



MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations 2015
Higher 1

CANDIDATE
NAME

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CIVICS
GROUP

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INDEX
NUMBER

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H1 BIOLOGY

8875/02

Paper 2

17 September 2015

2 hours

Additional Materials: Answer papers

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

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 diagrams, graphs or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

Section A

Answer **all** questions.

Section B

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

At the end of the examination,

1. Fasten your answer papers to section B securely together.
2. Hand in the following separately:
 - Section A
 - Section B

The number of marks is given in brackets [] at the end of each question or part question.

ANSWER SCHEME

For examiner's Use	
Section A	
1	/ 8
2	/ 10
3	/ 8
4	/ 14
Section B	
5 / 6	/ 20
Total	/ 60

This paper consists of __ printed pages.

[Turn over]

Section A

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

QUESTION 1

Fig. 1.1 shows a structure involved in one of the steps in gene expression in a eukaryotic cell.



Fig. 1.1

a) Describe the importance of the structure shown in Fig. 1.1 in gene expression. [2]

- Polyribosome / many ribosomes to translate a single mRNA at any one time
- Increases the rate of translation / polypeptide synthesis

b) Transfer RNA (tRNA) is also involved in gene expression.

Describe how its structure facilitates its function in gene expression. [2]

- tRNA 3' CCA stem binds to correct amino acid
- Contains an anti-codon which is complementary to a specific mRNA codon
- There are 20 different kinds of tRNAs which bring the corresponding amino acid to the A or P (in the case of initiator tRNA) sites on the ribosome

c) Glucose transporters (GLUTs) are transmembrane proteins found in the cell surface membrane of many cells, such as liver and muscle cells. These cells increase the number of GLUTs when there is a need for the body to lower its blood glucose concentration.

Outline how GLUTs on the cell surface membrane are formed after its polypeptide is synthesized in the rough endoplasmic reticulum. [4]

- The GLUT polypeptide is embedded in the Endoplasmic Reticulum (ER) membrane...
- ...and the polypeptide chain folds into its 3D conformation in the lumen.
- In the ER/GA lumen, the protein undergoes glycosylation.
- ER vesicles with the embedded protein buds off from the ER and travel towards and fuses with the cis face of the Golgi apparatus.
- The protein gets embedded in the GA membrane, and the modified protein is packaged into a Golgi vesicle which buds off from the GA.
- [compulsory] The Golgi vesicle with the embedded protein moves towards and fuses with the cell surface membrane via exocytosis.

[Total: 8]

QUESTION 2

Fig. 2.1 shows four ways by which spindle fibres may attach to chromosomes.

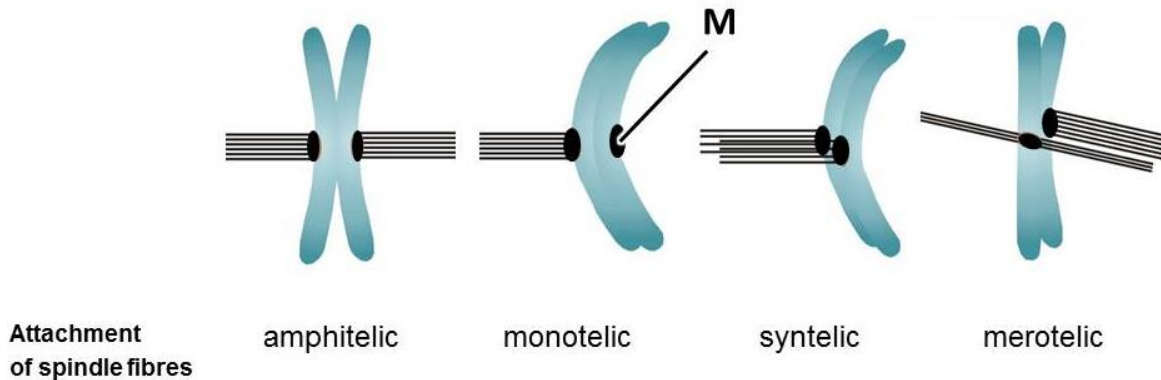


Fig. 2.1

a) Explain why there are two sister chromatids per chromosome in mitosis. [2]

- DNA replication occurred in S phase of interphase, before mitosis
- The number of DNA molecules doubled
- Resulting in two sister chromatids which are attached to each other by their centromere

b) With reference to Fig. 2.1,

i) Identify structure **M** and explain its role. [2]

- Kinetochore proteins...
- Which are complementary in shape and hence bind to centromere
- This allows their attachment to spindle fibres

ii) state and explain how spindle fibres should be attached to sister chromatids during mitosis. [2]

- Amphitelic attachment of spindle fibres to chromatids / kinetochore / centromere...
- ...where spindle fibres from each pole of the cell attaches to the kinetochore on one sister chromatid of each chromosome
- This ensures that each sister chromatid is pulled to opposite poles of the cell during anaphase

c) Explain how a mutation in a gene that usually slows mitosis might increase the chances of a cancerous growth forming. [3]

- Mutations in a tumour-suppressor gene...
- ...may result in a change in primary structure of the protein hence affects its folding into its 3-dimensional structure
- non-functional protein that cannot slow mitosis, thus mitosis speeds up.

d) Suggest an outcome of the syntelic attachment of spindle fibres to the sister chromatids during meiosis II. [1]

- Unequal distribution of chromosomes in daughter cells
- Non-disjunction of chromosomes
- Aneuploidy of daughter cells
- **AVP**

[Total: 10]

QUESTION 3

Coat colour in cats is determined by a gene with two alleles coding for black and orange, which exhibit co-dominance.

When black cats are mated with orange cats:

- the female offspring are always tortoiseshell (black and orange patches).
- the male offspring are always the same colour as the mother.

a) Explain what is meant by *gene* and *co-dominance* in the above context. [2] **KWU-1**

Gene

- sequence of nucleotides/bases that codes for a polypeptide that results in either black or orange coat colour

Co-dominance

- the allele for black coat and the allele for orange coat are equally expressed in a heterozygote, resulting in a tortoiseshell phenotype

b) Using the symbols **B** for the allele for black coat and **O** for the allele for orange coat, construct a genetic diagram to show the cross between a tortoiseshell female and a black male. [4] **HISP-2**

X^B – allele B carried on the X chromosome

X^O – allele O carried on the X chromosome

Y – Y chromosome

Parental phenotype	tortoiseshell female		black male		
Parental genotype	$X^B X^O$		$X^B Y$		[1]
Gametes	$\textcircled{X^B}$	$\textcircled{X^O}$	$\textcircled{X^B}$	\textcircled{Y}	[1]
Offspring genotype	$X^B X^B$	$X^B Y$	$X^B X^O$	$X^O Y$	[1]
Offspring phenotypic ratio	black female	black male	tortoiseshell female	orange male	[1]
	1	1	1	1	

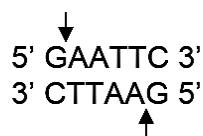
c) Explain why any tortoiseshell cat cannot be a male. [2] **KWU-1**

- Tortoiseshell is heterozygous ($X^B X^O$)
- Males are heterogametic / only has one X chromosome
- Therefore, only one copy of the gene, either the black or orange allele, is present.

[Total: 8]

QUESTION 4

Restriction enzymes typically recognize palindromic sequence comprising 4 to 8 base pairs. For example, the recognition site for *EcoRI* is



The arrows indicate the site of cleavage. Such restriction enzymes typically consist of two identical subunits (homodimer), each comprising an active site.

Another class of restriction enzymes recognize non-palindromic sequence. For example, the recognition site for *BbvCI* is



a) Using the above information, suggest how the structure of *BbvCI* restriction enzyme enables it to cleave non-palindromic sequence. [3]

- Consist of two different protein subunits / heterodimer
- Two different active sites
- Each active site has a complementary shape to each of the sequence

OR

One has a complementary shape to 5' CCTCAGC 3' and the other has a complementary shape to 5' GCTGAGG 3'

Restriction enzymes are indispensable tools used in genetic engineering. Golden Rice™ is a genetically modified form of rice that produces relatively large amounts of beta-carotene in the endosperm. Beta-carotene is metabolised in the human body to produce vitamin A.

b) Explain why rice has been genetically modified to produce extra beta-carotene. [2]

- **Ref. to** vitamin A deficiency in developing countries
- Rice is a staple food / forms a major part of diet in those countries
- Increases vitamin A in diet to prevent blindness

- c) The first type of Golden Rice™ produced only a very low mass of beta-carotene per gram of rice. Research continued to try to increase this.

Fig. 4.1 shows the metabolic pathway by which beta-carotene is synthesised in plants, and the enzymes that catalyse each step of the pathway.

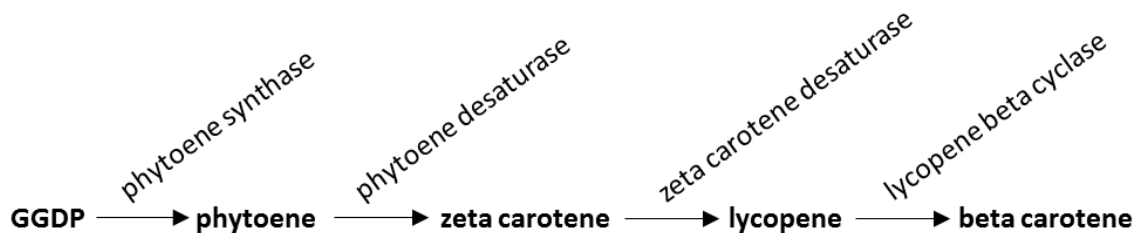


Fig. 4.1

The first type of Golden Rice™ contained a phytoene synthase gene, *psy*, from daffodils and a gene *crtl*, which produced the two desaturase enzymes, from the bacterium *Erwinia uredovora*.

Measurements of the quantities of intermediates in this metabolic pathway in rice endosperm showed that there was always a large amount of GGDP present, and that no phytoene accumulated in the tissues.

Explain how this suggests it was not the enzymes produced by the *crtl* gene that were limiting the production of beta-carotene. [2]

- GGDP present in large amounts / accumulates / remains high
 - Phytoene synthase is limiting because of its low expression / low activity
- [Reject: non-functional, since the pathway is on-going]**

OR

- Desaturases are not limiting production because phytoene does not accumulate
- Hence, desaturases are functioning normally / converting phytoene to other compounds

- d) An agreement has been made between the commercial company that owns the production rights of golden rice and its developers. This allows the developers to give the rice to government-run breeding centres in rice-dependent countries. This agreement has addressed some concerns that initially arose from growing Golden Rice™.

State these concerns that initially arose from growing Golden Rice™. [2]

- GM seeds could be difficult for farmers in developing countries to obtain.
- GM seeds are too expensive for farmers to buy
- Patenting prevents farmers from re-sowing the GM seed from Golden Rice™ crops
- Erodes farmers' income
- Prices of such genetically engineered rice crops could be raised.
- **AVP**

The polymerase chain reaction (PCR) is a molecular technique which involves the use of DNA primers to amplify a section of DNA from a minute starting amount.

- e) Explain why the nucleotide sequence of primers is critical to its function in PCR. [2]
- Primer has to be complementary to the 3' regions of the sequence to be amplified.
 - Ensures specificity – only the sequence of interest is amplified.
- f) Scientists have found a new method of copying DNA that is faster than PCR. The new method, called helicase-dependent amplification (HDA), uses the enzyme helicase to separate the two strands of DNA. This means that DNA can be copied at a constant temperature of 37°C. In all other mechanical aspects, HDA works in exactly the same way as PCR.
- i) Explain why HDA will not work with *Taq* DNA polymerase. [2]
- The optimal temperature for *Taq* polymerase is 72°C.
 - At a constant temperature of 37°C where HDA is carried out, *Taq* polymerase will be inactive [Reject: denatured]
- ii) Explain why HDA is faster than PCR in amplifying DNA. [1]
- Since HDA operates at a constant temperature, time is not wasted in heating and cooling the mixture.

[Total: 14]

Section B
Answer **one** question.

Write your answers on the separate answer paper provided.
Your answers 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 questions **(a)**, **(b)**, etc., as indicated in the question.

QUESTION 5

- a)** The optimum pH for the activity of rubisco is pH8 (alkaline).

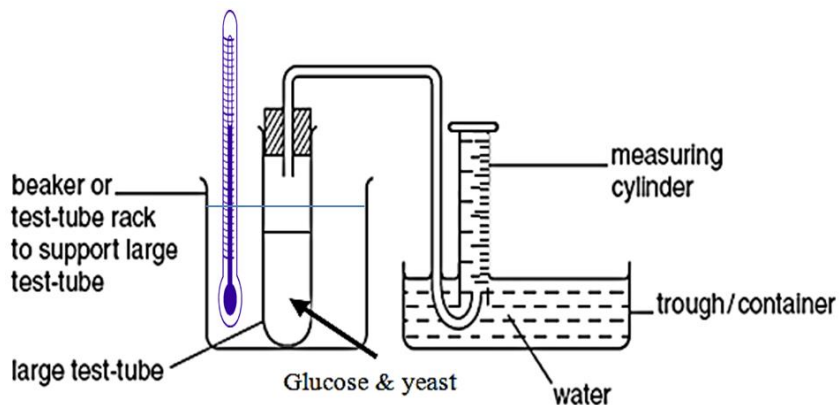
Describe how the illumination of chloroplasts leads to optimum pH conditions for rubisco. [7]

1. Photolysis of water at PS-II to form proton and electrons
2. To replace the excited electrons emitted from photosystems
3. Transported along the thylakoid membrane
4. By electron carriers of progressively lower energy levels
5. Energy released from electron transport
6. Used to pump protons from stroma into thylakoid space
7. Lesser amount of protons in the stroma raises pH to alkaline
8. RUBISCO is in stroma

- b)** Respiratory enzymes in yeasts oxidize glucose, releasing carbon dioxide as a by-product.

Describe an investigation into the effect of varying temperatures on the rate of respiration in yeasts. [8]

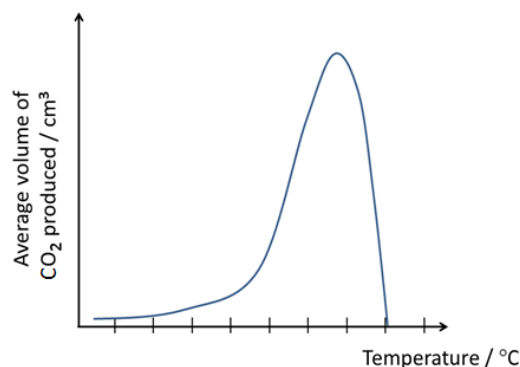
- Design each experimental set-up to correspond to a range of temperatures - 10°C, 20°C, 30°C, 40°C, 50°C, using hot/cold water and thermometer
- The following factors were controlled to remain constant for each temperature investigated.
 - The concentration and volume of glucose
 - The concentration and volume of yeasts
 - Time allowed for respiration to occur
- Acclimatize yeasts and glucose solution separately at the temperature being investigated
- Mix an equal amount of yeasts and glucose solution and stir well.
- Set up the apparatus below **[Accept: gas syringe or other appropriate apparatus]**



- After a **fixed time** (e.g. 5min), the volume of carbon dioxide gas released is read off from the inverted measuring cylinder.
- **Three replicates** were carried out for each temperature so that the **average volume** can be computed to **minimize error**.
- **Negative control** – a set-up **without yeasts** serves as a negative control to show that carbon dioxide production is due to yeasts undergoing respiration.
- Table of results

Temperature / °C	Volume of carbon dioxide produced in 5 min / cm ³			
	1	2	3	Average
10				
20				
30				
40				
50				

- Graph



- Risks and precautions

Risk	Precautions
Yeasts can be a skin irritant	Wear gloves and goggles. Wash hands immediately when come into contact.

c) Explain the role of variation in evolution. [5]

1. Members of a population are genetically different thus exhibit phenotypic variation within the population / **idea of** different alleles in a population
2. Some variations allow an individual to be better adapted / at a selective advantage
3. Better adapted individuals survive to reproductive age to pass on advantageous alleles to their offspring.
4. Individuals with less adaptable variation die before reproductive age.
5. **Idea that** allele frequency changes over time.
6. Variation is important as it decreases the chances of extinction as a result of natural selection.

[Total: 20]

QUESTION 6

a) Compare tropocollagen and amylose.

[6]

Similarities [at least 1]

1. Both are **polymers**/ made up of many monomers.
2. Both are macromolecules that are **insoluble in water**.
3. **Length** of chains may **vary**.
4. Both are stabilised by **hydrogen bonds**.

Differences [max 5]

	Tropocollagen	Amylose
6. Elements	C, H, O, N, S	C, H, O
7. Nature	Fibrous protein	Polysaccharide
8. Monomer	Amino acid	α -glucose
9. No. of types of monomers	20 types	1 type
10. Bond between monomer	Peptide bond	α -1,4 glycosidic bonds
11. Hydrogen bonds	Hydrogen bonds between chains	Hydrogen bonds within chain
12. Overall shape	Linear (chains) shape	Helical shape
13. No. of chains	3 polypeptide chains	1 polysaccharide chain
14. Function	Structural material found extensively in connective tissue, bones, cartilage, dermis (skin), blood vessels and teeth	Energy store (in plant cells)
15. Site of synthesis	Rough endoplasmic reticulum and Golgi apparatus	Cytosol
16. AVP	AVP	AVP

- b) The cell surface membrane consists of phospholipids and cholesterol. Describe how their structures and properties are related their functions. [6]

PHOSPHOLIPIDS	
Structure and property [max 3]	Function [max 3]
<p>1. Amphipathic - comprises hydrophobic fatty acid tails and hydrophilic phosphate heads.</p> <p>2. Forming a lipid bilayer where hydrophobic fatty acid tails face inwards and hydrophilic phosphate heads face outwards/the aqueous cytosol and extracellular matrix.</p> <p>3. Phospholipids are held by weak hydrophobic and hydrophilic interactions, hence can move laterally/are fluid.</p> <p>4. Carbohydrate chains can be linked to lipid to form glycolipids.</p> <p>[Reject: Consists of one glycerol, two fatty acid chains and one phosphoric acid group – no corresponding function].</p>	<p>2a. Lipid bilayer separates cell from the extracellular environment.</p> <p>2b. Hydrophobic region allows it to act as a barrier/regulates transport across membrane, as it allows only small, hydrophobic/lipid-soluble/non-polar substances to pass through.</p> <p>[Max 2]</p> <p>3a. Idea that it can form vesicles, OR</p> <p>3b. Its fluidity create transient gaps to allow diffusion of small, non-polar molecules, OR</p> <p>3c. Its fluidity allows the membrane to can reseal itself if it is disrupted, OR</p> <p>3d. AVP</p> <p>4a. Glycolipids are involved in cell-cell recognition. Carbohydrate chains serve as cell surface marker that is unique in different tissues of an individual, and between individuals [mark once].</p>
CHOLESTEROL	
<p>5. Amphipathic – hydrophilic OH group and hydrophobic hydrocarbon rings.</p> <p>6. Is embedded within the membrane via hydrophobic and hydrophilic interactions with phospholipids.</p>	<p>6a. Regulates fluidity of the membrane.</p> <p>6b. At high temperatures, it restricts movement of phospholipids, thus prevents the membrane from becoming too fluid.</p> <p>6c. At low temperatures, it prevents close packing of the phospholipids, thus prevents the membrane from becoming too rigid.</p>

c) Outline how agarose gel electrophoresis is carried out **and** explain its theoretical basis. [8]

Outline	Explain
1. DNA is mixed with loading dye containing glycerol and bromophenol blue	<p>A. Glycerol adds density to DNA, allowing it to sink to the bottom of the well</p> <p>B. Bromophenol blue serves as a visual indicator during loading</p> <p>C. Very small molecular weight, therefore migrates faster than DNA molecules – track the progress of DNA migration</p>
2. DNA fragments loaded into well at one end of the gel nearer to cathode	D. DNA is negatively charged (due to phosphate group) and migrates towards the anode (positive pole)
3. Electricity is switched on and DNA migrates to the anode	<p>E. Agarose gel functions as a 'molecular sieve' through which DNA can migrate through</p> <p>F. Separates DNA fragment based on their molecular size</p>
4. The use of DNA ladder which contains DNA fragments of known molecular sizes	G. As a reference to estimate the size of an unknown DNA sample by comparing.
5. The gel is stained with ethidium bromide to view the DNA bands	H. Ethidium bromide intercalates between the bases and fluoresces under UV light.

[Total: 20]