen bonds formed between O atom of the -CO group of one amino acid and H atom of the -NH group of another amino acid** of the **polypeptide backbone.**
4. The polypeptide chain has to be precisely folded in the **tertiary structure** to bring the constituent amino acid residues together to form the active site.
5. Tertiary structure maintained by the interactions among **R groups** of amino acids

such as hydrogen bonds, hydrophobic interaction, ionic bonds and disulphide bonds.

6. Active site amino acid residues **R groups** form a shape and charge that is complementary to substrate.
7. **R groups** of **contact residues** forms temporary interactions e.g. weak hydrogen bonds, ionic bonding with the substrate and binds the substrate
8. **R groups** of **catalytic residues a**cts on bonds of the substrate.

Words highlighted in red were missed by some students, pls take note of them.

(b) Describe how photophosphorylation differs from oxidative phosphorylation [6]

Features	Oxidative phosphorylation	Photophosphorylation
Location	inner mitochondrial membrane	thylakoid membrane of chloroplast
Functions in the presence of..	oxygen	light
Source of energy	Glucose	light
No. of electron transport chain	one	two
Electron flow	linear - one-way	linear or cyclic
Final electron acceptor	oxygen	NADP (non-cyclic) P700 (cyclic)
Involvement of water	water produced	photolysis of water
Establishment of proton gradient	protons pumped outwards from matrix across inner mitochondrial membrane into intermembrane space	protons pumped inwards from stroma across thylakoid membrane into thylakoid space
Products	ATP, water	ATP (cyclic) ATP, NADPH and oxygen (non-cyclic)

Well done too :)

(c) Describe the features of blood stem cells and explain their normal functions. [6]

- Blood stem cells are **undifferentiated/unspecialised**;
- Blood stem cells are found/located in the bone marrow (particularly the in the ribs, vertebrae, breastbone and pelvis);
- They are **multipotent** stem cells - they have the **ability to differentiate into a limited range of cell types** (and so are not pluripotent or totipotent);
- Capable of **self-renewal via mitosis** (→ undergo many rounds of proliferation) to give rise to **constant supply of blood stem cells** which
- **Differentiate** into mature types of blood cells (e.g. erythrocytes (RBC) and leucocytes (WBC)), to replace blood cells (haematopoiesis);
- Upon **signalling by growth factors**, it switches on the **transcription and translation of certain genes/differential gene expression**
- which results in production/synthesis of **specific proteins** to gives rise to **specific structures and functions** → specialised red blood cell/white blood cell;

[Any 6]

		OR	
6	**(a)**	Describe how the structure of phospholipids is related to the arrangement of phospholipids in cell membranes and explain the functions of cell membranes in one named cellular organelle	[8]

- Phospholipid has **charged / polar heads**, which can interact with one another by ionic bonds and intermolecular forces (hydrogen bonds);
- The charged / polar phospholipid heads are **hydrophilic** and interact with water and other molecules / ions in aqueous environment on either side of membrane through ionic bonds and intermolecular forces;
- The non-polar fatty acid / hydrocarbon tails are **hydrophobic** and interact with one another through hydrophobic interactions, facing inwards and creating a hydrophobic core of membrane bilayer;
- Phospholipids are arranged in a **bilayer**;
- **Non-polar fatty acid / hydrocarbon tails align** tightly together and **face inwards** of the bilayer while the **charged / polar phospholipid heads face outwards** to the **aqueous environment** on either side of membrane;
- Unsaturated fatty acid tails of the phospholipids results in **kinks** in the tails preventing phospholipids from being too closely packed, therefore maintaining fluidity of the membrane bilayer;

[max 5m]

Chloroplast

- **stalked particle / ATP synthase embedded** in **thylakoid membrane** to allow harnessing of proton motive force to generate ATP from ADP and phosphate groups;
- **proton gradient generated across thylakoid membrane** for ATP synthesis;
- **holds electron carriers of the electron transport chain** to transport electrons, releasing energy to pump H^+ into thylakoid space;
- **holds proton pumps** coupled to the electron carriers that actively transports H^+ against a concentration gradient;
- thylakoid membrane **holds the photosynthetic pigments** that absorb light energy during photosynthesis;
- thylakoid membrane **encloses the thylakoid space** to **allow a buildup of H^+**;
- inner membrane of the chloroplast contains **transport proteins** to allow transport of metabolites e.g. triose phosphate;
- **mitochondrion outer membrane contains enzymes** for various metabolic reactions e.g. tryptophan degradation;
- the envelopes of chloroplast allows for **compartmentalization** of the cell as the **chloroplast enzymes** require **different / specific conditions** from the rest of the cell to function;

Mitochondria

- **stalked particle / ATP synthase** embedded in the **inner membrane** of mitochondrion to allow harnessing of proton motive force to generate ATP from ADP and phosphate groups;
- **proton gradient generated across** the mitochondrion **inner membrane** for ATP synthesis;
- **holds electron carriers** of the electron transport chain to transport electrons, releasing energy to pump H^+ into the mitochondrial inter-membrane space;
- **holds proton pumps** coupled to the electron carriers that actively transports H^+ against a concentration gradient;
- outer and inner mitochondrial membrane **encloses the inter-membrane space** in mitochondrion to allow a **buildup of H^+**;

- both membranes of mitochondrion contains **transport proteins** to allow transport of metabolites e.g. triose phosphate;
- mitochondrion outer membrane contains enzymes for various metabolic reactions e.g. tryptophan degradation;
- the envelope of mitochondrion allows for **compartmentalization** of the cell as the mitochondrion enzymes require different / specific conditions from the rest of the cell to function;

Rough endoplasmic reticulum

- **compartmentalisation** of the cell to provide a **suitable microenvironment** for the **folding of the polypeptide chain / RER enzymes** require **different / specific conditions** from the rest of the cell for **post-translational modifications**;
- folded proteins are **packaged into vesicles** which bud / pinched off from the RER and are transported to Golgi Apparatus for post-translational modifications;
- contains **transport proteins** to allow polypeptide chains to pass through the cisternae membrane into the lumen;
- allow **attachment of ribosomes** for translation of mRNA to produce proteins targeted at membranes and for secretion;

Golgi Apparatus

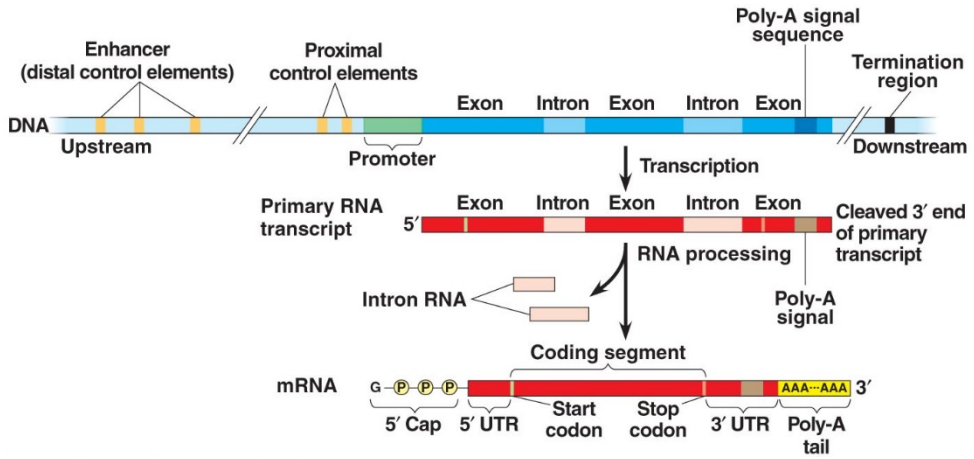
- **compartmentalisation** of the cell as **Golgi apparatus enzymes** require **different / specific conditions** from the rest of the cell for **post-translational modifications**;
- contains **transport proteins** to allow different molecules and ions to pass through the cisternae membrane into the lumen;
- modified proteins are **packaged into vesicles** which bud / pinched off from the Golgi apparatus;

Nucleus

- nuclear membrane **surrounds the chromosomal** DNA / forms the nucleus to **contain chromosomal DNA**;
- **compartmentalisation** of the cell as **enzymes for transcription require different / specific conditions** from the rest of the cell for transcription;
- nuclear membrane contains **transport proteins** to allow different molecules and ions to pass through the membrane into and out of the nucleus;

[max 3m for any one named organelle]

(b) Explain why and how eukaryotic pre-mRNA is processed. [6]



HOW (3 marks)

SPLICING –

1. The newly formed RNA transcripts (**pre-mRNA**) must undergo **RNA-processing** to yield functional **mature mRNA.**
2. **Small nuclear ribonucleoproteins** bind at the **splice sites** at **each end of the introns** to form **spliceosome.**
3. **Introns are removed/excised** and **exons flanking the introns** are **joined/spliced together** to form a **mature mRNA** with a **continuous coding**

WHY (3 marks)

1. Two different cells of different tissues can use the same gene to synthesize different proteins
2. The same type of cell at different times in the organism's life can use the same gene to synthesize different proteins.
3. RNA segments are either by treated as exons or introns in different cells.
4. A cell can carry out alternative splicing of exons, generating **different mature mRNA molecules and polypeptides** from the **same primary transcript/ pre-mRNA**, depending on which RNA segments are treated as exons and which as introns.

*AJC tutors' comments: Answers must address both **why** and **how**.*

(c)	Discuss the ethical implications of genetically modifying plants.	[6]

- GM plants grown as crops may lead to consumers having allergies as foreign proteins are produced in the plants, companies need to **label their GM crops for consumers to make informed choices / consumer safety is compromised**;
- **Animal genes** may be introduced to plant genomes, leading to concern of **vegetarians** or some religious groups which **followers are not allowed to consume certain animals**;
- Genetic modifications of certain plants may **affect food chains** / certain animals that feed on the plants.
- **E.g. of genetic modifications of plant** which **affect food chain**: Bt corn plant pollen blown onto milkweed plants can be ingested by the Monarch Butterfly;
- Cross-pollination of GM plants with other non-crop plants lead to transfer of genes, **affecting ecological balance**;
- E.g of **transfer of genes** to **non-crop plants** leading to **ecological balance** disrupted: Bt gene transferred to non-crop plants leading to these plants producing toxin killing desirable insects such as Monarch butterfly;
- GM crops lead to benefits that rich countries can enjoy due to more financial resources **at the expense of poorer countries (e.g. increasing dependence of poor countries on rich countries for expensive GM crops), increasing rich-poor divide**;
- GM crops can produce higher quality food to allow large companies that develop the technology / reduce costs to increase profit margins to **out-compete small scale farmers, increasing rich-poor divide**;
- Example of better quality food allowing higher quality food / cutting of costs to increase profit margins : Golden rice, Bt corn;
- Tampering with nature, where the mixing of genes among species may be seen as violation of organisms natural intrinsic values, crossing species boundaries;
- AVP;

[max 5m]

		Examiner's comments: *This question was low-scoring for most students as they failed to identify the ethical issues at the heart of their explanations. Most manage to explain the logical consequences or for-seeable developments of genetically modifying plants but they did not explain how these consequences or developments are ethical implications. For example, students explained GM crops having allergens that might cause an allergic reaction but they did not relate this to consumer safety or companies having the ethical responsibility to label their food as GM food. As a result, students failed to score any marks for this marking point.* *Vague statements about 'going against the natural way of life therefore tampering with nature', 'playing God' or 'beliefs of vegetarians' were rejected.* *Other vague statements such as 'alterations of the genome' were not credited as well. These explanations about tampering with nature should revolve around 'mixing of genes from different species' instead.* *Many students also confused religious groups with vegetarians by writing statements like 'GM plants may not be suitable for consumption for people of various religious groups who may be vegetarian'.* *Many answers mentioned the 'transfer of traits' during cross-breeding. This is inaccurate as genes are actually transferred or inherited, not traits. Students should be careful with the words / phrases they use in order to explain concepts accurately.* *There were various over-generalisations and simplifications of scientific concepts in the ethical issues raised. Examples include 'consumption of GM food leads to antibiotic resistant bacteria', 'cross breeding of GM plants with wild type plants lead to loss of biodiversity', 'GM food production technology is expensive and therefore lead to exploitation of the poor', 'unforseen circumstances in nature and biodiversity' and 'richer countries have the resources to produce the plant in high yield putting them at an advantage over poorer countries and widening the income disparities'. Students need to understand that ethical and social implications in the syllabus are grounded in scientific concepts which must be explained correctly and clearly. Students are advised to read their notes on social and ethical implications properly. In addition, there is a need to be careful not to mix up social and ethical implications of stem cells and gene therapy, GMOs and HGP. They are all different.* *Any points made in reference to animal rights were ignored as they do not answer the question.*	
			[Total: 20]