Civics Group	Index Number	Name (use BLOCK LETTERS)	H1

ST. ANDREW'S JUNIOR COLLEGE
2016 Preliminary Examination

H1 BIOLOGY **8875/2**

Paper 2: Core (Mark Scheme)

Monday 29th August 2016 2 hours

Additional Materials: Answer Paper
Cover Sheet for Section B

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagram, graph or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** the questions.

Section B
Compulsory question to be answered on writing paper provided.

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	/16
2	/12
3	/12
Sub-total	/40
Section B	
5 or 6	/20
Total	/60

This document consists of **15** printed pages.

[Turn over

Section A

Answer **all** *questions*.

QUESTION 1

Amylase is an enzyme that catalyses the break down of starch into maltose. A student investigated the effect of pH on the activity of amylase from saliva and pancreas. He monitored the time taken for 2.0 cm^3 of starch solution to be completely hydrolysed by the two types of enzymes at pH 5.0 and pH 8.5 respectively. The temperature of the reactions was kept constant at 37°C. He tabulated his findings in Fig. 1.1.

Fig 1.1

Amylase from	pH	Time taken for starch to be completely hydrolysed / s
Saliva	5.0	88
Saliva	8.5	35
Pancreas	5.0	252
Pancreas	8.5	26

(a)(i) Describe one similarity in the effect of pH on the activity of amylase from saliva and pancreas.

……..……..[2]

1 Both amylases have higher activity at pH 8.5 than at pH 5.0 ;
2 Amylase from saliva took 35s to completely hydrolyse starch at pH 8.5 but took 88s at pH 5.0 while amylase from pancreas took 26s to completely hydrolyse starch at pH 8.5 but took 252s at pH 5.0 ;

(ii) Describe two differences in the effect of pH on the activity of salivary amylase and pancreatic amylase.

……..……..[2]

1 Amylase from pancreas has a slightly higher activity than amylase from saliva at pH 8.5 as it took 9s less than salivary amylase to completely hydrolyse starch ;
2 Salivary amylase has a much higher activity than pancreatic amylase at pH 5.0 as it took 164s less to completely hydrolyse starch ;

(b) Collagen is an important structural component of skin, ligament and tendons. Describe the various levels of protein folding that gives it its fibrous structure.

……..……..……..[4]

1 The <u>primary structure</u> of collagen is made up of **more than 1000 amino acid residues** and is **rich in glycines, lysines and prolines** / has a repeating motif of **Gly-X-(hydroxyl)Pro** ;
2 In the <u>secondary structure</u>, each polypeptide folds spontaneously into a (alpha chain with a) **helical** structure ; **REJECT** α helix**,** references to hydrogen bonding
3 In the <u>quaternary structure</u>, three polypeptides coil around each other to form a <u>triple helix</u>, held together by <u>hydrogen bonds</u> between <u>–NH group of glycine</u> on each strand and <u>–CO group of amino acid residues</u> on the other two strands ; also involving <u>hydroxyproline</u> ;
4 (Higher levels of structure) Multiple tropocollagen assemble in a <u>staggered conformation</u>, held together by <u>covalent</u> cross linkages between <u>lysines and hydroxylysines</u> to form fibrils ;
5 Aggregation of <u>fibrils</u> to form <u>fibres</u> ; **REJECT** referenecs to microfibril, macrofibril

(c) Fig. 1.2 shows some onion cells undergoing mitosis.

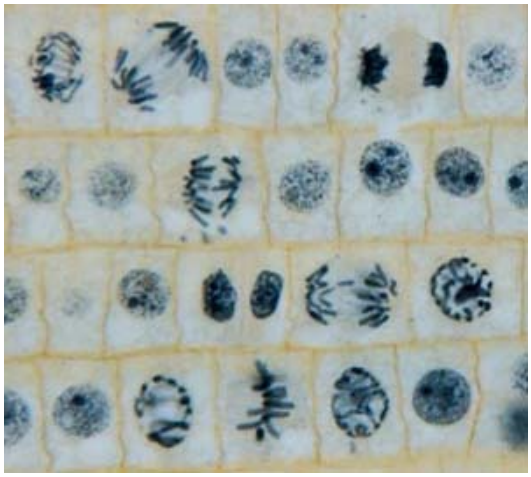
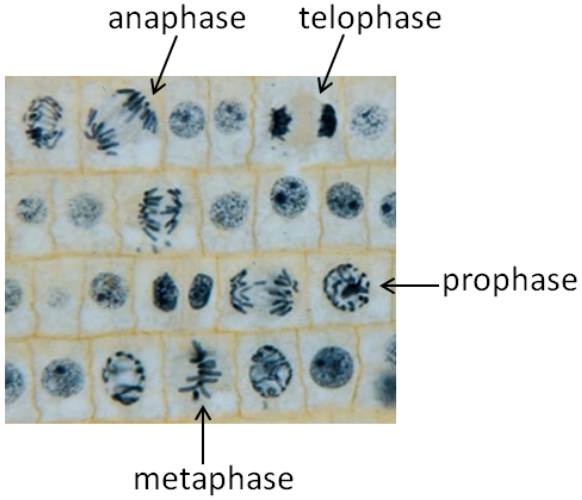


Fig. 1.2

(i) Identify (with arrows and labels) one cell each that is undergoing prophase, metaphase, anaphase and telophase.

……[1]



(ii) Describe the events of anaphase.

……[2]

1 Centromeres divide, sister chromatids separate into individual chromosomes ; **REJECT** centromeres split

2 Sister chromatids are pulled to **opposite poles** of the cell by shortening of kinetochore microtubules (with the centromeres leading) ;

(iii) Describe the process of cytokinesis in the onion cells.

……[2]

1 Cellulose (produced in the Golgi body) are packaged into Golgi vesicles and transported to the metaphase plate / middle of the cell ;

2 Where they **fuse together** (and deposit the new cell wall materials), forming the cell plate, until it completely separates the two daughter cells ;

(d) There are some reactions in plants which are crucial for its survival and growth. Explain the effect of a base addition to the gene coding for Ribulose-1,5-bisphosphate carboxylase/oxygenase (RuBisCO) enzyme.

……[3]

1 Addition of a base leads to **frameshift** mutation which results in a **different mRNA sequence** ;
2 Different amino acid sequence / primary structure (of polypeptide) ;
Different R group (as original amino acid) ;
3 Different 3D configuration of enzyme
/ Different 3D shape of active site ;
4 No fixing of carbon dioxide to RuBP to form PGA (in Calvin cycle) ;

OR

1 Addition of a base leads to **frameshift** mutation which results in a **different mRNA sequence** ;
2 Generation of **new stop codon**, resulting in **truncated** protein ;
3 No fixing of carbon dioxide to RuBP to form PGS (in Calvin cycle) ;

[Q1 Total: 16]

QUESTION 2

Fig. 2.1 shows a process happening in a eukaryotic cell.

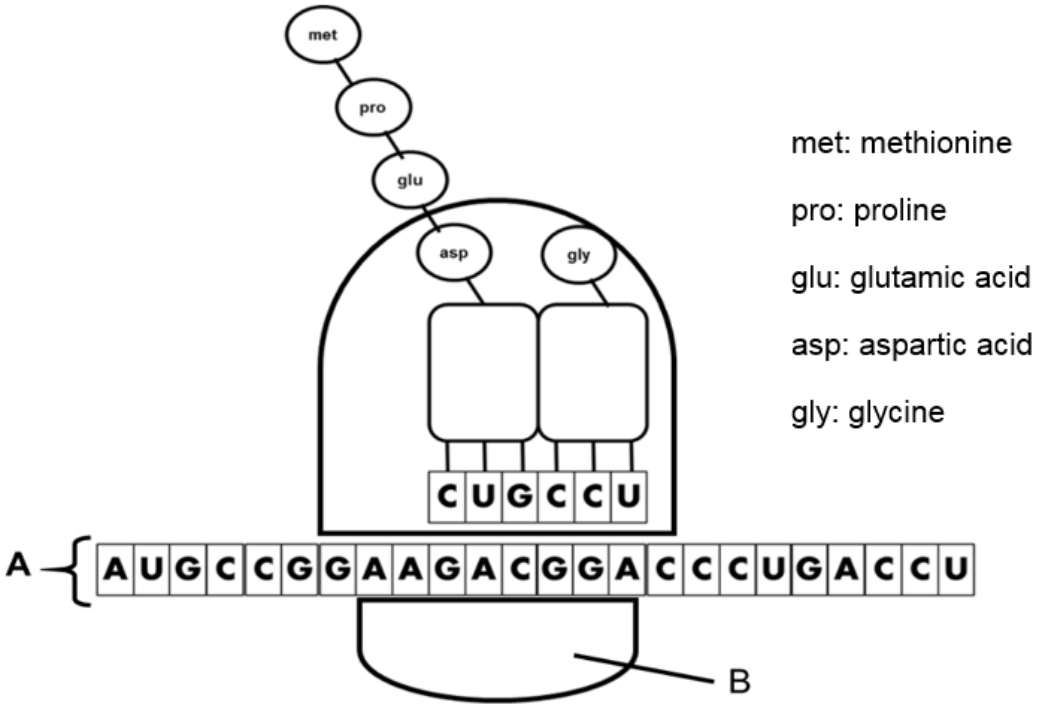


Fig. 2.1

(a) Name the structures labelled **A** and **B**. [1]

A: _____

B: _____

A: messenger RNA ;
B: small ribosomal subunit ;

(b) Relate the structure of **A** to its role in protein synthesis.

……[1]

1 Sequence of A is complementary to the DNA template ; hence, can relay information from nucleus to the cytoplasm
/ Codons in mRNA are complementary to/form complementary base pairs with anti-codons in tRNA ; specify the sequence of amino acids in a polypeptide;
2 Start and stop codon ; determines initiation and termination of translation;

(c) Outline one change to **A**, following completion of transcription in the nucleus before it can used for the process in Fig. 2.1.

……[1]

1 Splicing: Excision of introns and ligation of exons together by spliceosomes
/ Polyadenylation
/Addition of a **long chain of adenine nucleotides** to 3' ends of the pre-mRNA.

(d) How many amino acids does the protein, encoded by the section of **A** shown in Fig. 2.1, have?

……[1]

1 6 (UGA is a stop codon) ;

(e) An antibiotic which affects the elongation stage of the process in Fig. 2.1, is added shortly after initiation, such that truncated polypeptides are formed instead.

With reference to Fig. 2.1, suggest and explain how the antibiotic works to give rise to a tripeptide.

……[3]

1 Binds to the A-site / amino acyl (tRNA binding) site on ribosome (by complementary shape) ;
2 Prevents the entry of aminoacyl tRNA carrying **aspartic acid** / activated **aspartic acid** ;
/Prevents complementary base pairing between anti-codon, CUG, of tRNA (carrying aspartic acid) and corresponding mRNA codon GAC ;
3 No formation of peptide bond between **glutamic acid and aspartic acid** ;
(Elongation cannot proceed).

AVP:

1 Inhibits peptidyl-transferase of large ribosome ;
2 Ref. competitive/ non-competitive inhibition mechanisms ;
3 No formation of peptide bond between **glutamic acid and aspartic acid**.
(Elongation cannot proceed).

(f) Tetracycline is an example of a ribosome-targeting antibiotic which is effective only towards bacterial cells.

Suggest why tetracycline has no effect on eukaryotes.

……[2]

1 Eukaryotes have 80S ribosomes but bacteria have 70S ribosomes ;
2 Tetracycline is only **complementary in shape** to the **A-site**/aminoacyl (tRNA binding) site of the 70S ribosomes ;

(g) Discuss one problem of producing eukaryotic proteins using a prokaryotic host and how it can be overcome.

……..…….....……[3]

[Problem]

1 Prokaryotic hosts do not have spliceosomes and cannot remove introns in eukaryotic genes ;
2 Introns will be translated, causing the wrong amino acids to be incorporated into the protein or presence of stop codon in intron leads to premature termination of translation ;

[Solution]

3 Synthesize the cDNA of the gene from the mRNA using reverse transcriptase/ / Use of eukaryotic cells such as yeast or mammalian cells which can perform RNA splicing ;

OR

[Problem]

4 Prokaryotic hosts do not have Golgi body and RER and cannot perform post-translational modifications (such as glycosylation) ;
5 The polypeptides produced may not be biologically active ;

[Solution]

6 Use of eukaryotic cells such as yeast or mammalian cells as hosts for cloning and /or expressing eukaryotic genes of interest ;

OR

[Problem]

7 Only eukaryotic promoters (and other DNA control sequences) present / no prokaryotic promoters present
8 Bacterial cells may not be able to recognize eukaryotic promoter sequences (and other control elements)

[Solution]

9 Use an expression vector which contains a prokaryotic promoter (and any other control elements) necessary for the gene's transcription (and translation).

[Q2 Total : 12]

QUESTION 3

Some beetles have spines on their legs to help them capture prey. Three alleles determine the presence and type of spines a beetle will produce. The inheritance of a single L^C allele produces curved spines on the legs. The L^s allele is recessive to L^C allele, and produces straight spines. Beetles that are homozygous recessive for the L^n allele produces no spines on its legs.

When a beetle with curved spines was crossed with a beetle with straight spines, they produced the following offspring:

62 curved spines
28 straight spines
30 no spines

(a)(i) Define the term homozygous.

……[1]

1 Genotype of two **identical** alleles at a (particular) gene <u>locus</u> of homologous chromosomes

(a)(ii) Draw a genetic diagram to show the cross between the beetle with curved spines and the beetle with straight spines described above.

……[5]

Parental phenotype: Curved spines x Straight spines

Parental genotype: L^CL^n x L^sL^n

Gametes: L^C L^n L^s L^n

F_1 genotypes: L^CL^s L^CL^n L^sL^n L^nL^n

F_1 phenotypic ratio: 2 curved spines : 1 straight spines : 1 no spines

Mark scheme:
1 Parental genotype ;
2 Gametes (circles) ;
3 F_1 genotypes ;
4 F_1 penotypes corresponding with genotype ;
5 F_1 phenotypic ratio ;

(iii) If an F_1 offspring with curved spines was picked at random and test crossed with a beetle with no spines, what is the probability of producing beetles with no spines? Show your working.

……[2]

1 Probability of picking L^CL^n = ½
Probability of producing no spines when L^CL^n is test crossed = ½
2 Overall probability = ½ x ½ = ***<u>¼</u>***

(b) Explain how genotype is linked to phenotype.

……..……..……..……..……..……..……[4]

1 Paired alleles of a genotype are expressed to produce a phenotype ;
2 When **complete dominance** of one allele over the other, the dominant allele will be expressed in the phenotype in homozygous and heterozygous condition ;
3 Recessive allele will only be expressed in the phenotype in homozygous condition ;
4 When 2 alleles are **co-dominant**, both alleles are equally expressed in the phenotype of the heterozygote ;

[Q3 Total : 12]

Section B

Answer one question.

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.

4 **(a)** Using two examples, explain the significance of genetic engineering in improving the quality and yield of crop plants. [5]

(b) Discuss the ethical implications of genetically modified crop plants. [5]

(c) Explain the effects of temperature and carbon dioxide concentration on the rate of photosynthesis. [10]

[Total: 20]

OR

5 **(a)** A guppy *(Poecilia reticulate)* is a species of small fish which originates in the freshwater mountain streams of the islands of Trinidad and Tobago.

It was observed in one stream, the guppies have bright and colorful rainbow markings, while in another neaby stream they would be less brightly colored.

Explain how natural selection may bring about the evolution of the less brightly colored guppies in the other stream. [5]

(b) Explain why variation is important in selection. [5]

(c) Explain how gene mutations can result in diseases such as sickle cell anaemia. [10]

- **END OF PAPER –**

4 (a) Using two examples, explain the significance of genetic engineering in improving the quality and yield of crop plants. [5]

Pest-resistant plants [improved yield]

1 Eg. Corn / potato / broccoli / tomato plant crops are genetically engineered to carry the Bt toxin gene (from the bacteria *Bacillus thuringiensis*);; which is expressed to produce the Bt toxin;
2 When an insect pest ingests Bt toxin, enzymes in the caterpillar's stomach convert it into an insect-specific toxin, causing paralysis and death;;
3 crop losses can be reduced, leading increased profits in agriculture;;

Herbicide resistant plants [improved yield]

1 E.g. Glyphosate-resistant soybean / tomato crops are genetically engineered to carry the EPSP synthase gene which is then expressed to produce **high** levels of EPSP synthase in the plant;;
2 This results in resistance towards glyphosate-containing herbicides which works by inhibiting EPSP synthase,
3 and genetically engineered crops are able to survive in the presence of glyphosate-containing herbicides while weeds are destroyed.

4 crop losses can be reduced, leading increased profits in agriculture;; **[award once in entire essay]**

Plants with improved nutritional qualities [improved quality]

1 E.g. Golden rice produced by transplanting genes from daffodil and bacteria;; that encode for proteins involved in synthesis of beta-carotene;;
2 Beta-carotene is a precursor for synthesising Vitamin A.
3 Help prevent Vitamin A deficiency in developing countries, which can lead to blindness and susceptibility to disease;;

Plants with delayed ripening [improved quality]

1 Eg. Flavr-Savr tomato are genetically engineered to carry an antisense gene of the polygalacturonase enzyme which encodes for an antisense RNA complementary to the mRNA that codes for the enzyme which is normally responsible for the ripening process,
2 polygalaturonase mRNA is not translated and no enzyme produced.
3 delay in fruit ripening / reduced spoiling during transport / improved shelf life;; / larger and has greater flavour;;

(b) Discuss the ethical implications of genetically modified crop plants. [5]

Meddling with biological processes [Ethical]

1 Some groups or individuals see the generation and use of GMO as intolerable meddling with biological states or processes that have naturally evolved over long periods of time [Reject: "playing God"]

Religious issues on GM foods [Ethical]

2 religious implications in food choice, especially when GM foods are unlabelled;

3 Eg. incorporation of pig genes into plants/other animals;

Human health and safety

4 Introduction of foreign gene may result in production of secondary metabolites which may be **toxic t**o animals themselves and/or livestock/humans that consume them.

5 New proteins in GM plants may be potentially **allergenic** to humans that consume them.

6 Vectors used in GE contain genes for **antibiotic resistance**. When these transgenic crops are eaten, these genes may pass from the plant to the *E. coli* in the gut, making them resistant to antibiotics.

(c) Explain the effects of temperature and carbon dioxide concentration on the rate of photosynthesis. [10]

Temperature [Max 6]

[Max 2]

1 At low temperatures, the rate of photosynthesis is low.
2 Low kinetic energy of enzymes and substrate molecules, molecules move slowly;
low frequency of effective collisions between enzyme and substrate ;
3 Less ESC formed per unit time and less products formed per unit time.

[Max 2]

4 An increase in temperature to the optimum temperature of the enzyme, increases the rate of photosynthesis.
5 Increase in kinetic energy of enzymes and substrate molecules, increase in frequency of effective collisions between enzyme and substrate ;
6 The rate of photosynthesis doubles for every 10°C increase in temperature up to the optimum temperature.

[Max 2]

7 As temperature increases beyond optimum temperature, rate of photosynthesis decreases, and eventually stops.
8 Disruption of hydrogen, ionic bonds, and hydrophobic interactions maintaining the 3D conformation of enzyme,
9 hence disruption of the 3D conformation of active site; enzymes denatured; rate of reaction is zero when all enzymes are denatured.

Carbon dioxide concentration [max 4]

10 An increase in the concentration of carbon dioxide increases the rate of photosynthesis linearly.
11 Carbon dioxide is fixed in the Calvin cycle (light-independent reaction) to form PGAL which is then converted to sugar and other complex molecules in other biochemical pathway. An increase in the carbon dioxide concentration increases the rate at which carbon is incorporated into carbohydrate in the Calvin cycle, and so the rate of photosynthesis increases.

12 As carbon dioxide concentration continues to increase, the rate of photosynthesis reaches a maximum and remains constant.
13 *[*An increase in carbon dioxide concentration has no effect on the rate of photosynthesis as other factors such as light intensity become limiting.

5 (a) A guppy *(Poecilia reticulate)* is a species of small fish which originates in the freshwater mountain streams of the islands of Trinidad and Tobago.

It was observed in one stream, the guppies have bright and colorful rainbow markings, while in another neaby stream they would be less brightly colored.

Explain how natural selection may bring about the evolution of the less brightly colored guppies in the other stream. [5]

Natural selection

1 Genetic variations exist within the guppies population due to mutation ;
2 The selection pressure is exerted by the presence of predators (e.g. larger fish);
3 Guppies that are less brightly colored have a selective advantage because they are less easily spotted and eaten by predators (as compared to the big and colourful guppies) ;
4 They are better to survive to reproductive age and produce viable, fertile offspring, passing these alleles conferring advantageous characteristics to their offspring ;
REJECT advantageous characteristics

Evolution

5 **Over many generations**, guppies which are less brightly colored become the predominant phenotype, leading to **change in allele frequencies** in the population.

(b) Explain why variation is important in selection. [5]

1 **Genetic variations** may be caused by (**spontaneous) mutations** which **creates new alleles** and increases the gene pool for natural selection to operate ;
2 This results in **phenotypic variation** in a given population which is needed for **natural selection** to act on ;
3 Populations with variations are generally better adapted to changes in environment ;
4 Different environment have different selection pressures which 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 ;
5 Resulting in the individual able to **survive till reproductive age and reproduce** successfully, thus passing down **alleles conferring advantageous characteristics to the next generation ;**
6 In the absence of variation, selection pressure acts equally on all individuals. Hence, evolution by natural selection cannot occur ;

(c) Explain how gene mutations can result in diseases such as sickle cell anaemia. [10]

1 change of sequence of DNA due to a base substitution in the haemoglobin β chain gene causes a change in mRNA codon
2 resulting in change in the (sixth) amino acid from glutamic acid to valine
3 results in change in the amino acid **sequence** / primary structure of HbS protein
4 Glutamic acid is hydrophilic whereas valine is hydrophobic
5 R-group of valine form different bonds with other amino acids result in different tertiary structure / 3D conformation

[Effects of change of DNA sequence on haemoglobin and red blood cells]

6 **At low oxygen concentration,** solubility of deoxygenated HbS decreases.
7 HbS molecules stick to each other via their **hydrophobic regions**, resulting in the polymerisation of the molecules into long fibres inside red blood cells.
8 fibers of abnormal haemoglobin deform red blood cells into sickle shape.

9 sickle-shaped RBCs are ineffective in transporting oxygen gas.
10 sickle-shaped RBCs clump and clog small capillaries , thus obstructing other cells from moving through the capillaries.
11 sickle-shaped RBCs have shorter life span compared to normal cells and hemolyse readily.