VICTORIA JUNIOR COLLEG

JC 2 PRELIMINARY EXAMINATION 2019

NAME : _____

CT CLASS : _____

H2 BIOLOGY **9744/1**

Paper 1 Multiple Choice **1 hour**

Additional material: Multiple choice answer sheet

READ THESE INSTRUCTIONS FIRST

Write your name, exam number on the answer sheet provided.

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

There are **30** questions in this paper. Answer all questions. For each question there are four possible answers A, B, C and D.

Choose the **one** you consider correct and record your choice **in soft pencil** on the separate answer sheet.

Read the instructions on the answer sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this paper.

The use of an approved scientific calculator is expected, where appropriate

This document consists of 22 printed pages

1 The electron micrograph in Fig 1.1 shows an abundance of organelle X that is typically found in muscle cells.

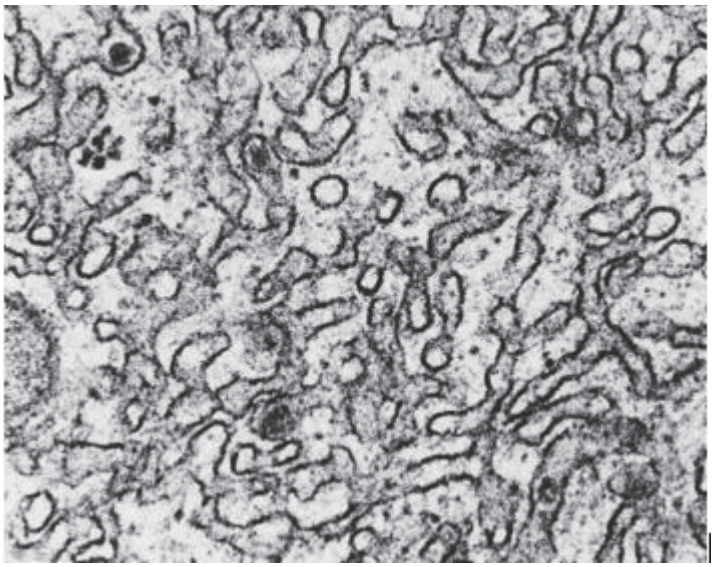


Fig 1.1

Source: https://www.sciencesource.com/archive

Which option below shows the correct match of structure to function for organelle **X?**

	Structure	**Function**
A	Consists of a system of interconnected tubules	Storage of calcium ions
B	A stack of membranes with swollen ends and associated with vesicles	Synthesis of lipids, phospholipids and steroid hormones
C	Extensively folded partitions called cristae which project into the semi-fluid matrix	These infoldings greatly increase the surface area for the attachment of electron carriers and enzymes for aerobic respiration.
D	Small food vacuoles dispersed throughout the cytoplasm	Serve as the digestive component and organelle-recycling facility of animal cells

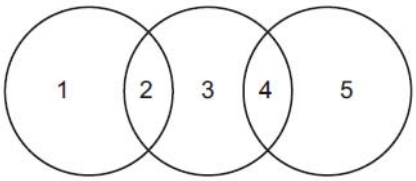
2 Below are statements written by a student to describe transport of material across the cell surface membrane.

Which of the options below matches correctly the process with the descriptions?

1. It is used for secretion of enzymes.
2. It is used to release undigested products.
3. It involves removal of part of cell surface membrane
4. It is similar to budding
5. The process cannot take place in the presence of a respiratory inhibitor.

	Endocytosis	**Exocytosis**
A	1, 5	2, 3, 4
B	3, 5	1, 2, 5
C	3, 4	1, 2, 5
D	1, 2, 5	3, 4

3 The diagram shows the relationship between different polysaccharides and glycosidic bonds formed between the monomers



Which row is correct?

	1	2	3	4	5
A	Amylopectin	α 1,6	Cellulose	β 1,4	Glycogen
B	Amylose	α 1,4	Glycogen	β 1,4	Amylopectin
C	Cellulose	β 1,4	Amylose	α 1,4	Glycogen
D	Glycogen	α 1,6	Amylopectin	α 1,4	Amylose

4 Which one of the following statements about haemoglobin is correct?

A Haemoglobin structure contains both α helices and β pleated sheets

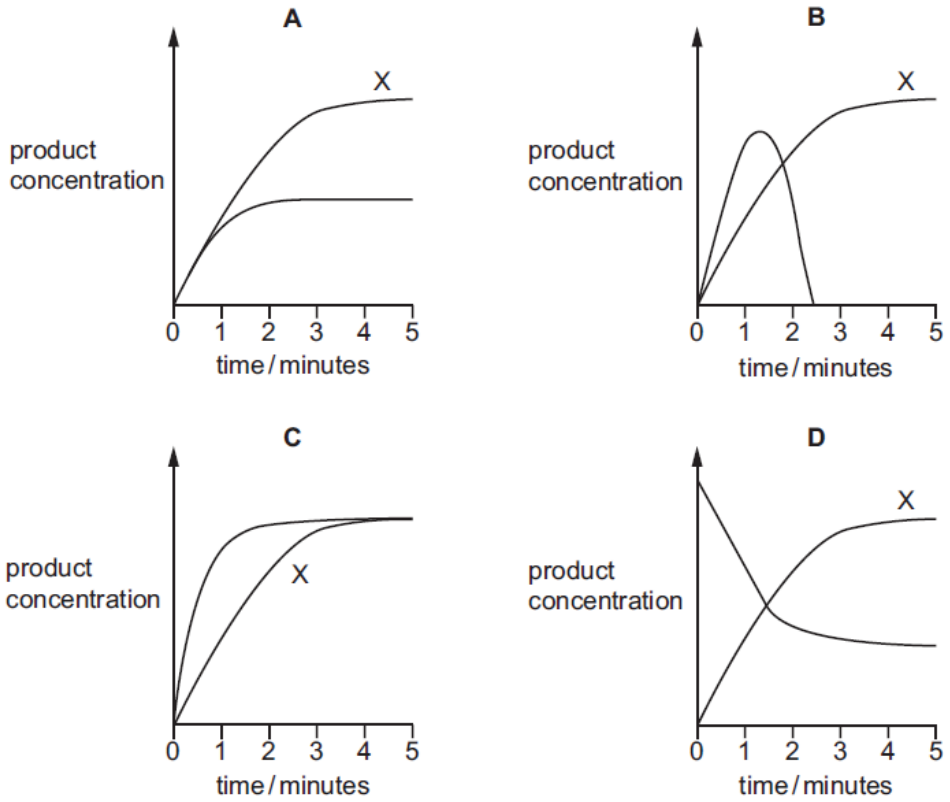
B Haemoglobin has a quartenary protein structure with 4 identical subunits

C Haemoglobin structure involves hydrogen, ionic, disulfide bonds and hydrophobic interactions

D Haemoglobin contains 4 non-prosthetic heme groups

5 Two experiments were carred out using an enzyme from humans. The first experiment, X, was carried out at a constant temperature of 37°C. During the second experiment, the temperature was increased from 37°C to 80°C. All other factors were kept the same.

Which graph shows the results?



6 A mutation occurred within the DNA sequence coding for an enzyme, causing a decrease in the rate of a reaction catalysed by this enzyme.

Which statements could explain the decrease in the rate of reaction?

1. The enzyme has a greater affinity for the inhibitor.
2. There are now more contact residues at the active site of the enzyme.
3. The activation energy for the reaction with the mutated enzyme is greater.

A 1, 2 and 3

B 1 and 2 only

C 1 and 3 only

D 2 and 3 only

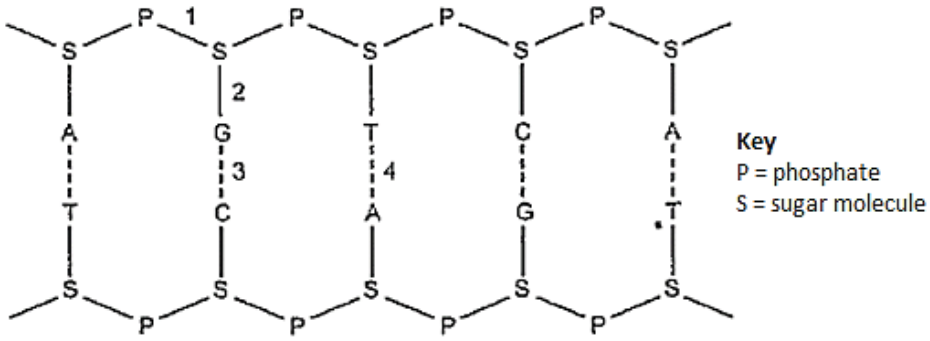
7 Some of the features of different types of stem cells **P, Q** and **R** are listed below.

1. They are able to develop into all the cell types of the body to form a whole organism.
2. They can develop into a wide range of different types of cell.
3. They can give rise to cells of the three primary layers.
4. They can only develop into a limited range of cell types.
5. They are unspecialised cells found in differentiated tissue.

Which of the following options shows correctly the features of the different stem cells?

	P (inner cell mass)	**Q (morula)**	**R (umbilical cord blood)**
A	1,2 and 3	3 and 4	2 and 5
B	2 and 3	1, 2 and 3	4, 5
C	1, 2 and 3	2, 5	1, 3
D	2 and 3	4, 5	2, 3

8 The diagram shows part of a nucleic acid.



Which row correctly describes the bonds shown in the diagram at positions 1, 2, 3 and 4?

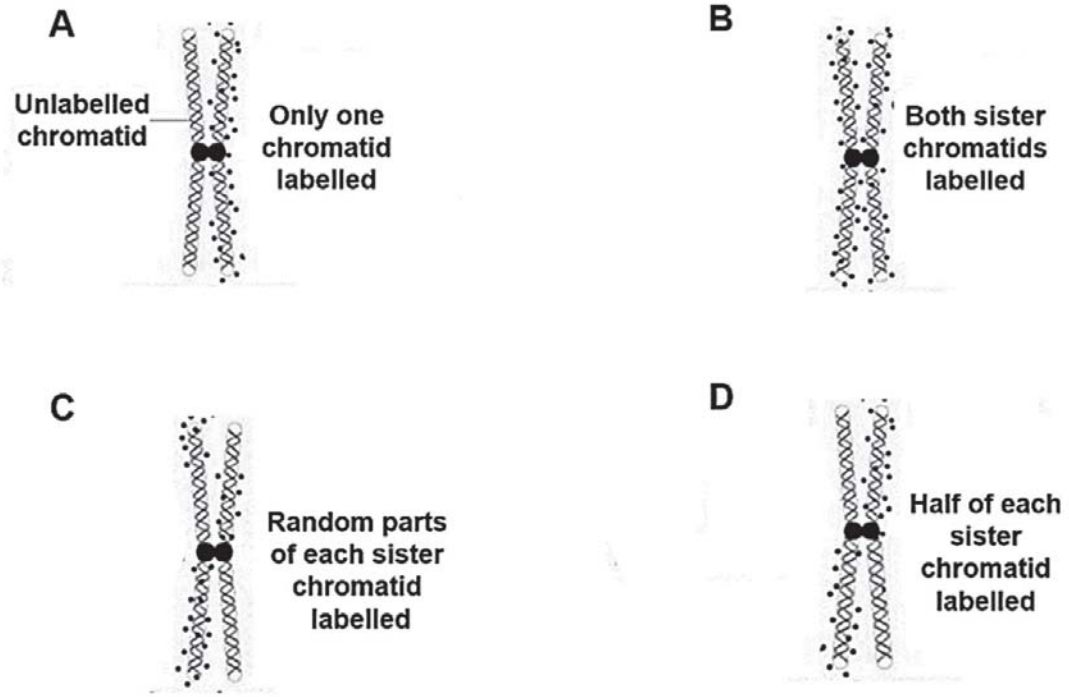
	Can be found in RNA	Is formed by condensation	Is formed during DNA replication	Is easily broken by changes in temperature or pH
A	1, 2	2, 3	1, 2, 3	4
B	3, 4	1	2, 3	2, 3
C	1, 2, 3	1, 2	1, 4	3, 4
D	1	1, 3, 4	1, 2	3, 4

9 Taylor, Woods, and Hughes performed an experiment on actively dividing root cells of the broad bean to investigate the mechanism of DNA replication in eukaryotes.

The broad bean plant, *Vicia faba*, was grown in media containing ^{3}H-thymidine, a radioactive isotope of hydrogen, for the time it took the actively dividing root cells to undergo one generation. ^{3}H containing nucleotides will be incorporated into DNA. The radioactive DNA can be detected using photographic film, in a process known as autoradiography.

After one generation of root cell division, the plants were then transferred to a media with only non-radioactive nutrients for the second round of cell division. Their results confirmed that eukaryotic DNA replicates semi-conservatively.

Which of the following shows correctly the appearance of a eukaryotic chromosome after the second round of DNA replication?



10 Puromycin is an antibiotic produced by the bacterium *Streptomyces alboniger*. It is a potent translational inhibitor in both prokaryotic and eukaryotic cells.

Based on the information given, it is reasonable to conclude that puromycin works by preventing the

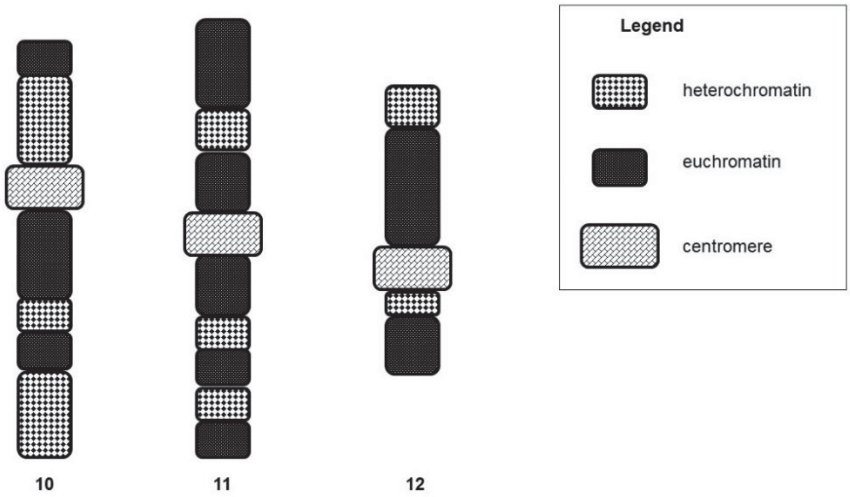
A translation of the first codon which results in f-methionine being added.

B formation of peptide bond between adjacent amino acids during translation.

C association of 50S and 30S subunits of the ribosome.

D binding of the ribosome to the promoter region of mRNA.

11 A chromosome mapping exercise was carried out on a DNA sample extracted from liver cells of a healthy donor. The distribution of heterochromatin and euchromatin in several chromosomes is represented in a model shown in the figure below.



Which of the following statement can be deduced from the chromosome map?

A Chromosome 11 has increased number of intron regions compared to chromosome 12.

B A greater proportion of chromosome 10 being organized as heterochromatin enables the most number of genes to be compacted in it.

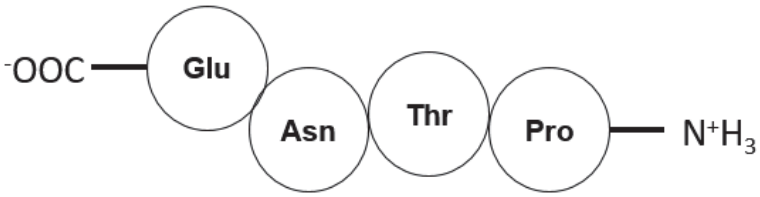
C The position of the centromeres along the chromosome is independent of the distribution of the heterochromatin and euchromatin regions.

D Chromosome 12 will express the greatest amount of proteins in all the cell types of the organism as it has greater proportion of the chromosome organized as euchromatin.

12 The table below shows the anticodon sequences for four amino acids.

Amino acid	**Anticodon (3' – 5')**
Asparagine (Asn)	UUA
Glutamic acid (Glu)	CUU
Proline (Pro)	GGA
Threonine (Thr)	UGG

A cell makes a polypeptide with the amino acid sequence:



What was the sequence of bases on the strand of the DNA that codes for this polypeptide chain?

A 5' – TTCATTGGTAGG – 3'

B 5' – CTTTTATGGGGA – 3'

C 5' – GGATGGTTACTT – 3'

D 5' – AAGTAAGGATCC – 3'

13 A biopsy was conducted on breast cancer patients to extract samples of cancer cells. DNA from these sample cells were isolated and treated with DNase I, an enzyme that degrades free double-stranded DNA in a non-specific manner. After digestion, the DNase I enzyme was removed. Any remaining intact DNA was extracted, made single stranded and mixed with radioactively labelled DNA probes specific for these genes.

Sample	**DNase I treatment**	**Gene specific to radioactive DNA probes**	**% binding of radioactive DNA to remaining DNA after DNase I digestion**
1	No	*PTEN* gene	90
2	Yes	*PTEN* gene	19
3	No	*BRCA* gene	88
4	Yes	*BRCA* gene	87

Which of the following conclusions may be drawn from the results shown above?

A *PTEN* and *BRCA* genes are both tumor suppressor genes.

B *PTEN* gene sequence is heavily methylated in these cells.

C There is reduced transcription of the *BRCA* gene in these cells.

D Mutation has occurred in *PTEN* gene while *BRCA* gene remained intact.

14 Which of the following shows correctly the type of genetic material or enzymes present in the named viruses?

	T4 phage	**Lambda phage**	**HIV**	**Influenza virus**
A	DNA polymerase	integrase	(-) sense RNA	(+) sense RNA
B	Lysozyme	DNA	(+) sense RNA	(-) sense RNA
C	DNA	Reverse transcriptase	DNA	RNA dependent RNA polymerase
D	DNA	DNA	integrase	protease

15 Random mutations were induced in genes involved in lactose metabolism. Each culture of bacteria had a single mutation. When the mutant bacteria were plated on culture medium containing high lactose and no glucose, some cultures show inability to metabolise lactose.

Which of the following mutations can account for this defect in lactose metabolism?

Mutations in the

1. regulatory gene of the *lac* operon
2. gene coding for the Catabolite Activator Protein (CAP)
3. CAP binding site of the *lac* operon
4. gene coding for sigma factor of RNA polymerase
5. DNA binding site for transcription factor

A 2 and 4 only

B 1, 2 and 5 only

C 1, 3 and 5 only

D 2, 3 and 4 only

16 Liver cancer is the third leading cause of cancer-related deaths worldwide. Scientists use animals to model human diseases.

In a mouse model experiment, deletion of *mdr* gene leads to the accumulation of bile acids that initiates liver inflammation, a process that recruits white blood cells to the target site. These white blood cells secrete Tumour Necrosis Factor-α (TNF-α) that binds to the corresponding receptor on liver cells. This in turn activates a specific transcription factor resulting in the elevated levels of an anti-apoptotic protein and the production of a growth-promoting protein. These proteins are involved in the progression of liver cells into cancer cells.

The findings of this study indicates that deletion of the multi-drug resistance (*mdr*) gene in liver cells leads to the development of liver cancer.

Based on the information above, which of the following can be inferred?

A *mdr* gene is a tumour suppressor gene which codes for a protein involved in apoptosis and growth inhibition.

B The progression to liver cancer requires mutations in proto-oncogenes and tumour suppressor genes.

C The progression to liver cancer can occur when a loss-of-function mutation in the *mdr* gene results in the over-expression of the other proto-oncogenes.

D The development of metastatic liver cancer is accelerated with the recruitment of more white blood cells due to elevated levels of TNF-α.

17 Klinefelter syndrome, also known as 47(XXY) is the set of symptoms that result from two or more X chromosomes in males. This condition arises due to non-disjunction that occurs in the formation of gametes in the affected individual's parent. If one of these atypical reproductive cells is fertilized by a normal gamete, the child will have an abnormal chromosome number.

Which of the following is **not** a possible explanation for the production of a child with Klinefelter's syndrome?

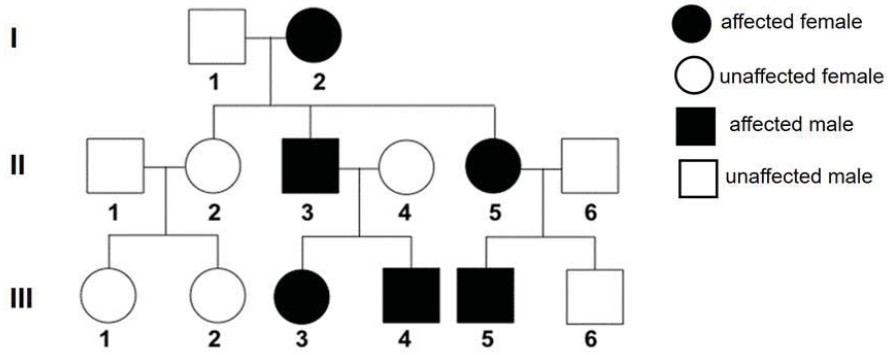
A Non-disjunction occurs during meiosis I in the formation of sperms resulting in the production of a sperm with both XY chromosomes which subsequently fertilized a normal egg cell.

B Non-disjunction occurs during meiosis I in the formation of egg cells in the mother, resulting in the production of an egg with two X chromosomes which is subsequently fertilized by a sperm with an Y chromosome.

C Non-disjunction occurs during meiosis II in the formation of egg cells resulting in the production of an egg with two X chromosomes which is subsequently fertilized by a sperm with an Y chromosome.

D Non-disjunction occurs during meiosis II in the formation of sperms resulting in the production of a sperm with both XY chromosomes which subsequently fertilized a normal egg cell.

18 Red-green colour blindness in humans is inherited in a sex-linked recessive manner. Another type of heritable colour vision deficiency in humans, known as blue-yellow colour blindness, is shown in the pedigree chart below.



Identify the option that shows **conclusive** evidence for the mode of inheritance of blue-yellow colour blindness.

A The trait must be autosomal because there are equal frequencies of male and females inheriting the trait in generation **II** and generation **III**. The trait must be dominant because it appears in generation **II** and generation **III**. All offspring from this expanded pedigree will always be at risk of the trait.

B The trait must be X-linked as **I2** blue-yellow colour blind mother has **II3** son and **II5** daughter with same trait. The trait must be recessive as the parents **I1**, **II4** and **II6** must be carriers.

C The trait must be autosomal as **II3** blue-yellow colour blind father has son **III4** with the same trait. The trait must be dominant as children **III1** and **III2** will normal vision must have parents **II1** and **II2** with normal vision.

D The trait must be X-linked as **II5** blue-yellow colour blind mother has son **III6** with normal vision and son **III5** with the same colour blindness. The trait must be dominant since **II5**, a heterozygote has blue-yellow colour blindness.

19 DNA analysis may be used in genetic screening. A boy suffers from a sex-linked genetic disease that results from lack of a functional protein. His DNA was analysed, so was that of his parents and two sisters. The family's pedigree and DNA profiles are shown in Figure 19.

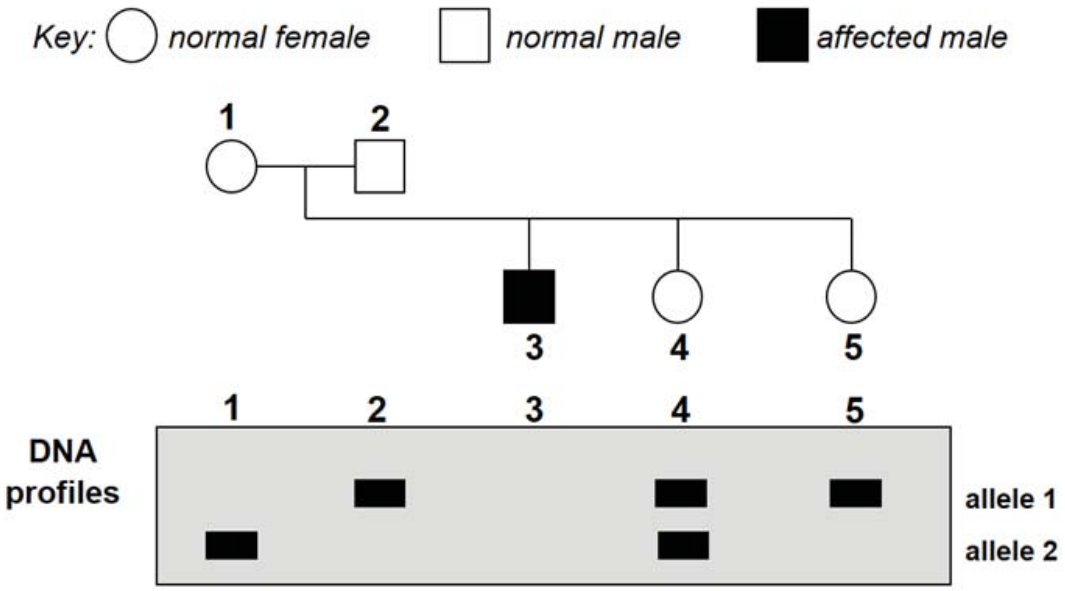


Fig 19

Which of the following statements cannot explain why the profile of Individual 3 did not show any band?

A Mutation occurs in allele 1

B Mutation occurs in allele 2

C Probe is complementary to the region that is mutated

D Mutation is a deletion of a large region of the gene

20 Which of the following event would lead to an increase in ATP production after pyruvate was added to a suspension of mitochondria with continuous supply of oxygen?

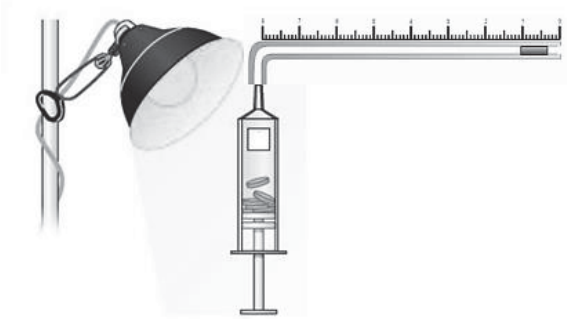
A Increasing the supply of NAD^+ and H^+ to the electron transport chain.

B Increasing the number of ATPase on the inner mitochondrial membrane.

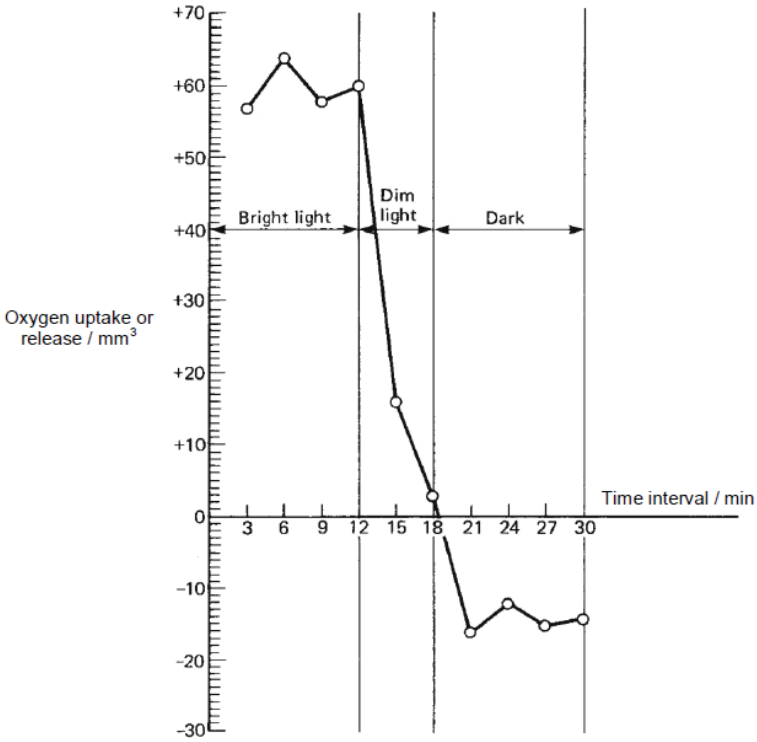
C Increasing the permeability of the inner mitochondrial membrane to protons.

D Lowering the pH in the space between inner and outer mitochondrial membranes.

21 Leaf discs were cut and immersed in a syringe containing sodium bicarbonate solution as shown in the figure below. The syringe was then attached to a glass tubing to investigate the volume of oxygen released.



Over a period of 30 minutes, the discs were first exposed to bright light, then dim light and finally left in the dark. Oxygen release was recorded as positive values and oxygen uptake was recorded as negative values. The results obtained are shown in the graph below.



Which conclusion can be reached from these results?

A Light saturation occurs at around 18.5 minutes.

B Dim light drastically decreases the rate at which oxygen is used as a final electron acceptor.

C The rate of photolysis of water increases drastically in bright light compared to the dim light.

D Light is limiting the rate of photosynthesis for the first 18 minutes of the experiment, after which another factor becomes limiting.

22 The table shows some chemical conversions that may occur in the cells of living organisms.

1	Glucose → cellulose
2	Glucose → pyruvate
3	Glucose → glycogen
4	Glycogen → glucose
5	Starch → glucose

Which of the following options is correct?

	Cow liver cells	**Rat muscle cell**	**Beetroot cell**
A	2, 5	2, 3, 4	1
B	3, 4	3	1, 2
C	1, 2, 3	3, 4	2, 5
D	2, 5	3, 4, 5	2, 5

23 Which of the following is **false** regarding the signaling pathway?

A Activated adenylyl cyclase converts intracellular ATP into cAMP and this increased cAMP level serves to amplify ligand signal to produce a stronger response.

B A single ligand can elicit many cellular responses through the interaction with different enzymes involved in various cellular processes.

C Activated kinase can stimulate the increased expression of relay proteins which can go on to activate the subsequent kinases via a phosphorylation cascade.

D The G protein-coupled receptor signalling pathway provides many potential checkpoints for regulation through the inactivation of the G protein and the breakdown of the cAMP molecule.

24 The following table shows the classification of the common earthworm. Certain taxonomic ranks are missing from this table.

Taxonomic rank	**Named taxonomic group**
Domain	Eukaryotae
Kingdom	Animalia
	Annelida
	Clitellata
	Haplotaxida
	Lumbricidae
Genus	*Lumbricus*
Species	*terrestris*

Identify the correct combination of statements below.

	Taxonomic rank that shares the highest number of derived traits with the common earthworm	Members of the same class as earthworm must also be members of
A	Animalia	Haplotaxida
B	*Lumbricus*	Annelida
C	*Lumbricus*	Lumbricidae
D	*terrestris*	Animalia

25 There is sparse fossil evidence for changes in dinosaurs near the lineage that leads to birds and the origin of flight. Recent discovery of dinosaur bones from Mongolia provide supportive evidence for the divergence of birds and dinosaurs from a common ancestor. More intriguing is the finding that the common ancestor to lineages that give rise to modern day birds (avian) and land-bound dinosaurs had small body size.

Fig. 25 shows the phylogeny and body size change within paraves. The small body size and foot bone structure of Mahakala (indicated by arrow) are avian traits found in the paravian ancestor.

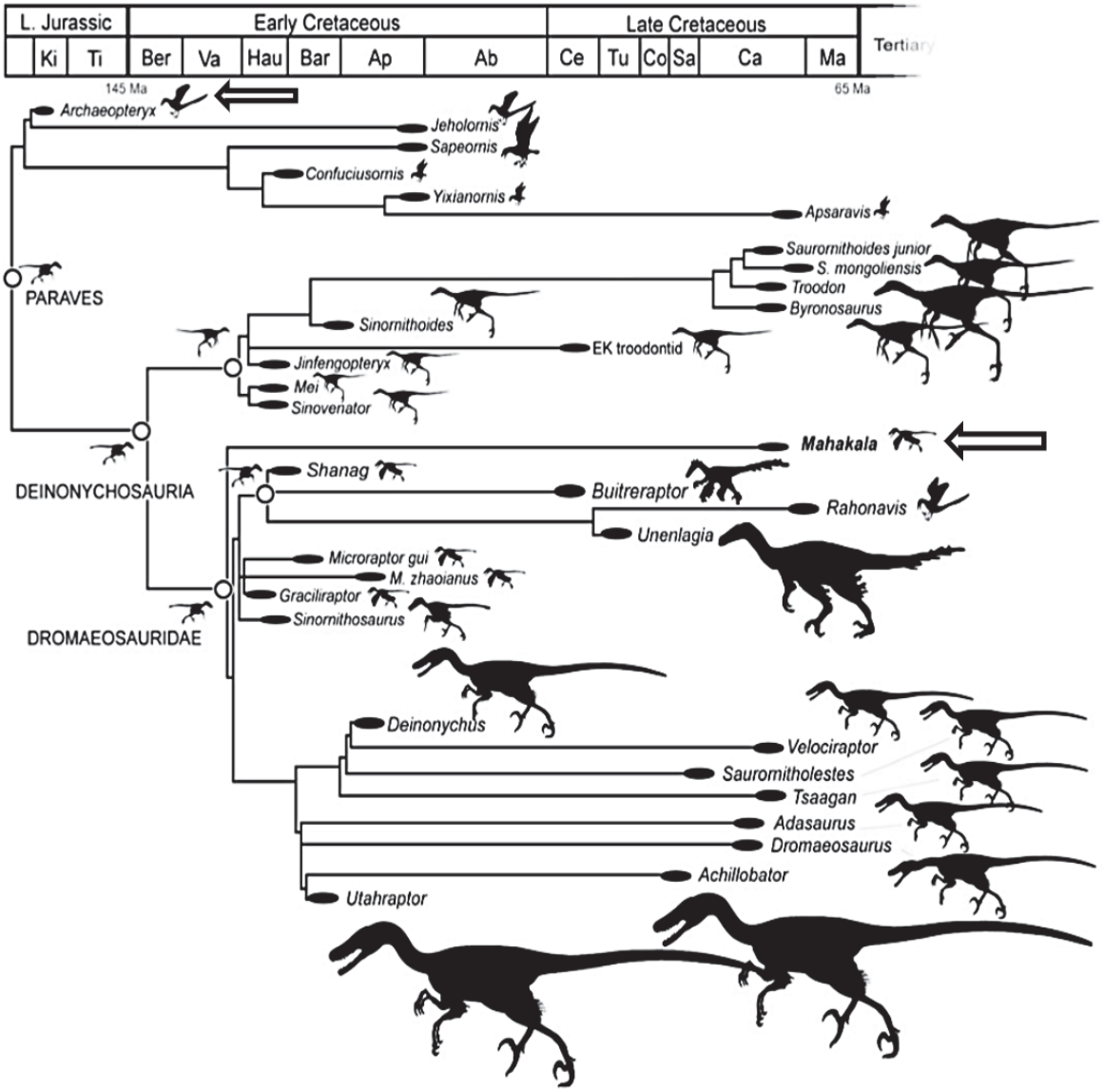


Fig. 25. Source: AH Turner et al (2007). Science 317, 1378-81.

Based on the information provided and the cladogram shown, what conclusions can be inferred?

1. Miniature body size is an ancestral trait
2. Gigantism occurred independently in at least four clades
3. *Archaeopteryx*, the transitional fossil with both reptilian and avian features, diverged from the paravian common ancestor at the same time as the lineage that gave rise to giant dinosaurs.
4. Structure of the foot bone in *Mahakala* and *Archaeopteyx* are derived traits.

A 3 only

B 1 and 2 only

C 3 and 4 only

D All of the above

26 Which of the following is an example of convergent evolution?

A An evolved resemblance between organisms from different species, often as a means to protect a species from predators. Some species of birds use sight to identify palatable insects, whilst avoiding the poisonous/vile-tasting ones. Over time, palatable insects may evolve to resemble poisonous or vile-tasting one.

B A disease-causing allele occurs within the population at a greater prevalence than would be estimated by sheer chance, as the carriers have an advantage over those who do not have the genetic mutation.

C Bats and dolphins are able to navigate the world using sound. It was found that 200 genes common to both bats and dolphins have undergone mutation independently, over the course of evolution. These genes are associated with echolocation and with sight.

D Recent molecular evidence shows high degree of similarity between dogs and the gray wolf that was domesticated about 130,000 years ago.

27 Below are statements about the primary responses of B and T lymphocytes.

Which of the following is true?

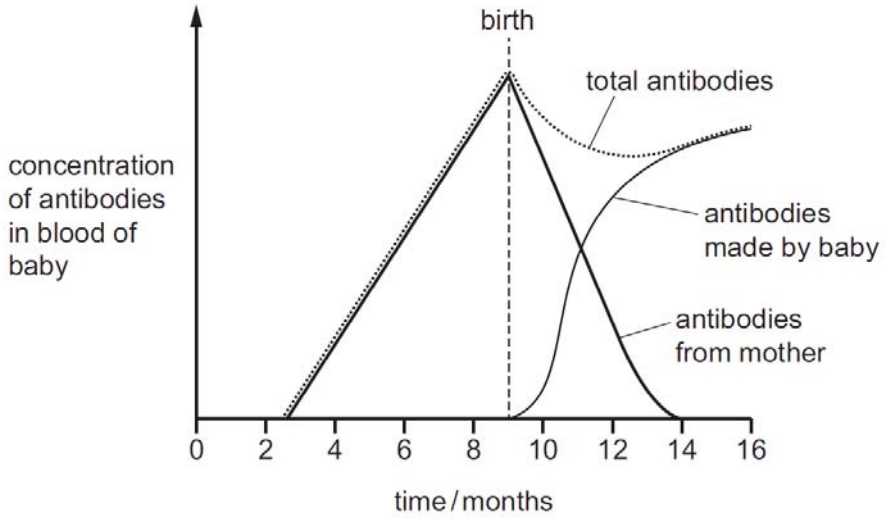
A Activation of the T lymphocytes can occur due to antigen binding directly to specific receptors on their cell surface membrane.

B Both types of lymphocytes release cytokines to activate other immune cells.

C Only B lymphocytes undergo clonal expansion to generate more cells when activated.

D The cytotoxic T cells can recognise infected cells by attaching to the MHC-peptide complex.

28 The graph shows the changes that occur in the concentration of antibodies in the blood of a baby before birth and during the first few months after birth.



Which description about the changes in immunity during the first few months after birth is correct?

A passive artificial immunity decreases, active natural immunity increases

B passive natural immunity decreases, active natural immunity increases

C active artificial immunity decreases, active natural immunity increases

D active natural immunity decreases, active artificial immunity increases

29 Some of the risk factors that increase the probability that a person will develop a more severe form of dengue disease are listed

1. Having previously been infected with a different variant of the virus
2. Having a genetic susceptibility to the virus
3. Living in a region where mosquitoes carry a more virulent form of the virus
4. Living near open sewers
5. Having a chronic disease such as diabetes

Some of these risk factors increase the probability of being infected with the virus while others increase the risk of developing severe dengue disease following infection.

Which of these risk factors increase the probability of developing severe dengue disease following infection?

A 3 and 5 only

B 2, 3 and 4 only

C 1, 2 and 5 only

D 1, 2, 3 and 5 only

30 Which of the following statements below describes a problem associated with the melting of the Arctic tundra?

Arctic Tundra

Source: unsplash.com

A Erosion, landslides, and sinking of the ground.

B Changes in plant species composition at low latitudes.

C Release of clean thawed freshwater for drinking and other human activity needs.

D Sea water pH rising beyond levels that corals can survive in, leading to mass extinctions

-End of paper-

VICTORIA JUNIOR COLLEGE

JC 2 PRELIMINARY EXAMINATION 2019

NAME : _____

CT CLASS : _____

H2 BIOLOGY **9744/02**

Paper 2 Structured Questions **2 hours**

READ THESE INSTRUCTIONS FIRST

Write your Name and CT Class on the cover page of this paper.
Write in dark blue or blue pen.
You may use a soft pencil for any diagrams or graphs.
Do not use any staples, paper clips, highlighters, glue or correction fluid.

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

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 the appropriate units.

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

For Examiner's Use	
1	
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10	
11	
Total	

This document consists of 25 printed pages

1 Lysosomes are the primary catabolic compartments in eukaryotic cells. They contain more than 40 different enzymes such as proteases, nucleases, phospholipases. **Fig 1.1** below shows a simplified structure of a lysosome with a large amount of proteins found on its surface. These proteins are highly glycosylated with oligosaccharides on the side facing the interior of the lysosomes.

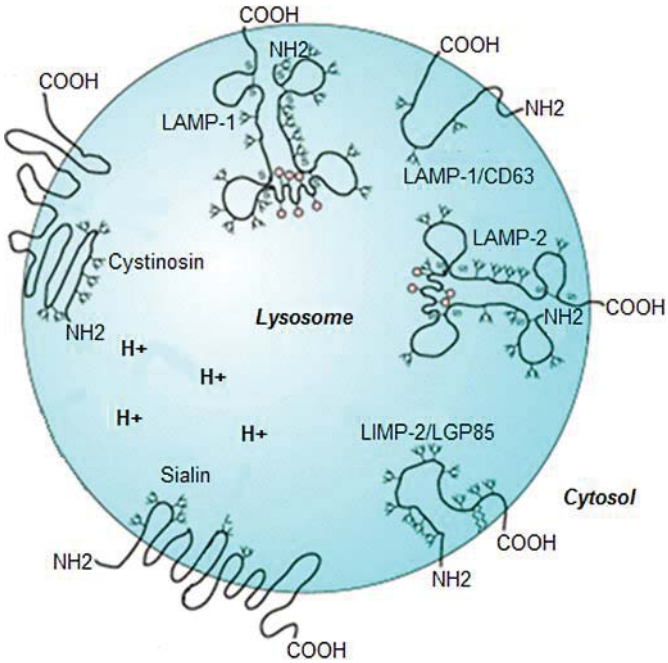

Fig. 1.1

(a) Describe the importance of the Golgi apparatus in the formation of lysosomes.

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…… [3]

(b) The interior of the lysosome has a pH of 4.5 whereas that of the cytoplasm is 7.2.

(i) Suggest how the lysosomes are able to maintain such a pH.

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…… [3]

(ii) Suggest an advantage to the cell that the optimal pH of lysosomal enzymes is pH 4.5.

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…… [1]

(c) Another structure in the cytoplasm is also responsible for the hydrolysis of proteins.

Name this structure and state two differences between this structure and lysosome.

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……

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…… [3]

[Total: 10]

2 Aspartate transcarbamoylase (ATCase) is an allosteric enzyme that catalyzes the first step in the synthesis of pyrimidines in the cytoplasm. Cytidine triphosphate (CTP) and uridine triphosphate (UTP) are two products of pyrimidine biosynthesis.

Purines (in the form of ATP and GTP) are synthesized in a separate pathway.

Fig. 2.1 shows the effect of CTP and ATP on the activity of ATCase.

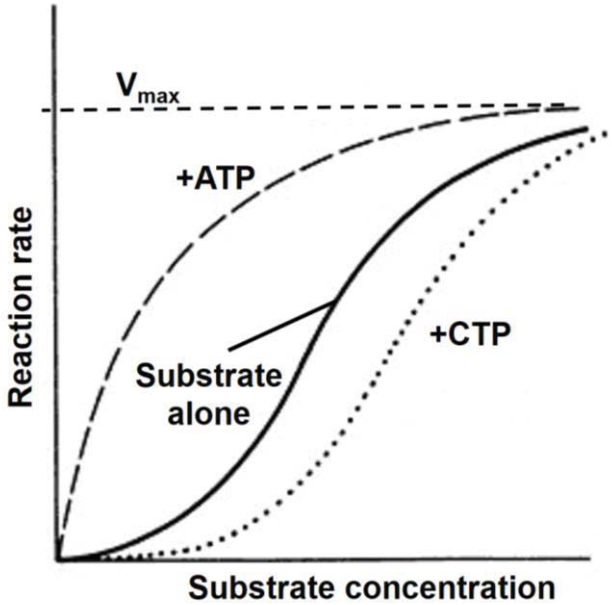

Fig. 2.1

(a) What do you understand by the term "allosteric enzyme"?

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.....

.....

.....

.....

.....

.....

..... [4]

(b) Using information from **Fig. 2.1**, explain the role of CTP and ATP in the regulation of ATCase activity.

CTP:

……

……

……

…… [2]

ATP:

……

……

……

…… [2]

(c) Suggest a reason why ATP synthesised in a different pathway is used to regulate ATCase activity.

……

…… [1]

(d) For some enzymes, studies show that there is slight movement of some amino acids at the active site during the attachment of the substrates.

Suggest an explanation for the above observation.

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……

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…… [3]

[Total: 12]

3 Found in the cell walls of fungi and the exoskeleton of insects, chitin is the second most abundant organic polymer after cellulose on Earth.

A section of chitin is shown in **Fig 3.1.**

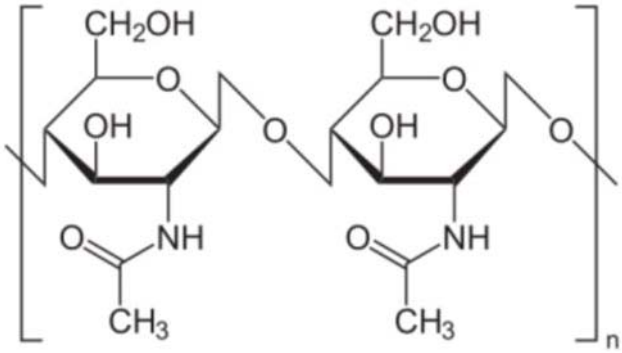

Fig. 3.1
https://www.differencebetween.com/

(a) Based on your knowledge of cellulose,

(i) state one similarity and one difference in the structure of chitin and cellulose.

.....

.....

.....

..... [2]

(ii) suggest how the structure of chitin shown in **Fig 3.1** would allow it to function as a structural component in insects and fungi.

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..... [3]

(b) Unlike chitin and cellulose, triglyceride is an example of a storage biomolecule.

In the space below, draw the molecular structure of a triglyceride.

Label the components that make up this molecule and the bonds that hold them together.

[3]

[Total: 8]

4 The building blocks of anterior (head) – posterior (tail) axis patterning in *Drosophila* embryo (fertilised oocyte) are laid out during oocyte (egg) formation. Four genes are responsible for the polarity of the oocyte and then of the subsequent embryo. mRNA molecules of these four genes were found to be distributed along the anterior-posterior axis of the developing oocyte (**Fig. 4.1**).

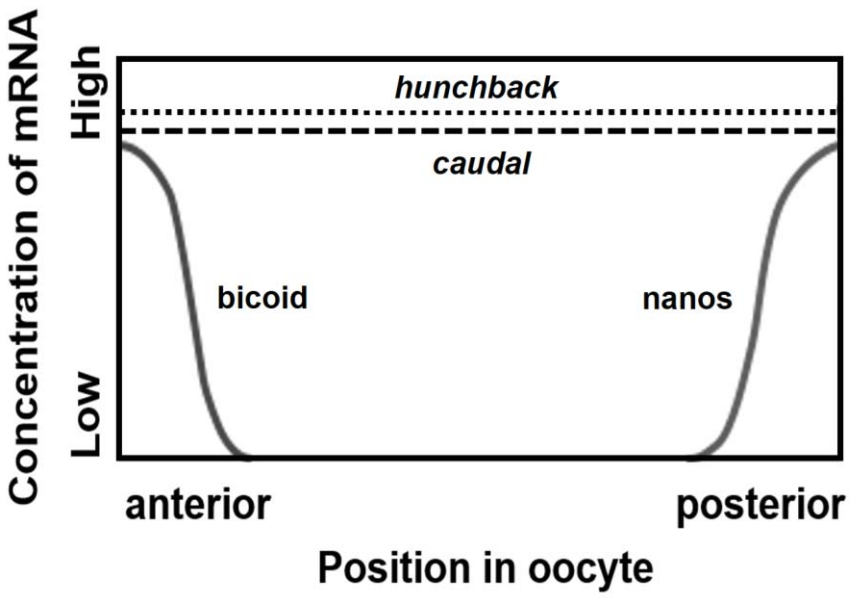

Fig. 4.1
https://en.wikipedia.org/wiki/Drosophila_embryogenesis

(a) With reference to **Fig 4.1**,

(i) explain the types of chromatin modifications that may be carried out on the *hunchback* and *caudal* genes.

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..... [4]

(ii) explain how the *hunchback* and *caudal* mRNA levels are maintained within the cell.

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…….… [2]

(b) The corresponding protein concentrations of the four genes were measured in the early stages of development of the *Drosophila* embryo (**Fig. 4.2**).

It was found that bicoid and nanos proteins act as repressors to block the translation of *caudal* and *hunchback* mRNA respectively.

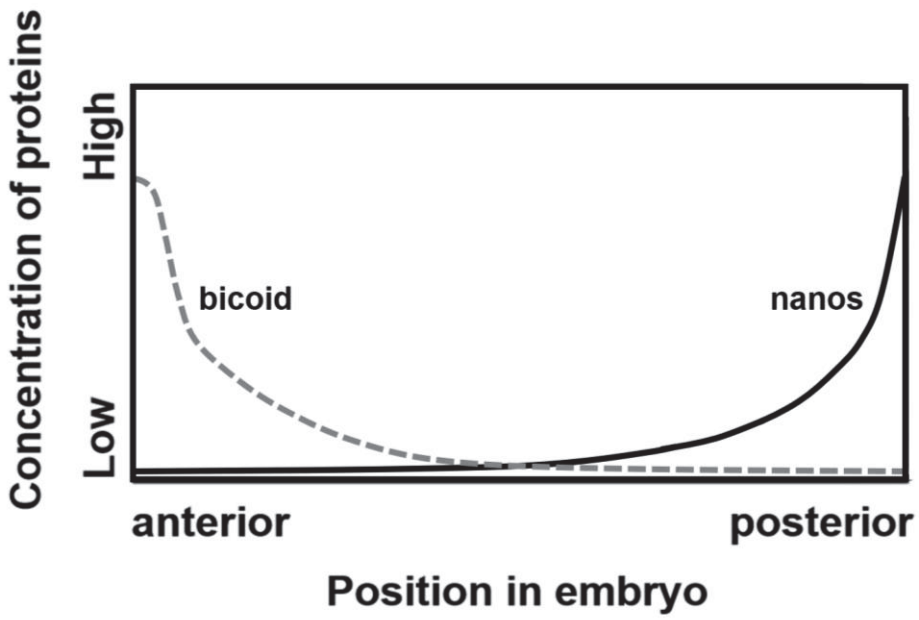

Fig. 4.2

Sketch **two** graphs in **Fig. 4.2**, representing the protein concentrations of caudal and hunchback and label them **C** and **H** respectively. [2]

[Total: 8]

5 **Fig 5.1** is an electron micrograph showing part of an animal cell.

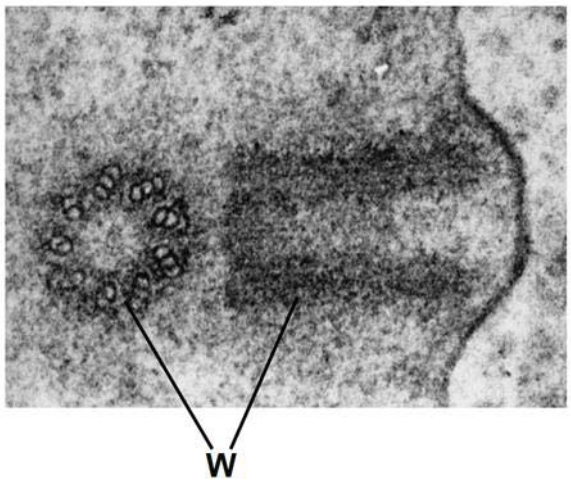

Fig. 5.1

(a) **(i)** Identify the structures labelled **W**.

……

…… [1]

(ii) Support your answer in **(i)** with 2 observable features shown in **Fig 5.1**.

……

……

……

…… [2]

(b) An abnormal increase in the number of structure **W** is frequently detected in many human cancers. Aneuploidy is common in tumour cells.

Suggest how an abnormal increase in number of structure **W** can lead to aneuploidy and cancer development.

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…… [3]

(c) Explain the importance of the various checkpoints in the production of identical daughter stem cells.

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…… [3]

[Total: 9]

6 **(a)** The typical bacterium is 2 μm in diameter. Explain how it is possible for the bacterium to have a genome that has a length and width of 1 mm and 2 nm, respectively.

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…….… [3]

(b) Bacteria are able to acquire new genes via horizontal gene transfer.

An experiment was set up to investigate horizontal gene transfer in bacteria.

Two strains of bacteria (A and B) are placed separately in the two arms of a Davis U-tube, as shown in **Fig. 6.1** below. The bacteria on both arms are separated by a filter.

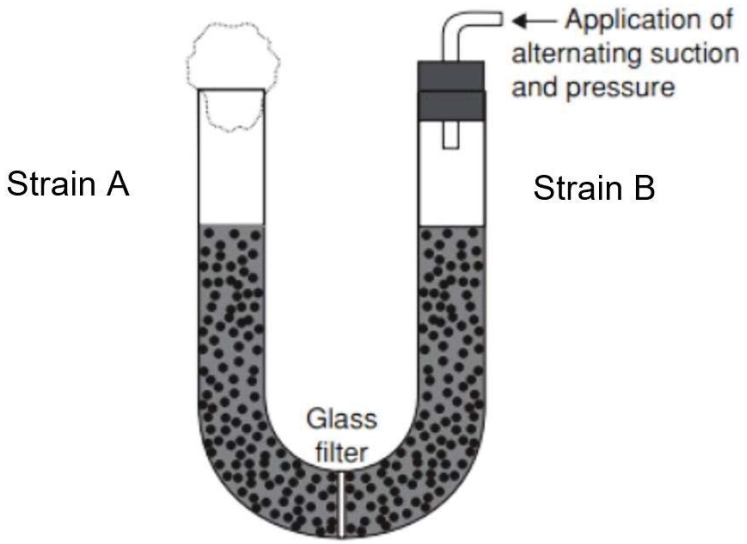

Fig. 6.1

With reference to **Fig. 6.1**, explain why conjugation was not observed in the two strains of bacteria.

……

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……

…….… [2]

(c) The same experiment was then repeated but with the addition of DNase into the medium.

When samples were removed from both sides of the filter, it was found that some bacteria taken from the strain A side of the Davis tube now contain genes from strain B bacteria.

The following hypothesis was proposed:

A filterable agent was released by the strain B cells. This agent was responsible for transferring the genetic information from B to A. This filterable agent was released by the strain B cells only when they were grown in association with strain A cells.

(i) Explain the purpose of adding DNase to the medium.

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…….… [1]

(ii) Suggest how strain B could have produced the filterable agent to transfer the genetic information to strain A.

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…….… [6]

[Total: 12]

7 To study the mode of inheritance of fruit colour and fruit shape in a variety of plants, a group of students conducted the following crosses.

Cross I: Plants, pure bred for both characteristics were crossed. All the F1 plants have red and oval fruits.

Cross II: Two plants (**W** and **T**) heterozygous for fruit shape and colour were picked from the field and test crosses conducted for both plants. The results of these crosses are shown below.

Phenotype of progeny	Number of progeny of test cross involving	
	Plant **W**	Plant **T**
Red, long	46	4
Yellow, oval	44	6
Red, oval	5	43
Yellow, long	5	47
Total	100	100

Table 7.1

(a) Explain how the data obtained from test crossing Plant **W** can be used to reveal about the relationship between the two genes under investigation.

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..... [4]

(b) Use a genetic diagram to explain the results of test cross involving Plant **T**.

You are to use the letters A/a for fruit colour and B/b for fruit shape.

[4]

(c) Distinguish between a gene and its alleles.

……

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…….… [3]

[Total: 11]

8 **Fig. 8.1** shows the net carbon dioxide fixation in a plot of sorghum plants grown in an open field over a two-day period in August.

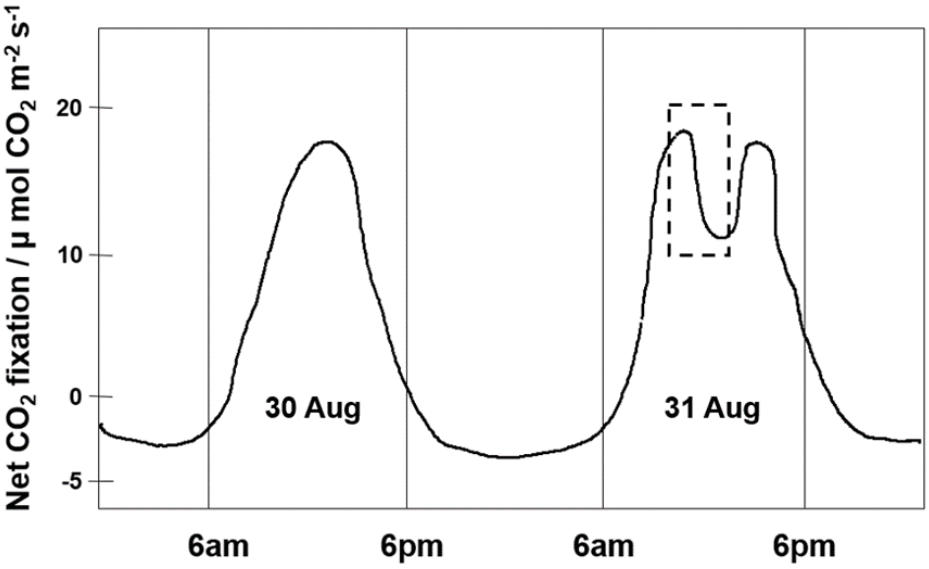

Fig. 8.1

(a) With reference to **Fig. 8.1**,

(i) explain the meaning of "limiting factor" by using data from Aug 30.

……

……

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……

…… [3]

(ii) suggest and explain what could have happened to cause the drop in the net CO_2 fixation in the boxed up area.

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…….… [4]

(b) A competitive inhibitor to the enzyme involved in the formation of reduced NADP was introduced to the plants at 6pm of 30th Aug.

Sketch a graph on **Fig. 8.1** to indicate the net CO_2 fixation for these plants and label it as **R**. [1]

(c) State two differences between Calvin Cycle and Krebs Cycle.

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…….… [2]

[Total: 10]

9 Madagascar, the fourth-largest island in the world, sits in the Indian Ocean several hundred kilometers off Africa's southeastern coast and houses an amazing variety of plant and animals, many of which are endemic (found only) to the island. The island is made of many different habitat types from deserts to rainforests.

The vangas of Madagascar represent an example of adaptive radiation that is considered by many evolutionary biologists to be as notable as Darwin's finches. The ancestor of all vangas colonized the island of Madagascar about 20 million years ago. That single ancestral species gave rise to 22 descendant vanga species, representing a great variety of feeding strategies via adaptive radiation (**Fig. 9.1**).

Fig. 9.1
Source: Proceedings of the National Academy of Sciences, 2012.

(a) Using **Fig. 9.1**, and the information provided, explain how adaptive radiation of the Madagascan vangas can come about.

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..... [5]

(b) What kind of information can scientists use to conclusively prove that the vangas are closely related species.

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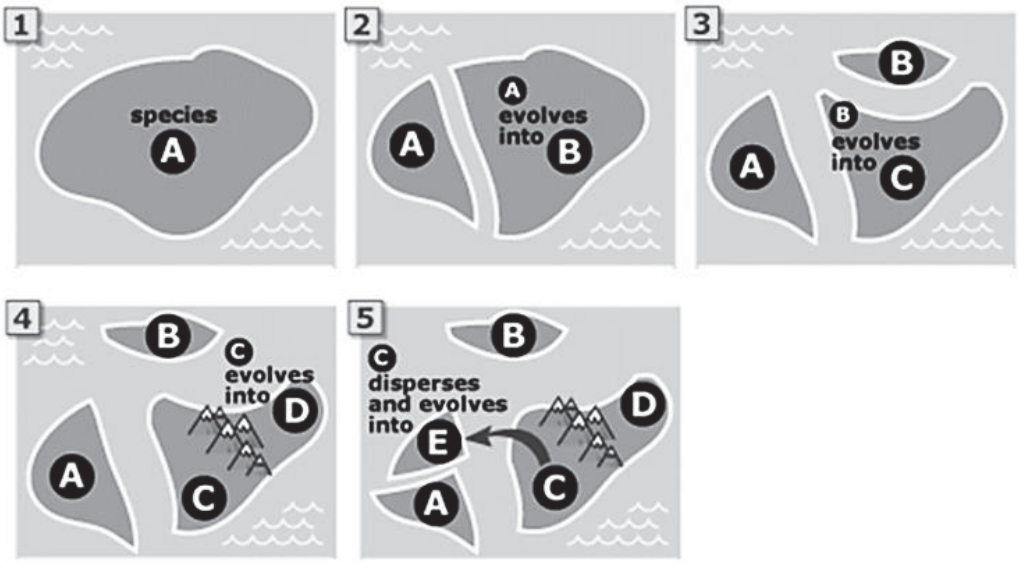
..... [1]

(c) Pictures 1-5 show a possible hypothetical chain of events that occur in the evolution of species A-E.



Source: https://evolution.berkeley.edu/evolibrary/news/091001_madagascar

In the space below, construct a phylogenetic tree to reflect their evolutionary relationships.

[3]

[Total: 9]

10 *Vibrio cholerae* is a bacterium that causes cholera. Many people who have recovered from cholera rarely become ill again from the disease.

(a) Explain why people who have recovered from cholera rarely become ill again from the disease.

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…… [3]

(b) **Fig. 10.1** shows a simplified diagram of an antibody.

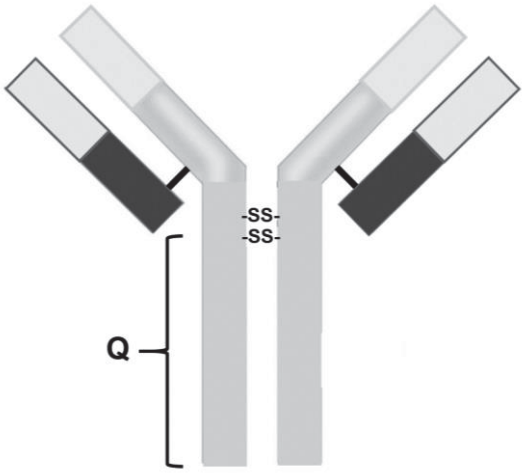

Fig. 10.1

(i) Explain how antibodies produced against an antigen may differ in the region **Q**.

……

……

……

…… [2]

(ii) State the significance of **(i)**.

……

…… [1]

[Total: 6]

11 **Fig 11.1** shows the effect of increase in temperature on the survival of five different species of insects found in the same locality. All of the insects feed on milkweed plants. For each species, the mean value (•) and standard deviation (line) of survival was determined. A positive Cohen's d value means that there is an increase in the mean value of survival and a negative d value means that there is a decrease in the mean value of the survival.

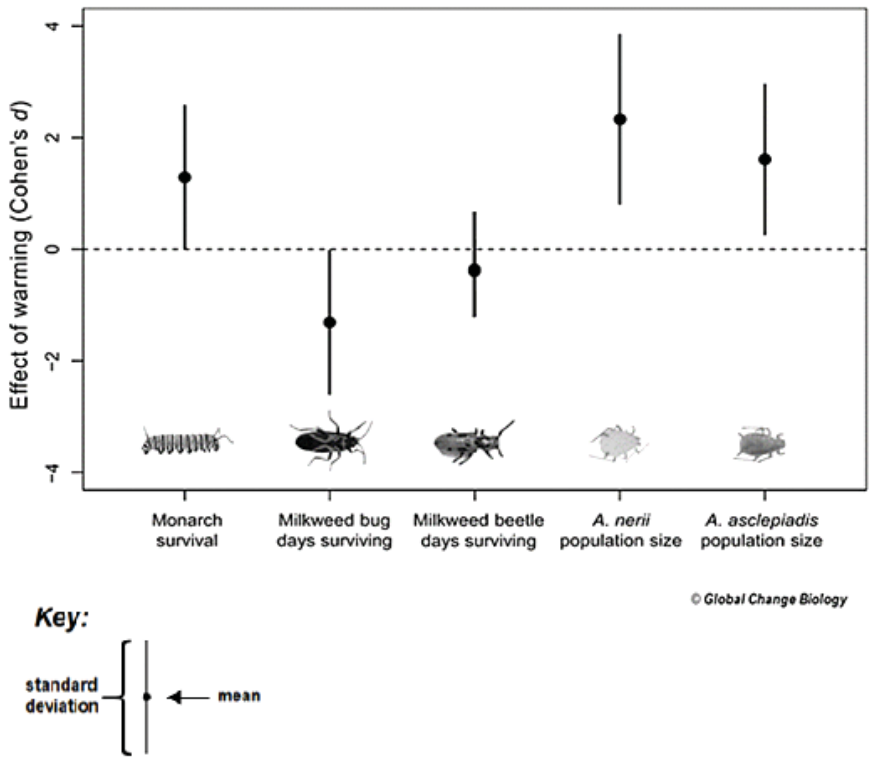

Fig. 11.1
https://conservationcorridor.org/2017/12/warmer-temperatures-and-connectivity-interact-to-influence-metacommunity-diversity/

(a) **(i)** Suggest why some insect species show positive d values whereas others show a negative d values although they are found in the same locality.

……

…….… [1]

(ii) State the importance of knowing the standard deviation for each set of data.

……

…….… [1]

(b) Discuss the impact of continued warming on the different populations of insect species found on the same milkweed plant.

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…….… [3]

[Total: 5]

---------- End of Paper ----------

VICTORIA JUNIOR COLLEGE

JC 2 PRELIMINARY EXAMINATION 2019

NAME : _____

CT CLASS : _____

H2 BIOLOGY **9744/3**

Paper 3 Longer Structured and Free-response Questions **2 hours**

READ THESE INSTRUCTIONS FIRST

Write your Name and CT Class on the cover page of this paper.
Write in dark blue or blue pen.
You may use a soft pencil for any diagrams or graphs.
Do not use any 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 writing paper provided.
Indicate the question number of the essay that you have attempted in the box on the left.

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 the appropriate units.

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	
Section B	
Total	

This document consists of **12** printed pages

Section A

Answer all the questions in the spaces provided

1 Otto Warburg made a striking discovery in the 1920s, when he found that cancer cells prefer to metabolize glucose by glycolysis, even in the presence of normal levels of oxygen. This is a paradoxical finding in light of the common understanding that glycolysis is a less efficient pathway for producing ATP compared to oxidative phosphorylation. This became known as the Warburg effect.

(a) **(i)** State why oxidative phosphorylation is more efficient at producing ATP.

[1]

Mutation of *p53* gene was found to prevent expression of the gene *SCO2* in cancer cells. *SCO2* codes for synthesis of cytochrome c oxidase protein, the last electron carrier of the electron transport chain.

(ii) Suggest and explain the effects of lack of expression of *SCO2* in the highly proliferative cancer cells.

[5]

(iii) Discuss two possible consequences of the effects in (ii) on the survival of cancer cells.

[4]

(b) Aerobic glycolysis (another term for Warburg effect) is now generally accepted as a metabolic hallmark of cancer.

AMP-activated protein kinase (AMPK) plays a central role in regulating cellular energy homeostasis.

In a study to understand AMPK's role in cancer, an additional copy of the *myc* gene and the *AMPK* gene were introduced into the genome of a group of mice.

Myc gene codes for the myc protein that stimulates cell division in these mice. Control mice have the artificially introduced *myc* gene and normal alleles($\alpha 1^{+/+}$) in the *AMPK* gene. Table 1.1 below shows the genetic modification of the experimental mice.

	Genotype at AMPK locus
Control group Mice carrying additional copy of *AMPK* gene with normal alleles	$\alpha 1^{+/+}$
Experimental group 1 Mice carrying carrying additional copy of *AMPK* gene with one mutant allele	$\alpha 1^{+/-}$
Experimental group 2 Mice carrying carrying additional copy of *AMPK* gene with two mutant alleles	$\alpha 1^{-/-}$

Table 1.1

The onset of tumors for the three groups of mice was measured (in weeks) and shown in Fig 1.2.

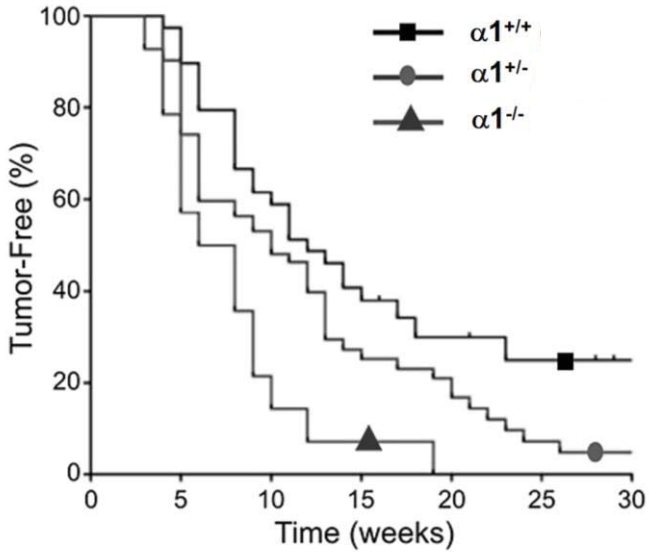


Fig. 1.2
(Source: Fauber et al, Cell Metabolism (2013) vol. 17, pp113–124)

(i) Explain why the control group of mice develop tumors.

[2]

(ii) Describe the results obtained for the experimental groups of mice.

[4]

(iii) Suggest possible explanations for the results shown in Fig 1.2.

[3]

(c) Fig. 1.3 shows one signalling pathway that regulates AMPK activity in the glucose metabolism in cancer cells.

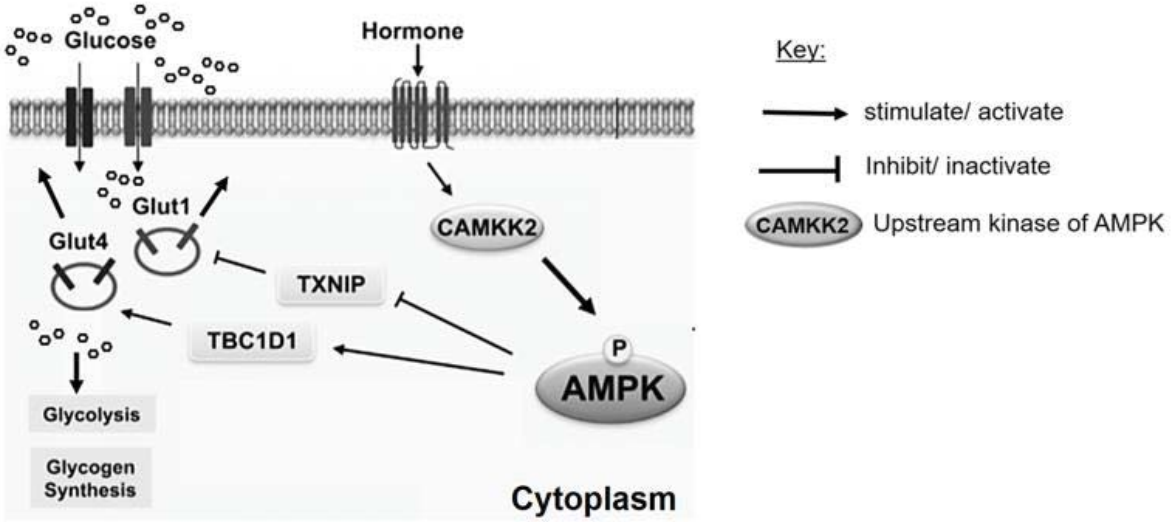


Fig. 1.3
(adapted from Garcia and Shaw, Molecular Cell Review (2017) vol 66, pp789-800)

(i) With reference to Fig. 1.3, describe how binding of the hormone to the receptor can result in the uptake of glucose by the cells.

[4]

(ii) Using your knowledge of blood glucose homeostasis, compare the signaling pathway shown in Fig. 1.3 with that of the glucagon signaling pathway.

[3]

(d) Other than being the site of aerobic respiration, the mitochondrion is widely accepted as an evidence supporting the Endosymbiont Theory.

Explain the Endosymbiont Theory and state two features of the mitochondrion that support this theory.

[3]

[Total: 29]

2 **(a)** Explain briefly the mechanism that generates B cells that can recognize all possible infectious agents.

[5]

(b) Suggest why the structure of a B cell receptor is different from the antibody produced by the same B cell.

[3]

(c) Plasma cells and memory cells differ in their relative abundance of organelles.

(i) State the differences in the relative abundance of two named organelles.

[2]

(ii) Explain the significance of these differences stated in (i).

[3]

[Total: 13]

3 A group of students decided to collect data to prove that temperature can influence plant morphology. Data was collected from young rain trees at three different locations (A, B, C) with different number of cars passing through per hour.

Table 3.1 and Fig 3.2 show the data they have collected.

Location	A	B	C
Number of cars per hour	Less than 5	Between 5 and 20	More than 20
Average number of stomata per leaf	37	33	25

Table 3.1

Gasoline was the preferred car fuel used by motorists in these locations. Gasoline produced carbon monoxide, carbon dioxide, nitrogen oxide, sulfur dioxide after it undergoes combustion. Combustion of gasoline releases a lot of heat.

Fig 3.2 show the temperature changes at the locations where the data was collected.

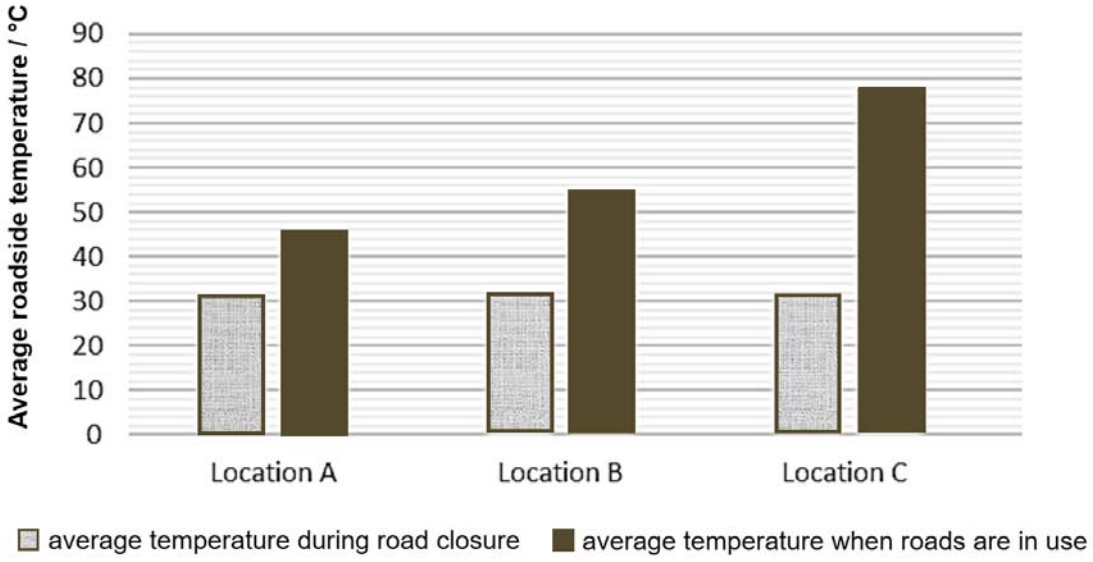


Fig 3.2

(a) What conclusion can one draw from the data in Table 3.1.

[1]

(b) Explain how the following factors can impact the number of stomata.

- Use of gasoline
- Number of cars

Use of gasoline

[2]

Number of cars

[2]

(c) Comment on the extent of validity of the experiment if the data was collected from five young rain trees.

[3]

[Total: 8]

Section B

Answer **one** question in this section

Write your answer on the writing paper 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 parts **(a), (b)** as indicated in the question.

4 **(a)** A critical step in the evolution of eukaryotic cells was the development of an endomembrane system and the acquisition of special membrane-enclosed organelles.

Justify this statement using named examples. [13]

(b) Interactions between different biomolecules (proteins, carbohydrates, lipids, nucleic acids) within cells and between cells and the environment are critical to the survival of cells.

Discuss the importance of interactions between proteins with other biomolecules in the structure, growth and reproduction of a prokaryotic cell. [12]

[Total: 25]

5 **(a)** The monarch butterfly (*Danaus plexippus L.*) is a long distance migratory species of butterfly in North America. It has experienced population declines in recent years due to global warming effects.

In the oceans, the Chinook salmon migrate hundreds of kilometres from their place of birth to the ocean and back. Climate change has reduced the numbers that survive this journey.

The effect of climate change is far reaching. Climate change affects an individual species in terms of its survival and spread, as well as all other species that are associated with it.

Discuss how climate change can impact land and marine ecosystems. [13]

(b) Research has shown that the genome of humans and other mammals contain DNA derived from viruses. About 8% of the human genetic material in the genome was found to be of viral origins. Many of these viral DNA are non-coding sequences.

Explain the significance of the functions played by different types of non-coding DNA. Suggest how viral DNA could have entered the human genome and discuss the importance of studying them. [12]

[Total: 25]

VICTORIA JUNIOR COLLEGE

JC 2 PRELIMINARY EXAMINATION 2019

NAME : _____

CT CLASS : _____

H2 BIOLOGY **9744/4**

Paper 4 **2 hours 30 minutes**

---

1. Write your name and CT group in the spaces at the top of this page.
2. Write in dark blue or black pen. You may use an HB pencil for any diagrams or graphs.
3. Answer all questions in the spaces provided on the Question Paper.
4. Students with the microscope and slide **must start with Question 2 first.**
5. 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.
6. 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.

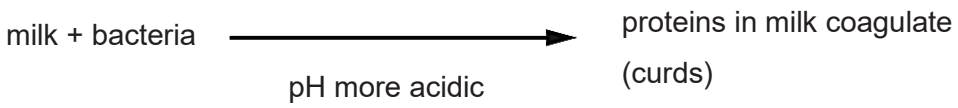
For Examiner's Use	
1	
2	
3	
Total	

This document consists of **19** printed pages, excluding the cover page.

Answer **all** questions.

1. Milk contains proteins which are used to make cheese.

During cheese making, bacteria are added to the milk. The bacteria change the pH of the milk to acidic, causing the proteins to coagulate (clot) forming curds. The curds are then used to make cheese.



Estimating the protein concentration in milk is important when making cheese.

You are required to investigate the protein concentration present in milk using two different methods.

You will need to:

- make simple dilutions of the proteins in the milk, **M** for use in both methods.
- carry out the biuret test on each concentration, to provide a measure of the concentration of proteins present in the milk in method **(I)**
- observe the coagulation of milk in method **(II)**.

It is recommended that you wear suitable eye protection.

You are provided with:

- 1.0% of milk, labelled **M**
- Milk with unknown protein concentration, labelled **U**
- Potassium hydroxide solution, labelled **K**
- Copper sulfate solution, labelled **C**

If **K** comes into contact with your skin, wash it off immediately under cold water.

(a) You are required to make simple dilutions of the proteins in the milk, **M** (1.0%) to obtain 4 other concentrations of milk. Present your dilution table in the space below.

[2]

Method (I)

Read step 1 to step 9 before proceeding.

1. Prepare all the concentrations of milk stated in **(a)** in the test tubes provided.

2. Stopper one of the test tubes with the rubber bung provided. Invert the test tube to ensure that the contents are well mixed. Repeat with each of the test tubes.

3. Label the spotting tile with the concentrations of milk prepared in step 1.

4. Use a pipette to put 2 drops of 1.0% milk into the labelled well on the tile.

Any milk remaining in the pipette should be **put back** into the test-tube so that as little of the milk as possible is removed from the test-tube. **You will need this milk for step 13.**

5. Repeat step 4 with each of the concentrations of milk.

6. Put 1 or 2 drops of **K** into each of the concentrations of milk on the tile and mix.

7. Put 0.5 cm^3 of **C** into each mixture on the tile, using the syringe labelled **C**.

8. Leave for 2 minutes for the color to change.

9. Compare the color with the standard colors shown in the color chart. Record the color of the mixture in **(b) (i)**.

(b) (i) Record your results in an appropriate table for the known concentrations of milk, using **only** the standard colors shown in the color chart.

*You will need to leave appropriate space to record your results from Method **(II)** in the **same** table below.*

[4]

You are now required to estimate the concentration of milk in sample **U**.

(ii) Describe how you would determine the protein concentration in sample **U**. [2]

_____

_____

_____

_____

(iii) Estimate the concentration of milk in sample **U**. [1]

_____

_____

(iv) Besides repeating the experiment, explain how you would modify the experiment to increase confidence in your results. [2]

_____

_____

_____

_____

Method (II)

The concentration of protein in milk can also be estimated by the extent of coagulation produced in acidic conditions.

You are provided with 1.0 mol dm^{-3} hydrochloric acid, labelled **A**.

If **A** comes into contact with your skin, wash it off immediately under cold water.

Read step 10 to step 14 before proceeding.

10. Put 2 cm^3 of **A** into each of the test-tubes containing the known concentrations of milk protein (from step 4) and **U**. Do **not** stir or mix **A** with the milk.

11. Observe the changes in the milk in all of the test tubes for up to 1 minute.

12. If coagulation is not visible after 1 minute, you may need to carefully tilt each test-tube to move the milk and then observe the coagulation.

13. Repeat the experiment to investigate the protein concentration in sample **U**.

14. Based on your observations, use the key in **Fig. 1.1** to record the results in the **same** table in **(b) (i)**.

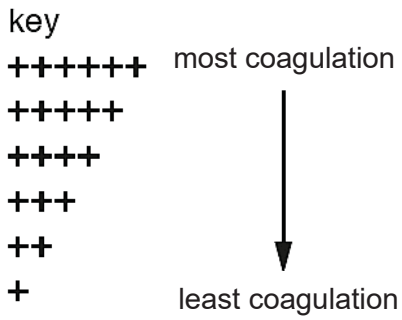


Fig. 1.1

(c) Complete **Fig. 1.2** to show the position on the line of each of the percentage concentrations of milk stated in the dilution table in **(a).**

Put the label **U** on **Fig. 1.2** to show an estimate of the concentration of milk which provides a measure of the proteins in **U**, using the result in **(b) (i)**.

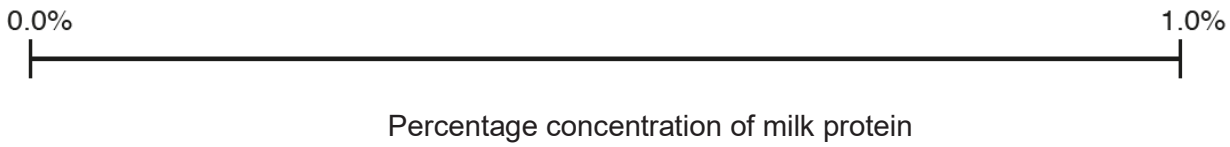


Fig. 1.2

[2]

(d) (i) Both methods **(I)** and **(II)** provide a subjective and quick estimation of the protein concentration in milk **U**.

Evaluate both methods in terms of their accuracy in determining the protein concentration in the milk. [3]

_____

_____

_____

_____

_____

_____

(ii) Describe **one** improvement to the procedure in method **(II)** to allow one to obtain a more accurate result. [2]

_____

_____

_____

_____

(e) Milk proteins can also be coagulated using the enzyme rennet.

A student investigated the effect of temperature on the activity of rennet, shown by the percentage coagulation of the milk.

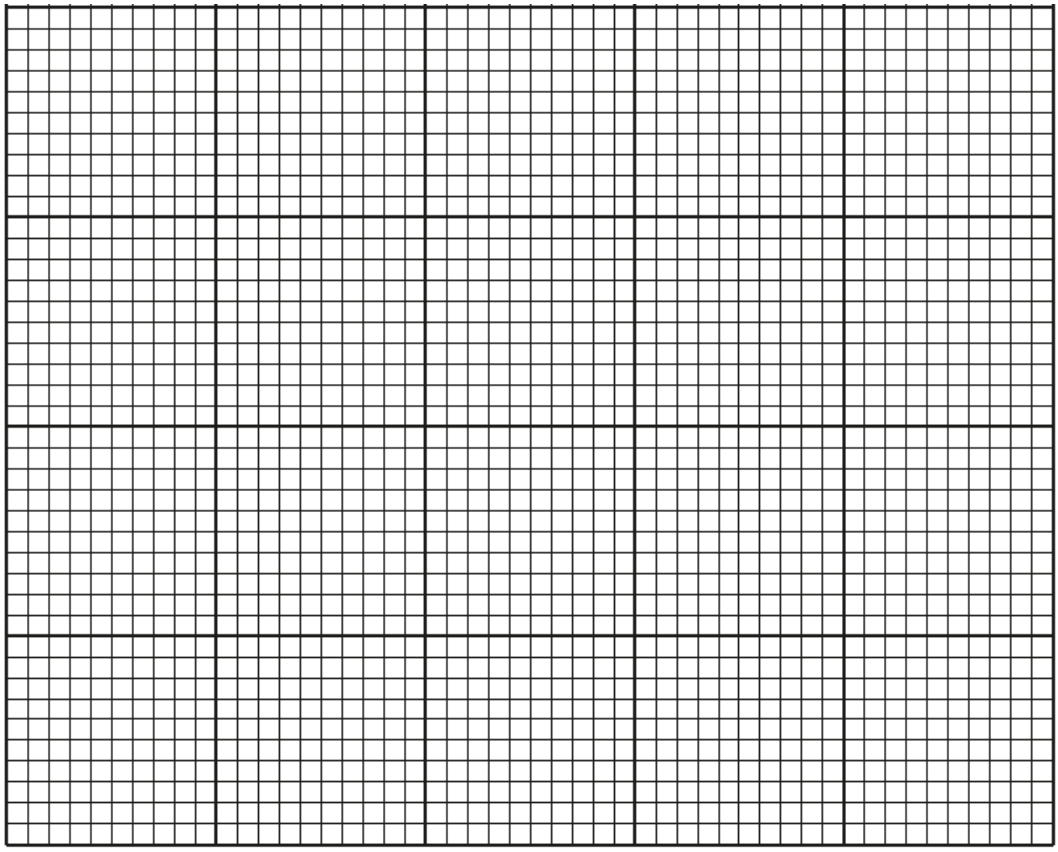
The results are shown in **Table 1.3**.

Table 1.3

Temperature / °C	Percentage coagulation of the milk / %
21.5	11
29.0	63
42.5	84
57.0	71
68.5	25

Plot a graph of the data in **Table 1.3** in the grid provided below.

Use a sharp pencil for drawing graphs.



[4]

[Total: 22]

2. **TSF** is a slide of a stained transverse section through a plant root.

You are not expected to be familiar with this specimen.

(a) Observe **TSF** using the 10x objective. An eyepiece graticule is attached to your microscope.

(i) Outline how you can use the graticule to help you draw an accurate plan diagram of **TSF** showing the correct proportions of the different tissues, without needing to calibrate the eyepiece graticule. [2]

(ii) Use the information that you have collected with the eyepiece graticule, make a plan drawing of **TSF** in the space provided below. You only need to draw **<u>half</u>** of **TSF** as indicated in **Fig 2.1.**

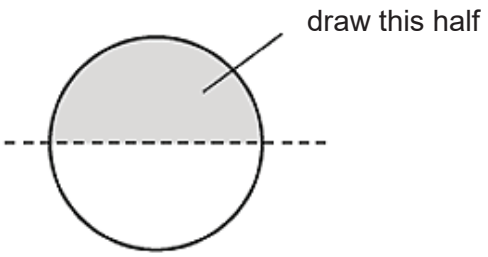


Fig. 2.1

[4]

(b) You are provided with a plastic ruler. Use the plastic ruler to calibrate your eyepiece graticule under 100x magnification.

(i) Explain why this is a less accurate method compared to the use of a stage micrometer. [2]

(ii) Calculate the magnification of your drawing. Show your working clearly. [2]

(c) Observe the central tissue in the root on **TSF**.

The cells in the central tissue are not identical.

Select one group of **four** adjacent (touching) cells that show some of the differences between these cells. Each cell must touch at least two of the other cells.

Make a large drawing of this group of **four** cells.

Use **one** ruled line to label the cell wall of **one** cell.

[4]

(d) A student carried out an experiment to determine the water potential of a plant material. He cut stalks of the plant material longitudinally and submerged them in sucrose solutions of different concentrations. His setup is shown in **Fig 2.2**.

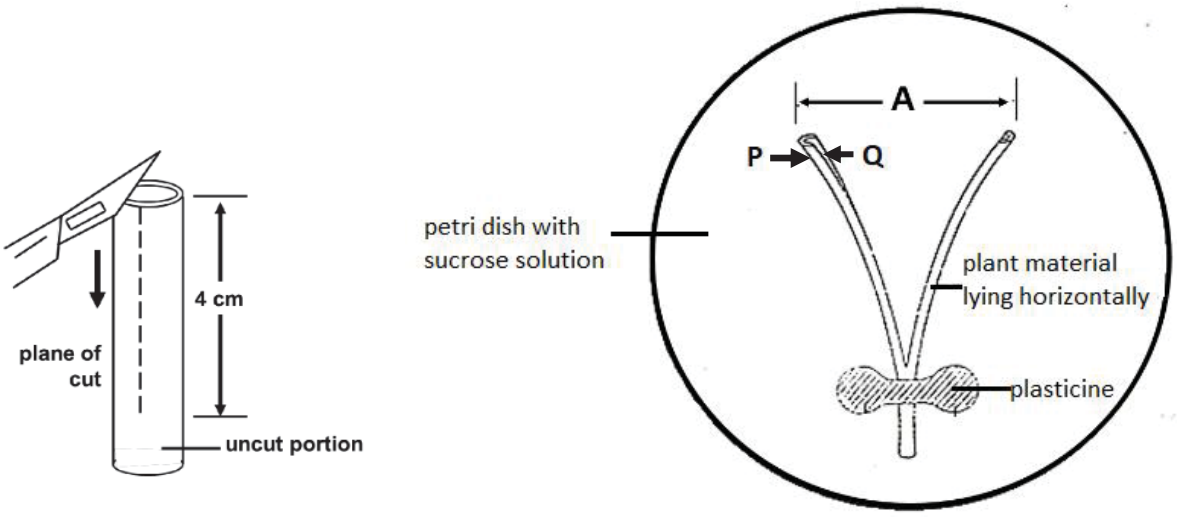


Fig. 2.2

Note: A - refers to the distance between the 2 halves of the stalk.

P and Q refers to the outer and inner regions of the stem.

He noticed that when the plant material is immersed in a solution with a higher water potential, the two sides of the stalk bent outwards i.e. distance A increases.

He hypothesises that this is due to the difference in structure between the cells at P and the cells at Q shown in **Fig. 2.2.**

Slide **K5** is a cross section of the plant material that he used for his experiment.

Observe the slide **K5** under the microscope.

Using high power, observe

- the cells that form the outermost layer (P) as well as
- the cells that are next to the central cavity of the section (Q).

(i) Prepare a table below to describe three structural differences between the cells found in P and Q.

[3]

(ii) Based on your observations in **(i)** above, provide an explanation for the increase in A when the stem is placed in a sucrose solution with a higher water potential than the cells. [3]

_____

_____

_____

_____

_____

_____

[Total: 20]

Name: _____ **CT Group**: _____

3. Tuberculosis (TB) is an infectious disease caused by the Gram positive bacterium *Mycobacterium tuberculosis* (Mtb). Mtb is sensitive to a certain class of antibiotics called penicillins that inhibit peptidoglycan synthesis in Gram positive bacteria.

In the first part of this question, you are required to investigate the effectiveness of four different types of penicillins, **P1** to **P4**, on Mtb.

As *M. tuberculosis* is highly infectious, you will only carry out a simulated test whereby the lawn of bacteria is represented as a blue surface on the agar plate. Effectiveness of the penicillins can be observed through decolourisation of the blue colour around the wells.

You are provided with:

- 1 nutrient agar plate containing "a lawn of *M. tuberculosis"*
- Microfuge tubes labelled **P1**, **P2**, **P3** and **P4** containing four different penicillins
- Microfuge tube labelled **W** containing 500 µl distilled water
- A ruler
- Marker pen
- A straw for creating wells in the nutrient agar
- 1 toothpick to remove the agar cylinder after creating wells with the straw
- 5 plastic droppers
- A wash bottle of distilled water

You should take care when using the Pasteur pipettes/ syringes to ensure no cross-contamination of samples and reagents occur.

Proceed as follows:

1. Use the straw provided to make 5 wells in the blue nutrient agar plate as shown in **Fig 3.1** below. Use a toothpick to help you remove the agar cylinder after cutting.

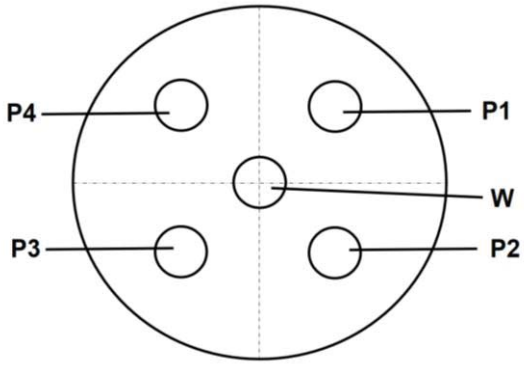


Fig 3.1

2. Label the wells accordingly before you perform step 3.

3. Use a dropper to deliver sufficient **P1** to the appropriate well so that **P1** is just below the surface of the surrounding agar.

   Deliver **P2**, **P3** and **P4** to the other three wells in the same way, taking care to use a different dropper to prevent cross-contamination of peniciilins.

4. To the central well, deliver distilled water **W** as in step 3. Incubate the plate for 5 minutes at room temperature.

5. After 5 minutes, measure the diameter of decolourisation for all the wells using the ruler provided (**Fig 3.2**) and record your results in **Table 3.3.**

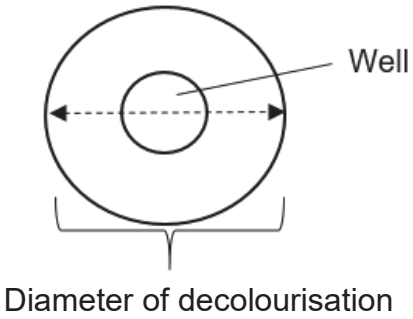


Fig 3.2

(a) **(i)** Complete **Table 3.3** below. [2]

Type of penicillin	Diameter of decolourisation /mm	Area of decolourised zone around the well / mm^2	Antimicrobial activity against Mtb

(ii) Identify the most effective of the four penicillins used and explain why. [2]

_____

_____

_____

_____

(b) Tuberculosis (TB) kills more people than any other infection. The bacterium *Mycobacterium tuberculosis* (Mtb) that causes TB can develop resistance to the antimicrobial drugs used to cure the disease. Multidrug-resistant TB does not respond well to isoniazid, the most powerful antibiotic against Mtb.

Scientists have identified a compound known as C10 that can reverse isoniazid resistance in Mtb. C10 apparently can restore isoniazid sensitivity in otherwise isoniazid-resistant Mtb strains.

A student investigating the antimicrobial activities of C10 and isoniazid hypothesised that isoniazid used in isolation is only effective when its concentration is at least 30%. However, when used in combination with C10, the absolute effective concentration of isoniazid becomes significantly reduced. The concentration of C10 that can restore sensitivity to isoniazid depends on the Mtb strains but is thought to be in the range of 2-10%.

Design an experiment to determine the most effective concentrations of isoniazid when used together with 2% C10 to kill Mtb.

In your plan, you must use:

- Nutrient agar plates containing bacterial lawns of *M. tuberculosis*
- a sterile solution of 20% C10
- a sterile solution of 100% isoniazid
- an incubator oven set at 37°C
- a cork borer
- a ruler
- sterile distilled water
- marker pen
- biosafety cabinet
- Bunsen burner
- 70% ethanol

You may select from the following sterilised apparatus and plan to use appropriate additional apparatus/material:

- syringes
- microfuge tubes
- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes and pipette fillers, glass rods, etc.

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- be illustrated by relevant diagram(s), if necessary
- identify the independent and dependent variables
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[9]

[Total: 13]

violet	pale violet	blue
violet	pale violet	blue
violet	pale violet	blue
violet	pale violet	blue
violet	pale violet	blue
violet	pale violet	blue
violet	pale violet	blue
violet	pale violet	blue
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violet	pale violet	blue
violet	pale violet	blue
violet	pale violet	blue
violet	pale violet	blue

Answers to MCQ

Q No	Answers	Q No	Answers	Q No	Answers
1	A	11	C	21	C
2	B	12	A	22	B
3	D	13	C	23	C
4	D	14	B	24	B
5	A	15	D	25	B
6	A	16	C	26	C
7	B	17	D	27	D
8	C	18	C	28	B
9	A	19	B	29	D
10	B	20	D	30	A

VICTORIA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION 2019 - H2 Biology
Proposed Answers – Paper 2

1 Lysosomes are the primary catabolic compartments in eukaryotic cells. They contain more than 40 different enzymes such as proteases, nucleases, phospholipases. **Fig 1.1** below shows a simplified structure of a lysosome with a large amount of proteins found on its surface. These proteins are highly glycosylated with oligosaccharides on the side facing the interior of the lysosomes.

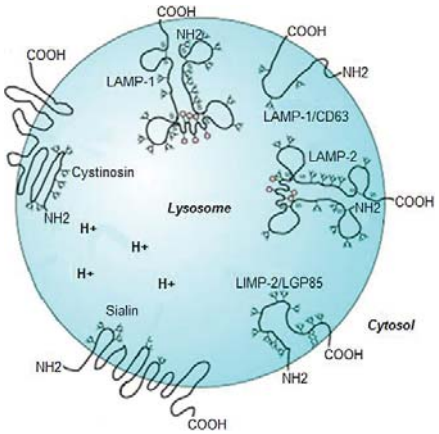


Fig. 1.1

(a) Describe the importance of the Golgi apparatus in the formation of lysosomes. [3]

- **Glycolysate/add the oligosaccharides to the proteins** that are present on the lysosome membrane;
- **Embedding of the glycoproteins onto the membrane of the GA;**
- **Sort and package** the different enzymes e.g. nucleases and proteases into the lysosome;
- [Idea of] Lysosome membrane is pinched off the Golgi apparatus;

  A! Proteins are embedded into the membrane of the Golgi apparatus before being pinched off;

(b) The interior of the lysosome has a pH of 4.5 whereas that of the cytoplasm is 7.2.

(i) Suggest how the lysosomes are able to maintain such a pH. [3]

- Membrane protein/ pump that can <u>actively transport H^+</u> from the cytoplasm into the lysosome;
- H^+ is prevented from diffusing back into the cytoplasm as it <u>charged</u>;
- and cannot cross the <u>hydrophobic core of the phospholipid bilayer</u>;

A! absence of protein channels that allow entry of protons via facilitated diffusion.

(ii) Suggest an advantage to the cell that the optimal pH of lysosomal enzymes is pH 4.5. [1]

- Idea that if the lysosome leaks/ burst (accidental), the enzymes will not be functioning at their optimal when they are released into the cytoplasm;
- AVP

(c) Another structure in the cytoplasm is also responsible for the hydrolysis of proteins.

Name this structure and state two differences between this structure and lysosome. [3]

Structure: Proteasome;

Any 2 below:

Lysosome	Proteasome
Membrane bound organelle	Non-membrane bound/ protein complexes
Proteins are not tagged with ubiquitin	Proteins are tagged with ubiquitin
Many different types of enzymes	Mainly proteases

[Total: 10]

2 Aspartate transcarbamoylase (ATCase) is an allosteric enzyme that catalyzes the first step in the synthesis of pyrimidines in the cytoplasm. Cytidine triphosphate (CTP) and uridine triphosphate (UTP) are two products of pyrimidine biosynthesis.

Purines (in the form of ATP and GTP) are synthesized in a separate pathway.

Fig. 2.1 shows the effect of CTP and ATP on the activity of ATCase.

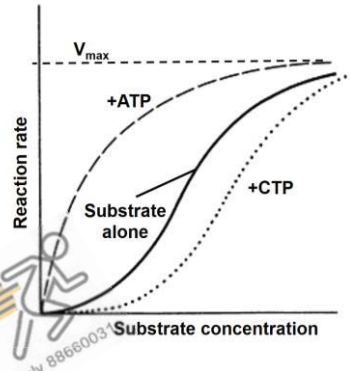


Fig. 2.1

(a) What do you understand by the term "allosteric enzyme"? [4]

- Enzymes that can <u>change their conformation</u> and hence activity;
- upon <u>binding of effector</u> to <u>regulatory</u> site/ a site other than the active site;

- Binding of positive effector/allosteric activator results in increase affinity for substrate binding at active site;

Or binding of the positive effector/allosteric activator maintains the active form of the enzyme allowing substrates to bind to the active sites -> increase in rate of reaction;

- Binding of negative effector/allosteric inhibitor results in decrease affinity for substrate binding at active site;

Or binding of the negative effector/allosteric inhibitor maintains the inactive form of the enzyme and substrates are not able to bind to the active sites -> decrease rate of reaction;

- Allosteric enzymes exhibits a phenomenon known as cooperativity/ binding of a substrate molecule to the active site of one subunit facilitates the binding of (other) substrate molecules to the active sites of the other subunits

(b) Using information from **Fig. 2.1**, explain the role of CTP and ATP in the regulation of ATCase activity.

CTP [2]:

- negative effector/ end-product inhibition/allosteric inhibitor;
- Evidence: Km is higher => affinity of enzyme for substrate is lower;

Or any valid data taken from graph

ATP [2]:

- positive effector/allosteric activator;
- Evidence: Km is lower => affinity of enzyme(ATCase) for substrate is higher;

Or any valid data from graph

(c) Suggest a reason why ATP synthesised in a different pathway is used to regulate ATCase activity. [1]

- Idea of pyrimidines and purines synthesis being coordinated so that there is equal proportion;

(d) For some enzymes, studies show that there is slight movement of some amino acids at the active site during the attachment of the substrates.

Suggest an explanation for the above observation. [3]

- Induced –fit hypothesis;
- Shape of active site is initially not complementary to the shape of substrates;
- Attachment of substrates induced a change in the shape of active site;
- Resulting in it being complementary -> slight movement in some amino acids;

[Total: 12]

3 Found in the cell walls of fungi and the exoskeleton of insects, chitin is the second most abundant organic polymer after cellulose on Earth.

A section of chitin is shown in **Fig 3.1.**

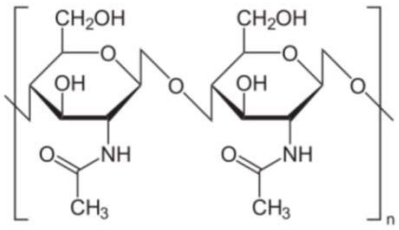


Fig. 3.1
https://www.differencebetween.com/

(a) Based on your knowledge of cellulose,

(i) state one similarity and one difference in the structure of chitin and cellulose. [2]

Similarities:
- Chitin and cellulose are both made from β glucose monomers;
- Both have monomers linked glycosidic bonds;
- Both are linear polymers;
- Both are polysaccharides;

Differences:
- Chitin contains Nitrogen but cellulose does not;
- Second Carbon in chitin glucose monomer binds to amine group, while second carbon in cellulose glucose monomer binds to hydroxyl group;

(ii) suggest how the structure of chitin shown in **Fig 3.1** would allow it to function as a structural component in insects and fungi. [3]

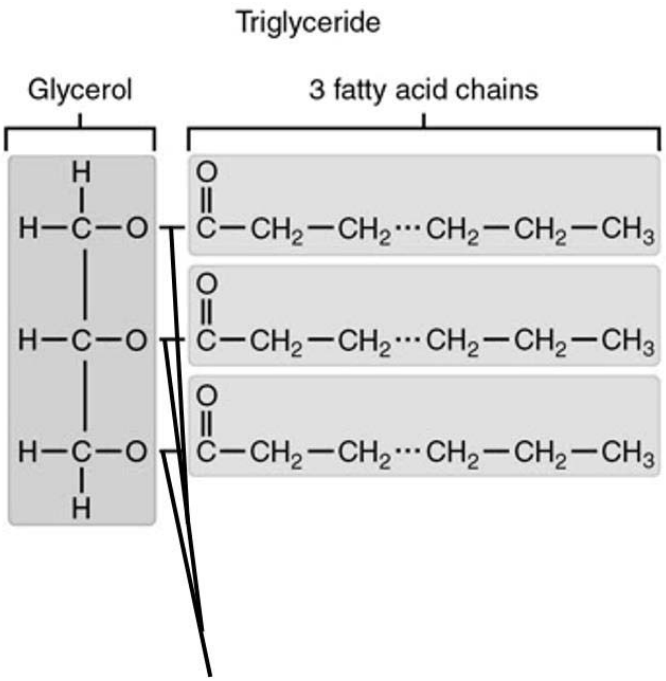
- Alternate residues flipped 180°, resulting in straight chain;
- Straight chain – hydrogen bonds can be formed between neighbouring chains, increase tensile strength;
- Polymers can be bundled up to form thicker/bigger fibers;
- Bulky molecule makes chitin a highly-insoluble carrier that makes a good outer layer of protection for both insects and fungi.

AVP;

(b) Unlike chitin and cellulose, triglyceride is an example of a storage biomolecule.

In the space below, draw the molecular structure of a triglyceride.

Label the components that make up this molecule and the bonds that hold them together. [3]



[Total: 8]

4 The building blocks of anterior (head) – posterior (tail) axis patterning in *Drosophila* embryo (fertilised oocyte) are laid out during oocyte (egg) formation. Four genes are responsible for the polarity of the oocyte and then of the subsequent embryo. mRNA molecules of these four genes were found to be distributed along the anterior-posterior axis of the developing oocyte (**Fig. 4.1**).

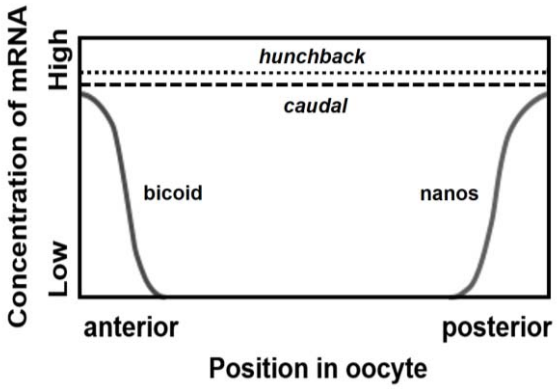


Fig. 4.1
https://en.wikipedia.org/wiki/Drosophila_embryogenesis

(a) With reference to **Fig 4.1**,

(i) explain the types of chromatin modifications that may be carried out on the *hunchback* and *caudal* genes. [4]

1. Histone acetylation;
2. Adding of acetyl groups to histones removes positive charge on histones;
3. leads to less electrostatic attraction / reduced affinity between histones and negatively charged DNA;
4. idea of DNA unwinding from histones / loosening of chromatin packaging/ form euchromatin;
5. DNA demethylation / removal of methyl groups from DNA;
6. Idea of greater accessibility of RNA polymerase / transcription factors to the promoter sequences;
7. Idea of loosely condensed chromatin facilitate assembly of general transcription factors and RNA polymerase at the promoter (to form transcription initiation complex);
8. Idea of upregulation of transcription / genes become transcriptionally active;
9. **<u>high</u>** levels / concentrations of mRNA observed for both *hunchback* and *caudal* genes; (½ mk each)

(ii) explain how the *hunchback* and *caudal* mRNA levels are maintained within the cell. [2]

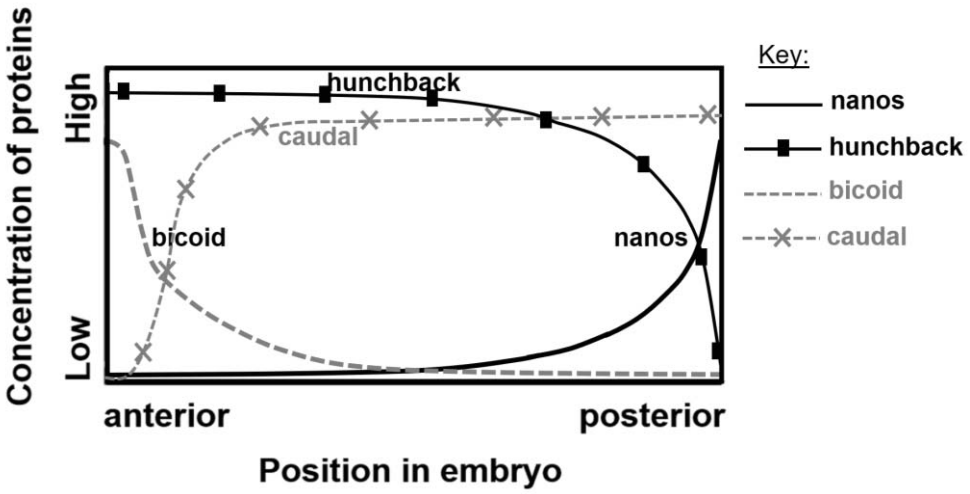
- (post-transcriptional control) 5' cap and 3' polyA tail added;
- to prevent digestion of mRNA by exonucleases;;
- (translational control) Idea of **increasing** the length of 3' polyA tail / **long** 3'polyA tail of the mRNA;
- to increase half life;;
- (translational control) Binding of certain proteins/inhibitors/hormones;
- which can slow down / block degradation of mRNA (by exonucleases);;

(½ mk each)

(b) The corresponding protein concentrations of the four genes were measured in the early stages of development of the *Drosophila* embryo (**Fig. 4.2**).

It was found that bicoid and nanos proteins act as repressors to block the translation of *caudal* and *hunchback* mRNA respectively.

Sketch **two** graphs in **Fig. 4.2**, representing the protein concentrations of caudal and hunchback and label them **C** and **H** respectively. [2]



[Total: 8]

5 **Fig 5.1** is an electron micrograph showing part of an animal cell.

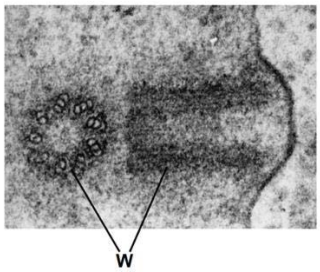


Fig. 5.1

(a) **(i)** Identify the structures labelled **W**. [1]

- Centrioles;

(R! Centrosome as this refers to a non-membrane bound region. Diagram points to 2 centrioles.)

(ii) Support your answer in **(i)** with 2 **observable** features shown in **Fig 5.1**. [2]

- a pair/idea of 2 of rod-like structures that are positioned at right angles/perpendicular to each other;
- transverse section (on the left) shows 9 triplets of microtubules arranged in a ring;
  R: 9 groups of 3 segments/ 9 sets of 3 tubulin subunits
  R: microtubules are long tubes made of tubulin because not observable.

(b) An abnormal increase in the number of structure **W** is frequently detected in many human cancers. Aneuploidy is common in tumour cells.

Suggest how an abnormal increase in number of structure **W** can lead to aneuploidy and cancer development. [3]

Unpacking the question	Marking point
"*abnormal increase in number of structure*" • What is the function of W? • What happens when W increase in number?	▪ Function of centrioles & consequences – max 1m (Any one below.) ➢ a. Centrioles constitute the microtubule organizing centre of the cell (MTOC) that organizes mitotic spindle formation/ for assembly of spindle fibers; ➢ b. Multiple numbers of centrioles (instead of the normal two at opposite poles of the dividing cell during mitosis) can lead to abnormal formation of spindle apparatus/ multiple spindle apparatus (idea of); Note: MTOC helps in the assembly of microtubules, resulting in the formation of spindle
"can lead to aneuploidy"	2. Relate to aneuploidy - 1m

	➢ [Idea of] Disrupts normal attachment of kinetochore tubules to kinetochore complex at centromeres of chromosomes, resulting in unequal separation of sister chromatids/nondisjunction of sister chromatids; (resulting in daughter cells having an additional or one less chromosome)
"can lead to aneuploidy and cancer development"	3. Relate to cancer development -1m ➢ Cells with extra chromosome: May carry additional copies of proto-oncogenes, resulting in overstimulation of cell growth and division/ that stimulate cell division or prevent apoptosis of cells with DNA damage; ➢ Cells with fewer number of chromosomes: These chromosomes may carry tumor suppressor gene which are important in preventing cell division or causes cell death (apoptosis) of cells with damaged DNA;

(c) Explain the importance of the various checkpoints in the production of identical daughter stem cells. [3]

- **G1 checkpoint @1m**

➢ monitors that **DNA** in parent stem cell **is undamaged before DNA synthesis** occurs in S phase/ damage in parent stem cell must be repaired before DNA replication,

➢ so that daughter cells will have genetic material identical to each other as well as to parent cell;

- **G2 checkpoint @1 m**

➢ monitors that DNA replication is **accurately** carried out at S/ any errors in DNA replication corrected

➢ so that daughter nuclei of stem cells are genetically identical to parent nucleus and to each other / identical daughter DNA molecules;

- **M checkpoint @1m**

➢ ALL chromosomes must be properly attached to kinetochore tubules to trigger onset of anaphase to ensure **equal separation** and distribution of sister chromatids into daughter nuclei of stem cells produced/ idea that daughter nuclei contain the **same number** and **type** of chromsomes.

[Total: 9]

6 **(a)** The typical bacterium is 2 □m in diameter. Explain how it is possible for the bacterium to have a genome that has a length and width of 1 mm and 2 nm, respectively. [3]

- Circular genome undergoes folding into ~ (50) loops/ loop domains through protein-DNA interactions;

- Loop domains are bound to central protein scaffold (that is attached to cell membrane);
- Each loop domain supercoils (A! twists/ folds upon itself as long as the idea that the twisting or folding is independent of other loop domains) by forming complexes with DNA-binding proteins;

[To become very compact to occupy nucleoid region of the cell]

(b) Bacteria are able to acquire new genes via horizontal gene transfer.

An experiment was set up to investigate horizontal gene transfer in bacteria.

Two strains of bacteria (A and B) are placed separately in the two arms of a Davis U-tube, as shown in **Fig. 6.1** below. The bacteria on both arms are separated by a filter.

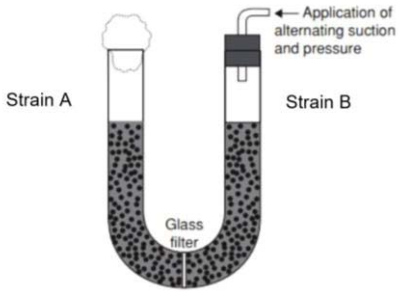


Fig. 6.1

(a) With reference to **Fig. 6.1**, explain why conjugation was not observed in the two strains of bacteria. [2]

- Ref to **presence of filter** (bacteria too big to pass through),
- **prevents cell contact** between strain A and strain B;
- **No attachment via sex pilus**/ no formation of **conjugation**/mating **bridge**; OR
- **No transfer of F plasmid from F^+/ donor cell to F^-/ recipient cell**;

(b) The same experiment was then repeated but with the addition of DNase into the medium.

When samples were removed from both sides of the filter, it was found that some bacteria taken from the strain A side of the Davis tube now contain genes from strain B bacteria.

The following hypothesis was proposed:

A filterable agent was released by the strain B cells. This agent was responsible for transferring the genetic information from B to A. This filterable agent was released by the strain B cells only when they were grown in association with strain A cells.

(i) Explain the purpose of adding DNase to the medium. [1]

- To enzymatically digests naked DNA and ensure that transformation cannot occur between the 2 strains of bacteria when bacteria cells die/ lyse;

(ii) Suggest how strain B could have produced the filterable agent to transfer the genetic information to strain A. [6]

- *Filterable agent is **lambda/ temperate phage present initially as prophage** in the bacterial DNA of strain **B**;
- *In the presence of strain **A** / when strain **A** is present, **lytic phase** of the bacteriophage occurs in strain **B/ viral DNA excise** itself **from the bacterial DNA**;
- *along with **some bacteria DNA** that is next to the viral integration, **packaged into viruses which are released by lysed strain B cells;**
- Bacteriophage **cross filter to infect**/ attach to bacterial cell wall (receptor) of **strain A** bacteria;
- **pass the bacterial DNA from strain B into strain A**, along with its own DNA**;**
- **infected cell** will **incorporate a new piece of bacterial DNA** i.e. **genetic recombination has occurred/ recombinant** cell's chromosome has a combination of DNA derived from 2 cells;
- through **specialized transduction**;

[Total: 12]

7 To study the mode of inheritance of fruit colour and fruit shape in a variety of plants, a group of students conducted the following crosses.

Cross I: Plants, pure bred for both characteristics were crossed. All the F1 plants have red and oval fruits.

Cross II: Two plants (**W** and **T**) heterozygous for fruit shape and colour were picked from the field and test crosses conducted for both plants. The results of these crosses are shown below.

Phenotype of progeny	Number of progeny of test cross involving	
	Plant **W**	Plant **T**
Red, long	46	4
Yellow, oval	44	6
Red, oval	5	43
Yellow, long	5	47
Total	100	100

Table 7.1

(a) Explain how the data obtained from test crossing Plant **W** can be used to reveal about the relationship between the two genes under investigation. [4]

Each bullet is 1m unless otherwise stated.

- Relationship between the 2 genes
  - The 2 genes are **linked** or show autosomal linkage;
  - found on the same (pair of homologous) chromosome; (1/2 m)

- Allele for <u>red is linked to allele for long</u>/ A! found on the same chromosome and <u>allele for yellow is linked to oval</u>;

- Using data (QV is expected)
  - Higher number red, long & yellow, oval (or QV 46 & 44) indicates that these are the parental combination of alleles as these alleles **did not show independent assortment** / tendency for alleles found on the same chromosome to be inherited together;
  - Lower number of **recombinant** progeny - red, oval & yellow long (or QV 5, 5) as they are a result of cross-overs (during meiosis) which is by chance/ rare event;

- Relationship between the 2 genes
  - 2 genes are close to each other on the chromosome with a map distance =10%;

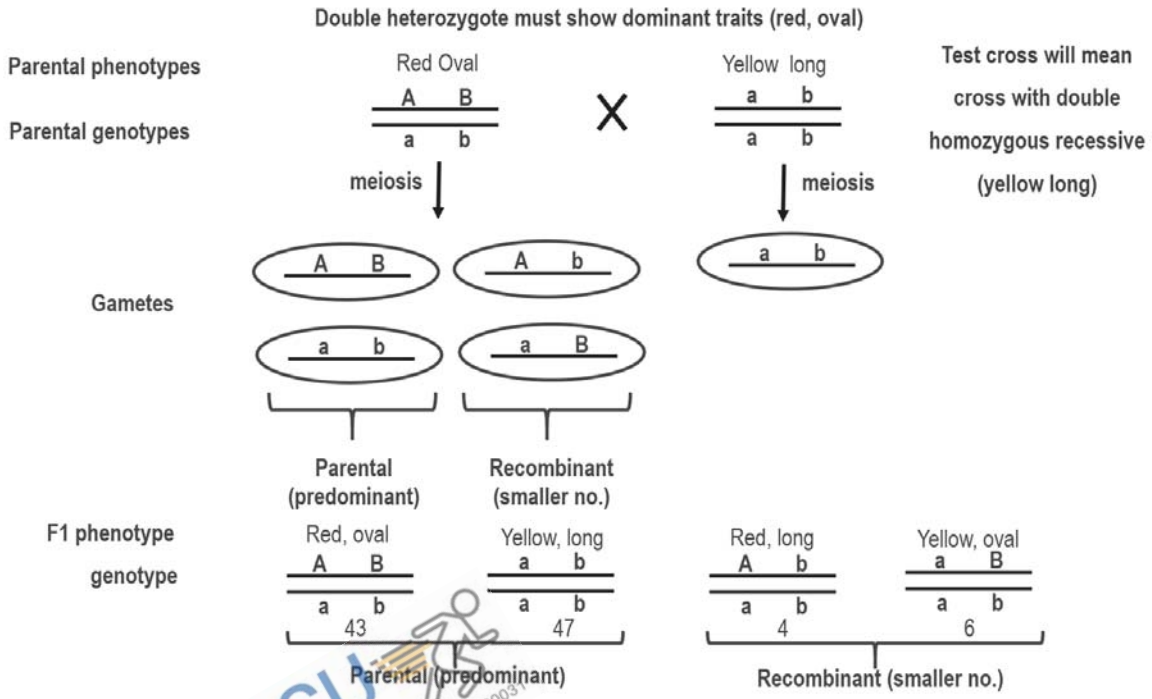
- **Deviates** from typical Mendelian test cross of double heterozygote with homozygous recessive of 1:1:1:1; (1/2 m)
  Note: this must be clearly stated as a deviation and not simply stating that the results should follow a 1:1:1:1 ratio;

(b) Use a genetic diagram to explain the results of test cross involving Plant **T**.

You are to use the letters A/a for fruit colour and B/b for fruit shape. [4]

Let A be the dominant allele for red fruit and a be the recessive allele for yellow fruit.

Let B be the dominant allele for oval shape and b be the recessive allele for long shape.



Genetic diagram – mark scheme

(i) Correct representation of genotypes for Plant T and double homo plant;

(ii) Correct gametes – parental and recombinant – circled and clearly identified;

(iii) Correct genotypes of Offspring

(iv) Correct phenotypes of offspring – relate number in Table 7.

(c) Distinguish between a gene and its alleles. [3]

- Gene: refer to sequence of nucleotides/bases or a specific length of DNA that codes for a particular polypeptide which determines a certain characteristic/trait;
- Alleles: refers to alternative forms of the gene;
- Alleles have slightly* different base sequences resulting in slightly* different proteins/different primary structures (for the same trait);
- Alleles (of a gene) occupy the same gene locus (on homologous chromosomes); (1/2 m)
- AVP;

[Total: 11]

8 **Fig. 8.1** shows the net carbon dioxide fixation in a plot of sorghum plants grown in an open field over a two-day period in August.

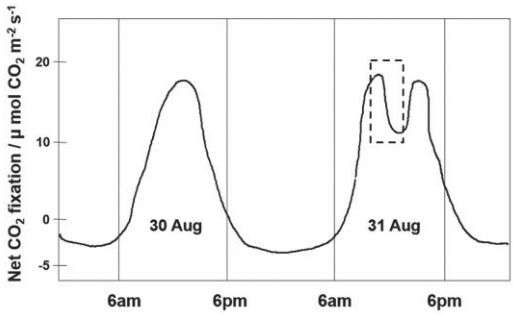


Fig. 8.1

(a) With reference to **Fig. 8.1**,

(i) explain the meaning of "limiting factor" by using data from Aug 30. [3]

- (Explanation of limiting factor) –
- Factor nearest its minimum value; Changing its quantity directly change the rate of process;
- Light intensity is the limiting factor;
- (Evidences from graph - max 2mk):
- No / low rate of CO_2 fixation when there is no light; QV - During night (QV 6pm to 6am) CO_2 fixation remains low at -2umol$CO_2m^{-2}s^{-1}$;
- As light intensity decreases, the rate of CO_2 fixation decreases; QV – (from 12pm – 6pm) rate of CO_2 fixation decreases from 16 to 0 umol$CO_2m^{-2}s^{-1}$;
- As light intensity increases, the rate of CO_2 fixation increases; QV - (from 6am to 12pm) rate of CO_2 fixation increases from -2 to 16 umol$CO_2m^{-2}s^{-1}$;

(½ mk each) Max 3

(ii) suggest and explain what could have happened to cause the drop in CO_2 fixation in the boxed up area. [4]

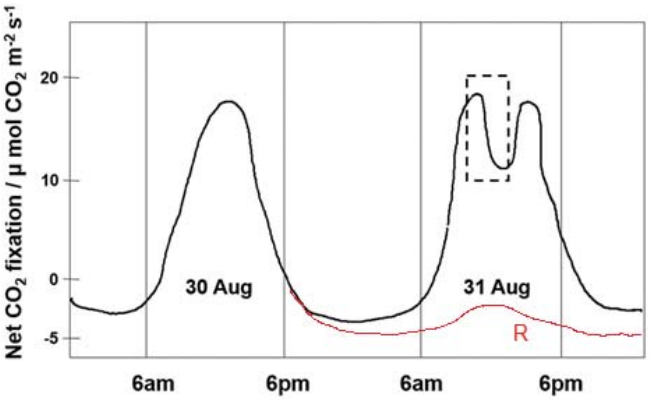
1. Presence of cloud cover / thunderstorm etc (accept logical idea of a weather condition that has screening effect on sun);
2. which reduced the amount of light intensity over a temporary period of time;
3. light provides the energy for the photoactivation of chl a;
4. light required for photolysis of water;
5. idea of less electron transfer along ETC
6. thus photophosphorylation / light dependent reactions does not take place;
7. idea that ATP and reduced NADP are reduced / not produced;
8. Calvin cycle requires both biochemical products to proceed;
9. Thus rate of Calvin cycle decreases;
10. QV;

(½ mk each)

(b) A competitive inhibitor to the enzyme involved in the formation of reduced NADP was introduced to the plants at 6pm of 30th Aug.

Sketch a graph on **Fig. 8.1** to indicate the net CO_2 fixation for these plants and label it as **R**. [1]

Answer:



Accept variations of graph which has rate lower than original graph from 6pm 30th Aug onwards. Graph must be completed throughout 31st Aug onwards.

(c) State two differences between Calvin Cycle and Krebs Cycle. [2]

	Calvin cycle	Krebs cycle
Location	Takes place in stroma of chloroplast;	Takes place in matrix of mitochondria;
Input	Requires ATP, NADPH and CO_2	Requires acetyl coA, ADP, NAD and FAD
Output (Products)	Produces triose phosphate which can be converted to starch for plant storage;	Produces reduced NAD, reduced FAD, ATP and CO_2;

Regeneration of compound	Process to regenerate Ribulose bisphosphate;	Process to regenerate Oxaloacetate;

(1mk for each valid difference)

[Total: 10]

9 Madagascar, the fourth-largest island in the world, sits in the Indian Ocean several hundred kilometers off Africa's southeastern coast and houses an amazing variety of plant and animals, many of which are endemic (found only) to the island. The island is made of many different habitat types from deserts to rainforests.

The vangas of Madagascar represent an example of adaptive radiation that is considered by many evolutionary biologists to be as notable as Darwin's finches. The ancestor of all vangas colonized the island of Madagascar about 20 million years ago. That single ancestral species gave rise to 22 descendant vanga species, representing a great variety of feeding strategies via adaptive radiation (**Fig. 9.1**).

Fig. 9.1
Source: Proceedings of the National Academy of Sciences, 2012.

(a) Using **Fig. 9.1**, and the information provided, explain how adaptive radiation of the Madagascan vangas can come about. [5]

Adaptive radiation is speciation from an ancestral species into numerous descendant species in a relatively short evolutionary time. Think of the conditions that will allow this to happen. Note that the context here is a single large island.

- Existence of numerous ecological habitats with different environmental conditions that exert different selective pressures (e.g. different types of food);
- *Ancestral population of vanga has members that have genetic variation that are manifested in their phenotype (e.g. bill shape and size);
- Birds that are at a survival advantage have higher reproductive success and pass down advantageous alleles to their offspring;
- Over many generations, the allele frequency changes in the population's gene pool;
- *Populations deriving from the ancestral species in the different habitats become physically isolated through vast distance or a physical barrier on the island of

Madagascar / become reproductively isolated in the same locality through behavioural or temporal mechanisms;

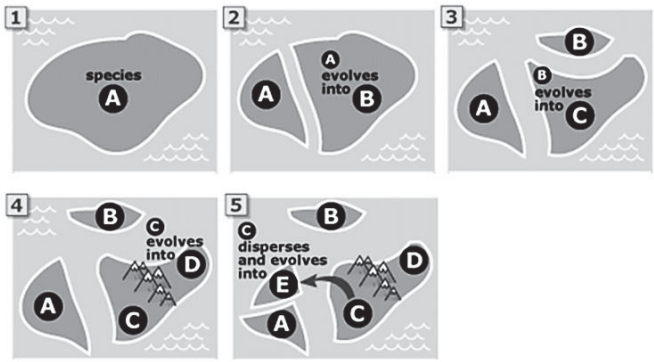
- *Each isolated population acquire independent mutations leading to distinct gene pools over time;

**essential points*

(b) What kind of information can scientists use to conclusively prove that the vangas are closely related species? [1]

- Genetic data/ molecular data;

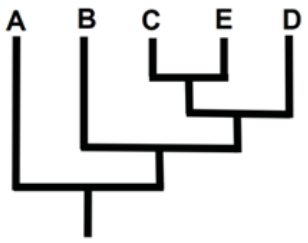
(c) Pictures 1-5 show a possible hypothetical chain of events that occur in the evolution of species A-E.



Source: https://evolution.berkeley.edu/evolibrary/news/091001_madagascar

In the space below, construct a phylogenetic tree to reflect their evolutionary relationships. [3]

Answer:



1. Species A on the left island is the outgroup (picture 2).
2. Then just follow the most recent divergence and work backwards in time (picture 5). Species C and species E will share most recent ancestor and thus are sister taxa.
3. Clade containing species D and the branch with common ancestor of C/E will be the next smallest clade.
4. Clade containing species B and branch to common ancestor of species D and sister taxa with species C and E will form the next larger monophylectic clade.

[Total: 9]

10 *Vibrio cholerae* is a bacterium that causes cholera. Many people who have recovered from cholera rarely become ill again from the disease.

(a) Explain why people who have recovered from cholera rarely become ill again from the disease. [3]

- Presence of memory B cells;

- Idea of memory B cells are long-lived / remain in body for long period;
- which have BCR specific to the antigen on the cholera bacteria;
- Able to be activated / undergo clonal expansion upon re-exposure to the cholera;
- Differentiate into (large numbers of) plasma cells;
- to produce and secrete more antibodies at faster speed with greater affinities against the bacterium
- Idea of 2° immune response responding **more rapidly and more effectively**;

(½ mk each)

(b) **Fig. 10.1** shows a simplified diagram of an antibody.

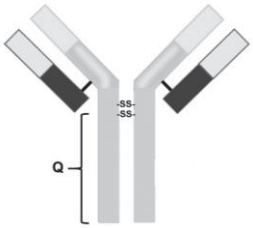


Fig. 10.1

(i) Explain how antibodies produced against an antigen may differ in the region **Q**. [2]

- **Class switching**;
- Due to stimulation by cytokines secreted by T helper cells;
- Excision of DNA;
- Which allows same VDJ segment to lie next to a different C gene;
- Allows the production of IgG, IgA or IgE;
- Idea that type of cytokine determines which constant genes are excised within heavy chain constant domain;

(½ mk each)

(ii) State the significance of **(i)**. [1]

- Enable antibody to interact with different effector cells / Enable different effector functions of the antibody / increase the range of effector cell functions;

[Total: 6]

11 **Fig 11.1** shows the effect of increase in temperature on the survival of five different species of insects found in the same locality. All of the insects feed on milkweed plants. For each species, the mean value (•) and standard deviation (line) of survival was determined. A positive Cohen's d value means that there is an increase in the mean value of survival and a negative d value means that there is a decrease in the mean value of the survival.

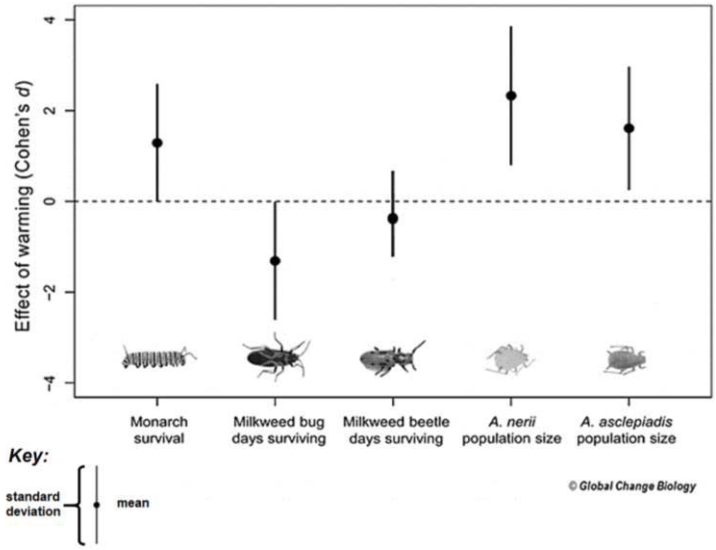


Fig. 11.1
https://conservationcorridor.org/2017/12/warmer-temperatures-and-connectivity-interact-to-influence-metacommunity-diversity/

(a) **(i)** Suggest why some insect species show positive d values whereas others show a negative d values although they are found in the same locality. [1]

- Difference tolerance range;

A! different thermal limits.

(ii) State the importance of knowing the standard deviation for each set of data. [1]

- Standard deviation (SD) is a measure of distribution of values about the mean,
- data sets with large SD means data is very heterogeneous and less reliable compared data sets with a small SD;

(b) Discuss the impact of continued warming on the different populations of insect species that are found on the same plant. [3]

- Continued warming affects survival of the different insect populations to different extent, (concise QV of the five insect populations);
- Insect populations with negative Cohen's d value at highest threat of death (milkweed bug), thus impacting on the possibility of extinction of the species whereas insect population with highest positive d value (*A nerri*) has highest chance of survival;
- Within each species, there are individuals that are outliers with higher d value that overlap (Monarch, *A. nerri* and *A. asclepiadis*) that will survive and compete for resources on the same plant;
- Those with better adapted phenotypes/ that are able to exploit resources better will be at selective advantage/have higher reproductive success and increase in number within their population;

A! reduced biodiversity on the same plant;

[Total: 5]

VICTORIA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION 2019 - H2 Biology
Proposed Answers – Paper 3

Section A

1 Otto Warburg made a striking discovery in the 1920s, when he found that cancer cells prefer to metabolize glucose by glycolysis, even in the presence of normal levels of oxygen. This is a paradoxical finding in light of the common understanding that glycolysis is a less efficient pathway for producing ATP compared to oxidative phosphorylation. This became known as the Warburg effect.

(a) (i) State why oxidative phosphorylation is more efficient at producing ATP. [1]

- Number of ATP molecules produced by OP is 14x more compared to glycolysis/ 28 molecules of ATP vs 2 net ATP from glycolysis);

(ii) Mutation of *p53* gene was found to prevent expression of the gene *SCO2* in cancer cells. *SCO2* codes for synthesis of cytochrome c oxidase protein, the last electron carrier of the electron transport chain.

Suggest and explain the effects of lack of expression of *SCO2* in the highly proliferative cancer cells. [5]

- Deficit of cytochrome C oxidase protein prevents <u>transfer of electron to the final electron acceptor O_2</u>;
- Electron carriers of ETC remains reduced so electrons from NADH (coming from glycolysis, Link and Krebs) and FADH (from Krebs) cannot be transferred down ETC;
- No release of energy to transport H^+ to intermembrane space → No set up of H^+ concentration gradient across inner mitochondrial membrane, No PMF and no chemiosmosis;
- *<u>No OP</u> and no synthesis of ATP in mitochondria;
  - <u>increase uptake of glucose</u> to sustain metabolism and cell division highly proliferative cancer cells;
  - <u>leads to increased lactate formation as more pyruvate act as alternate H acceptor</u>;

Note: 2m for effects, 2m for any of bullets 1-4
*essential point

(iii) Discuss two possible consequences of the effects in **(ii)** on the survival of cancer cells.[4]

Possible consequence 1:
- increased lactate production lowers pH in cell cytoplasm
- denature cytosolic enzymes
- disrupts cell metabolism and decrease survival of cancer cells

Possible consequence 2:

- increased lactate production carried away by new blood vessels of tumour mass/ angiogenesis
- Cell cytoplasm pH is not reduced
- Cell metabolism not disrupted
- No decrease in survival of cancer cells

(b) Aerobic glycolysis (another term for Warburg effect) is now generally accepted as a metabolic hallmark of cancer.

AMP-activated protein kinase (AMPK) plays a central role in regulating cellular energy homeostasis.

In a study to understand AMPK's role in cancer, an additional copy of the *myc* gene and the *AMPK* gene were introduced into the genome of a group of mice.

Myc gene codes for the myc protein that stimulates cell division in these mice. Control mice have the artificially introduced *myc* gene and normal alleles (□$1^{+/+}$) in the *AMPK* gene. Table 1.1 below shows the genetic modification of the experimental mice.

Table 1.1

	Genotype at AMPK locus
Control group Mice carrying additional copy of *AMPK* gene with normal alleles	$\alpha 1^{+/+}$
Experimental group 1 Mice carrying carrying additional copy of *AMPK* gene with one mutant allele	$\alpha 1^{+/-}$
Experimental group 2 Mice carrying carrying additional copy of *AMPK* gene with two mutant alleles	$\alpha 1^{-/-}$

The onset of tumors for the three groups of mice was measured (in weeks) and shown in Fig 1.2.

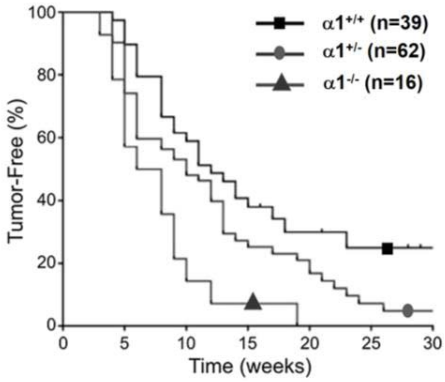


Fig. 1.2
(Source: Fauber et al, Cell Metabolism (2013) vol. 17, pp113–124)

(i) Explain why the control group of mice develop tumors. [2]

- Extra copy of *myc* gene will lead to overexpression of myc protein;
- lead to overstimulation of cell division resulting in tumor formation;

(ii) Describe the results obtained for the experimental groups of mice. [4]

- Group 2: These homozygous □1$^{-/-}$ mice displayed accelerated/earlier cancer development/ formation of tumors compared to control animals
- QV: with a median/average (idea of) tumor onset of 7 weeks for 50% of mice (and then 0% remaining tumor-free at 30 weeks);
- Group 1: Mice heterozygous for AMPK□1 (□1$^{+/-}$) took an intermediate length of time for 50% to show onset of tumours (idea that it is between the 2 homozygous groups of mice / between control and Group 2 e.g. faster than control, slower than Group 2);
- QV: 50% mice developing a tumors at 10 weeks (and 5% remaining tumor-free at 30 weeks);

(ii) Suggest possible explanations for the results shown in Fig 1.2. [3]

[Relate the genotype to the amount of functional protein AMPK]:
Either:

- Functional AMPK activates repressor that is involved in downregulating *myc* gene expression; [R! AMPK is a transcription factor as it is clear in stem that it is protein kinase thus its role is in signal transduction that elicits a cellular response that affects *myc* gene transcription]
- When both alleles are mutated, no functional AMPK, repressor is not activated, cannot migrate to nucleus to downregulate *myc* expression → earliest onset of tumour formation;
- When one A*MPK* allele is mutated, some functional AMPK, so lower levels of active repressor → lower rate of *myc* gene expression and later onset of tumour formation;

OR

- Functional AMPK inactivates activator that upregulates *myc* gene expression;
- When both alleles are mutated, no functional AMPK to inhibit activator, active activator migrates to nucleus to upregulate *myc* gene transcription → earliest onset of tumour formation;

- When one *AMPK* allele is mutated, some functional AMPK so lower levels of active activator → lower rate of *myc* gene expression and later onset of tumour formation;

(c) Fig. 1.3 shows one signalling pathway that regulates AMPK activity in the glucose metabolism in cancer cells.

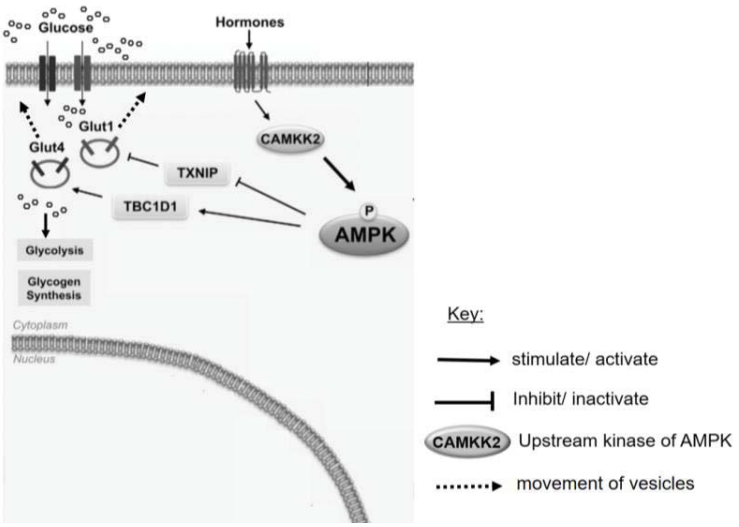


Fig. 1.3
(adapted from Garcia and Shaw, Molecular Cell Review (2017) vol 66, pp789-800)

With reference to Fig. 1.3, describe how binding of the hormone to the receptor can result in the uptake of glucose by the cells. [4]

- Hormone binding to GPCR receptor stimulates CAMKK2,
- CAMKK2 phosphorylates AMPK;
- Activated AMPK phosphorylates and activates TBC1D1, which stimulates translocation (A! formation) of vesicles containing Glut4 glucose transporters;
- At the same time, activated AMPK phosphorylates and inactivates TXNIP,
- Inactivated TXNIP unable to inhibit translocation (A! formation) of vesicles containing Glut1 glucose transporters;
- Increased no. of both types of glucose transporters in plasma membrane of cancer cell promotes glucose uptake for glycolysis as well as synthesis of glycogen in the cytoplasm;

(d) Using your knowledge of blood glucose homeostasis, compare the signaling shown in Fig. 1.3 with that of glucagon signaling. [3]

Similarity: both use seven transmembrane receptor/GPCR;
Differences:

1. Glucagon signalling involves production of cAMP, a second messenger whereas in Fig. 1.3, CAMKK2 is a kinase that is activated to phosphorylate AMPK; [A! signalling in Fig. 1.3 does not involve second messenger]
2. Glucagon signalling pathway activates protein kinase cascade that activates other cellular enzymes (e.g. glycogen phosphorylase) in the signal transduction pathway leading to cellular response cellular response whereas in Fig. 1.3, there is no kinase cascade involved; [A! glucagon signalling involves protein kinase cascade whereas signalling in Fig. 1.3 does not]
3. Glucagon signalling is involved in cellular response of releasing glucose into blood stream in response to blood glucose levels below norm whereas in Fig. 1.3, glucose uptake into the cell after cellular response of stimulating more vesicles containing glucose transporters to move to CSM;
4. In glucagon signalling, cellular response involves speeding up the rate of breakdown of glycogen (glycogenolysis) stored inside liver cells whereas in Fig. 1.3, glycogen synthesis occurs;
5. AVP;

(e) Other than being the site of aerobic respiration, the mitochondrion is widely accepted as an evidence supporting the Endosymbiont Theory.

Explain the Endosymbiont Theory and state two features of the mitochondrion that support this theory. [3]

[Endosymbiont Theory]

- That the mitochondrion was an aerobic <u>bacterium</u> that was engulfed by a primitive <u>eukaryotic cell</u>;
- Its initial symbiotic relationship evolved into an organelle of the eukaryotic cell when both lose genes that code for products whose functions can be supplied by the other;

[Evidence]

- Size of mitochondrion is same to that of a bacterium (~ 1-2 μm);
- Small circular DNA similar to the bacterial genome/ A! “chromosome”;
- 70S ribosomes similar to that of bacteria and different from the 80S in the cytoplasm;
- Presence of double membrane (suggesting that it has been engulfed)

[Total: 29]

2 a Explain briefly the mechanism that generates B cells that can recognize all possible infectious agents. [5]

- Somatic recombination involving both the variable regions of both the light and heavy chain gene loci;
- Multiple different copies of the V, D, J gene segments in germline DNA at the immunoglobulin heavy gene loci and V, J gene segments at the light gene loci;
- Only 1 segment from V, D and J gene segments is chosen and joined to the constant region sequence to make the heavy chain gene;
- Only 1 segment from V and J gene segments is chosen and joined to the constant region sequence to make the light chain gene;
- Many possible combinations of V(D)J due to gene rearrangements, resulting formation of a repertoire of B cells with different BCRs (B cell receptors) that are specific to different antigens present on infectious agents (after transcription and translation);

b Suggest why the structure of a B cell receptor is different from the antibody produced by the same B cell. [3]

- A hydrophobic region present in the Fc domain/constant region;
- that will allow the BCR to embed in the phospholipid of the cell membrane;
- whereas antibody is secreted and soluble and hence the hydrophobic region is either deleted or masked;

Or

- Class switching;
- They have different constant/ Fc region but same specificity for antigen (with the variable region or same VDJ segment next to a different C gene);
- leading to antibodies that serve different effector function/ resulting in different classes of Ig eg. IgG, IgM, IgD etc that are more efficient in killing the pathogen;

c Plasma cells and memory cells differ in their relative abundance of organelles.

(i) State the differences in the relative abundance of two named organelles. [2]

- Plasma cell has more of rough endoplasmic reticulum, golgi apparatus/ golgi body, mitochondria
  R: ribosomes as antibodies are synthesized within the lumen of the rER and not by the free ribosomes in the cytoplasm

(ii) Explain the significance of these differences stated in (i). [3]

- *Plasma cells are involve in production and secretion of large amounts of antibodies and antibodies are glycoproteins (whereas memory B cell for production of BCR only);
  Must have to explain the significance
- Explanation for organelle 1;

- Explanation for organelle 2;

- Explanation for rER: synthesis of the protein component of the antibody/translation of the mRNA that codes for antibody which will be secreted out of the cell (compared to free ribosomes) Or translation of heavy and light chains of the antibody;
  (There must be an indication that antibody is made up of proteins, otherwise, no mark.)
  (A: glycolysation occurring in rER)
  Mark once for protein synthesis only. No double awarding for ribosomes and rER.

- Explanation for GA:
  - Addition of carbohydrates/glycolysation to the constant domain of the antibody; Or
  - sorting, modify and packing of the antibodies into secretory vesicles for release to the outside via exocytosis;

- Explanation for mitochondria: provide energy/ATP for synthesis of the antibody/ vesicle formation to release the antibody at a high rate for a stronger and more effective immune response;

[Total: 13]

3 A group of students decided to collect data to prove that temperature can influence plant morphology. Data was collected from young rain trees at three different locations (A, B, C) with different number of cars passing through per hour.

Table 3.1 and Fig 3.2 show the data they have collected.

Location	A	B	C
Number of cars per hour	Less than 5	Between 5 and 20	More than 20
Average number of stomata per leaf	37	33	25

Table 3.1

Fig 3.2 show the temperature change at the locations where the data was collected.

Gasoline was the preferred car fuel used by motorists in these locations. Gasoline produced carbon monoxide, carbon dioxide, nitrogen oxide, sulfur dioxide after it undergo combustion. Combustion of gasoline releases a lot of heat.

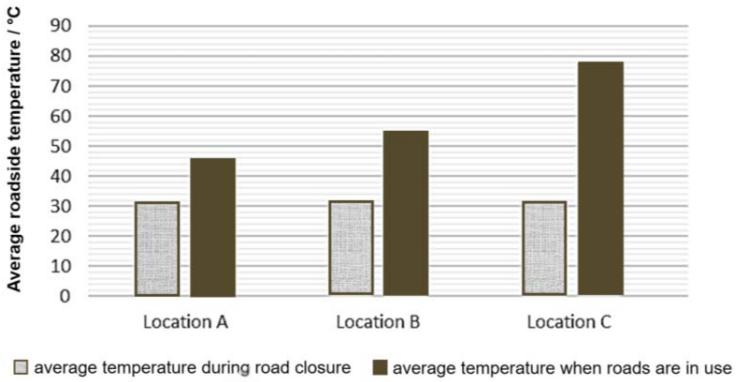


Fig 3.2

a What conclusion can one draw from the data in Table 3.1. [1]

- Lower average number of stomata in location with higher car traffic;

b Explain how the following factors can impact the number of stomata. [4]

- Use of gasoline
- Number of cars

Use of gasoline:
Cause [1]

- Combustion of gasoline releases lots of heat, when the environment gets too hot, the stoma closes to prevent loss of water vapour;

Effect [1]

- The stoma usually opens for carbon dioxide molecules to enter in order so that photosynthesis can take place.
- Prolonged closure of stoma can compromise capacity of plant to undergo photosynthesis, especially the Calvin cycle/light-independent reaction / Carbon fixation

OR

- Gasoline produced carbon dioxide after it undergo combustion. Environmental carbon dioxide levels are raised and less stomata is now necessary to sustain similar photosynthetic levels.
- @ Gasoline produced toxic gases carbon monoxide, carbon dioxide, nitrogen oxide, sulfur dioxide after it undergo combustion.
- Plants with less stomata may actually have a selective advantage and be selected for in a natural selection process, hence more plants observed with less stomata;

Number of cars: (similar points as above accepted)

Cause [1]

- Higher temperatures from more car exhausts will cause the roadside temperature to rise
- Heavier traffic flow will result in a higher level of pollution with higher levels of emissions of carbon monoxide, carbon dioxide, nitrogen oxide, sulfur dioxide.

Effect [1]

- stomata to close up in order to reduce water loss via transpiration / sufficient carbon dioxide.
- carbon monoxide, carbon dioxide, nitrogen oxide, sulfur dioxide toxic gases that can be detrimental to the plant
- Plants with less stomata may actually have a selective advantage and be selected for in a natural selection process, hence more plants observed with less stomata;

FYI: Guard cells might die from prolonged closure leading to lower numbers of stomata.

d It was later found that the data collected came from five young rain trees.

In view of this, comment on the extent of validity of the experiment. [3]

Valid if:

- Number of leaves – may be significant if at least 50 are taken from each tree and compared
- Leaves are randomly picked from all parts of the tree, high and low
- AVP;

Invalid if:

- Sample size too small for the number of trees (too few at 5 only)

- sampling is non random
- Small sample taken from a few trees may not reflect the selection pressure as being favourable in selecting for less stomata in leaves.
- AVP;

[Total:8]

Section B

4 (a) A critical step in the evolution of eukaryotic cells was the development of an endomembrane system and the acquisition of special membrane-enclosed subcellular organelles.

Justify this statement using named examples. [13]

This statement is valid for eukaryotes

Division of labour, specialization (within a cell); [4]

➢ Describe at least 2 different organelles and their function;

Examples: Rough Endoplasmic reticulum (ER), Smooth Endoplasmic reticulum (ER) Golgi Body etc

Compartmentation – optimum conditions, accessing the intermediates, enzymes [4]

➢ Describe at least 2 different organelles and their function

Example:

- Membranes consist of a **mosaic** of protein molecules floating in a **fluid** phospholipid bilay
- Separates cell content from the surrounding. It also allows for **compartmentalization** within the cell and hence the formation of specialized organelles.
- As a **barrier** to most water-soluble molecules and ions (due to the hydrophobic core of the bilayer). However, It allows fat-soluble substances and small molecules (e.g. carbon dioxide, oxygen) to move across easily.
- Provides **fluidity to the membrane** which is important for cell sealing and healing.
- Allow **water-soluble ions, glucose, amino acids** and proteins to be transported into or out of the cells as these molecules cannot diffuse through the hydrophobic core of the cell membrane.

Other possible examples: Nuclear envelope, lysosomes, etc

Acquisition of special membrane-enclosed subcellular organelles [3]

- More energy production/ efficiency of energy production – eg. mito, chloroplast
  - ➢ Describe 2 different organelles and their function

Example: Mitochondria, chloroplasts

Endosymbiont theory [2]

- ➢ This theory states that an early ancestor of eukaryotic cells engulfed an oxygen-using non-photosynthetic prokaryotic cell. Eventually, the engulfed cell formed a

relationship with the host cell in which it was enclosed, becoming an endosymbiont (a cell living within another cell).

- Over the course of evolution, the host cell and its endosymbiont merged into a single organism, a eukaryotic cell with a mitochondrion. At least one of these cells may have then taken up a photosynthetic prokaryote, becoming the ancestor of eukaryotic cells that contain chloroplasts.

QWC – must answer both parts on "development" as well as "acquisition. 1m

4 b Interactions between different biomolecules (proteins, carbohydrates, lipids) within cells and between cells and the environment are critical to the survival of cells.

Discuss the importance of interactions between proteins and the different biomolecules in the structure, growth and reproduction of a prokaryotic cell. [12]

<u>Framework for marking</u>

4m maximum for each example

- Identifying the biomolecule that the protein interacts with (eg. carbohydrate/ lactose) and the structure (eg. peptidoglycan cell wall) – 1m
- Description of the interaction (eg. complementary fitting or described etc) – 2m max
- Importance of the interaction to the prokaryote (eg. synthesis of proteins/ hydrolysis of lactose to glucose which is used for respiration)

QWC - Answers must include structure, growth and reproduction AND interactions with 2 other different biomolecules.

<u>Structure</u>: (examples)

1. Protein-carbohydrate – peptidoglycan cell wall – prevents cell from bursting when absorbing water;
2. Protein-DNA – packaging of genome – pack a lot of genetic material into a small space;
3. Protein-phospholipids – cell membrane structure – fluidity of membrane;
4. AVP

<u>Growth</u>: (examples)

1. Protein-carbohydrate – lac repressor with allolactose (inducer) – expression of lac operon
2. Protein- carbohydrate – maltose with protein transporter on cell membrane – uptake of maltose
3. Protein- carbohydrate- lactose with β- galactosidase – hydrolysis of lactose into glucose and galactose to provide respiratory substrate
4. Protein-nucleic acid/DNA/RNA – in transcription/translation etc – resulting in synthesis of enzymes involved in metabolism
5. AVP

Reproduction: (examples)

1. Protein-nucleic acid/DNA – DNA polymerase with DNA - DNA replication, synthesis of genetic material for daughter cells;
2. AVP

5 **(a)** The monarch butterfly (*Danaus plexippus L.*) is a long distance migratory species of butterfly in North America. It has experienced population declines in recent years due to global warming effects.

In the oceans, the Chinook salmon migrate hundreds of kilometres from their place of birth to the ocean and back. Climate change has reduced the numbers that survive this journey.

The effect of climate change is far reaching. Climate change affects an individual species in terms of its survival and spread, as well as all other species that are associated with it.

Discuss how climate change can impact land and marine ecosystems. [13]

Introduce major anthropogenic factors leading to global warming and brief on ecosystems [2max]

- Some examples of human activities (fossil burning, deforestation, ruminant ranching) that contribute to enhanced greenhouse effect that causes the global average surface temperature to increase;
- The effects of global warming are evidenced by melting glaciers and sea ice, shifting precipitation patterns, rising sea levels, extreme weather;
- Definition of ecosystems - a biological community of organisms in a particular area that interact with one another and with their physical environment (that includes weather, earth, sun, soil, climate, atmosphere);

Migration & Impact on Ecosystem [3 max]

- Migrate, adapt or perish – relate tolerance range to global warming
- Altitude and latitude movement - As temperatures change, plant and animal species are shifting their geographic ranges at faster rates - butterfly populations are shifting to higher elevations /to higher, cooler areas due to climate change and loss of habitat;
- Many aquatic species can find colder areas of streams and lakes or move northward along the coast or in the ocean;
- Idea of how increase in ocean temperature can impact the metabolic rate, physiology of Chinook salmon and their numbers;
- Idea of how increase in temperature affects the food webs e.g. butterfly caterpillars are important herbivores as well as a food source for small mammals and birds, thus they play a significant role in an ecosystem.
- Idea of how migration of animals into new areas may result in competition with the native species over food and other resources, causing imbalance in the native ecosystem;

- Their departure from their original habitat or death creates a physical vacuum and if they are keystone species, can lead to the decimation of the intricately entwined ecosystem altogether;
- This also raises a range of sustainability issues for the non-migrating fish species. Those unable to migrate may not survive in the disruption of food web.

Phenology [2max]

- Animals use predictable environmental cues for the timing and navigation of migration. A change in these cues will affect the phenology and extent of migration;
- Impact on flowering, laying eggs or migrating etc and relate to insects and fish not being able to regulate their body temperatures;
- mismatch in the availability and timing of natural resources can influence species' survival; E.g. if insects emerge well before the arrival of migrating birds that rely on them for food, it can adversely affect bird populations;
- impact of mismatch on the ecosystems eg. bringing together species that haven't previously interacted and creating mismatches between animals and their food sources

Reduction in biodiversity [2max]

- Species extinction - climate change and habitat destruction affect butterfly populations
- Animals that have narrow environmental or ecological tolerance are greatly affected. For example, species that must live at high altitudes or live in cold water with a narrow temperature range, such as salmon, face an even greater risk due to climate change.
- Coral reefs are bleaching due to warmer temperatures due to stress-induced expulsion or death of their symbiotic protozoa, zooxanthellae, or the loss of pigmentation within the protozoa.
- Increased ocean acidification reduces the ability of corals to create their skeletons and can compromise their fertilization process;
- Acidification may threaten the structure of sensitive ecosystems upon which some fish and shellfish rely;

Pest-host relationships / pathogen-host relationships [2max]

- Earlier thaw and shorter winters / longer growing seasons and warmer winters can extend growing seasons for insect pests and this can have devastating consequences on the ecosystems;
- Changes in migratory behaviour also alter the incidence of infectious disease and its transmission;

Other Impacts on land and marine ecosystems (on humans) [2max]

- Shifting climate conditions are affecting valuable ecosystem services, eg. role of coastal habitats in dampening storm surge or the ability of our forests to provide timber and help filter our drinking water;
- Shifts in the abundance and geographic range of economically important marine fish result in some local fisheries declining or disappearing;

- more frequent heavy rainfall events increase the movement of nutrients and pollutants to downstream ecosystems, likely resulting in ecosystem change and impacting quality of drinking water;
- Expanded distribution latitudinally and altitudinally of insects that are vectors of pathogens pose global health threat e.g. mosquitoes that carry dengue virus are now found more often in temperate countries and at higher elevation in Africa;

QWC – answers must shoe clearly the impact of climate change on the ecosystems.
[Students can restrict their answers to butterflies and salmon or include other examples.]

5 (b) Research has shown that the genome of humans and other mammals contain DNA derived from viruses. About 8% of the human genetic material in the genome was found to be of viral origins. Many of these viral DNA are non-coding sequences.

Explain the significance of the functions played by different types of non-coding DNA. Suggest how viral DNA could have entered the human genome and discuss the importance of studying them. [12]

- Centromeres;
- Site of assembly for kinetochore proteins;
- For attachment of spindle fibres;
- That allow equal separation of chromosomes during nuclear division;
- Prevent non-disjunction leading to aneuploidy or polyploidy from occurring;

- Telomeres;
- Act as buffers to prevent against loss / erosion of crucial genes due to end replication problem (from successive rounds of replication)
- Prevent fusion of chromosome ends / maintain integrity of chromosomal ends;
- Limit the life span of the cell as cell undergo cell apoptosis (when critical length of telomere is reached);
- Prevent accumulation of mutations in the cell line;

- Introns;
- Allows different combinations of exons in mature mRNA (idea of alternative splicing)
- Allowing 1 gene to code for more than 1 polypeptide;

- Control elements eg. promoters, enhancers, silencers
- Promoter – binding of RNA polymerase and general transcription factors;
- for initiation of transcription;
- Enhancer and silencers – interaction with specific transcription factors;
- resulting in upregulation and downregulation of transcription;
- gene regulation allows cells to perform specialized functions;

- idea prevents wastages of resources by only synthesizing proteins that are required;

- Retrovirus infect ancestor cell;
- Ref viral glycoproteins binding to specific receptors on host cell;
- Ref fusion of viral envelope with host plasma membrane;
- Viral RNA / genome undergone reverse transcription;
- Into viral DNA which is integrated into host DNA;
- Viral genome not removed or excised;
- Idea that presence of viral DNA does not affect fitness of organism;

- Idea of comparing viral non-coding DNA sequences;
- To determine extent of similarities / homology;
- Use to study phylogenetics – to trace the evolutionary relationships between organisms;
- Study how humans have evolved through changes to their genome;
- Idea of tracing cause / origins of infectious diseases;
- Idea of creating vaccines / drug design against similar viruses;

QWC – 1 (students addressed both components of non-coding DNA, as well as introduction of viral genome and its importance)

[Total: 25]

Victoria Junior College
Biology Department
2019 JC2 Preliminary
Answers 9744/4

Question 1

(a) You are required to make simple dilutions of the proteins in the milk, **M** (1.0%) to obtain 4 other concentrations of milk. Present your dilution table in the space below.

Percentage of concentration of milk / %	Volume of **M** / cm^3	Volume of distilled water, **W** / cm^3
1.0	10.0	0.0
0.8	8.0	2.0
0.6	6.0	4.0
0.4	4.0	6.0
0.2	2.0	8.0

1. Correct headers with units AND independent variable (% concentration of milk) as first column;
2. 4 proposed milk concentrations equally spaced apart, spanning across range AND Correct d.p.;

(b) (i) Record your results in an appropriate table for the known concentrations of milk, using **only** the standard colors shown in the color chart.

Percentage concentration of milk / %	**Colour change observed**	**Observation of extent of coagulation**
1.0	Violet	++++++
0.8	Violet	++++
0.6	Pale violet	+++
0.4	Blue	++
0.2	Blue	+
U	Violet	++++

1. Correct headers with units AND Independent variable in first column;
2. Correct trend for colour change (colour to progress from blue to pale violet to violet);
3. Correct trend for coagulation;
4. Students only used colours AND symbols from the chart and fig. respectively AND results are presented in the SAME table;

- Most students were able to record their observations based on strictly the colours depicted in the colour chart and the usage of '+' to denote extent of coagulation.

You are now required to estimate the concentration of milk in sample **U**.
(ii) Describe how you would determine the protein concentration in sample **U**. [2]

- Put 2 drops of **U** onto the spotting tile, then add 1-2 drops of K and 0.5cm^3 of C to it. (Accept repeat step 6 to step 9 with **U**)
- **Compare** with colour standards AND match the colour of sample to the **closest match** of colour in the standard milk concentrations

(iii) Estimate the concentration of milk in sample **U**. [1]

- 0.7% (accept 0.6 – 0.8%)

(iv) Besides repeating the experiment, explain how you would modify the experiment to increase confidence in your results. [2]

- Use a syringe to transfer fixed volume of milk to spotting tile for testing;
- To ensure that volume is constant across the samples;

OR

- Use a different pipettes for each concentration of milk to prevent cross contamination affect the results.

OR

- setup of tubes in water bath of a constant temperature;
- to ensure that temperature does not denature milk proteins;

OR

- set up a control tube by replacing the milk with equal volume of distilled water;
- this ensures that any colour change observed in experimental tubes is due to presence of proteins in the milk;

(c) Complete **Fig. 1.2** to show the position on the line of each of the percentage concentrations of milk stated in the dilution table in **(a).**
Put the label **U** on **Fig. 1.2** to show an estimate of the concentration of milk which provides a measure of the proteins in **U**, using the result in **(b) (i)**.

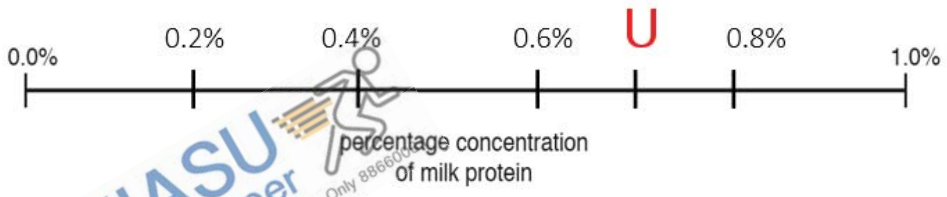


Fig. 1.2

- Accept 0.7% OR based on student's answer in (b)(iii)

[2]

(d) **(i)** Both methods **(I)** and **(II)** provide a subjective and quick estimation of the protein concentration in milk **U**.
Evaluate both methods in terms of their accuracy in determining the protein concentration in the milk. [3]

- Method (I) more accurate as colour change is more obvious and easily observed compared to method (II) of observing coagulation in milk (accept white colour of milk makes coagulation hard to observe);
- Method (I) more accurate as the colour chart present an actual observable reference point but method (II) does not;
- Method (II) more accurate as there are more benchmarks in standards from 1+ to 6+ while method (I) only has 3 colours for comparisons;
- Method (II) more accurate as it recorded quantitative data compared to recording qualitative data in method (I);
- AVP;

(ii) Describe **one** improvement to the procedure in method **(II)** to allow one to obtain a more accurate result. [2]

- Filter the solid and blot away any liquid;
- Weigh the mass of the coagulated milk;

OR

- Measure time taken for first coagulation to occur;
- To obtain a quantitative reading which reflect the protein concentration in milk;

OR

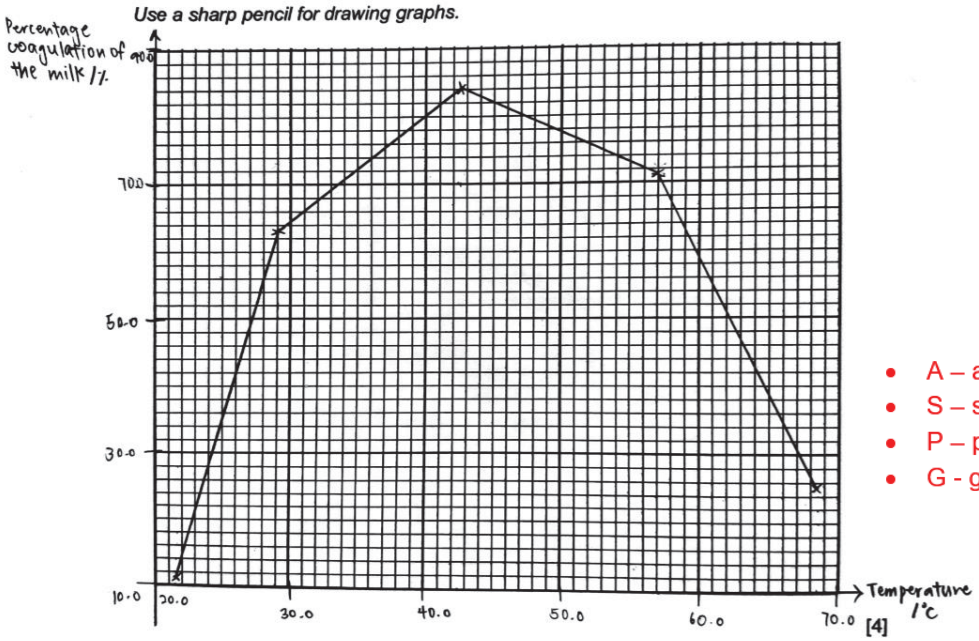
- Stagger the addition of A to each tube of milk;
- Ensure all milk samples have the same 1 minute for coagulation to occur;

OR

- accept pouring the milk + A onto a petri dish (accept other named apparatus with large surface area);
- To allow coagulation to be seen more easily;

(e) Plot a graph of the data in **Table 1.3** in the grid provided below.

Use a sharp pencil for drawing graphs.



[4]

- A – axis
- S – scale
- P – points plotted
- G - graph

Question 2

TSF- TS Ranunculus root

K5 – TS Ranunculus stem

(a) Observe **TSF** using the 10x objective.
An eyepiece graticule scale is attached to your microscope.

(i) Outline **how** you can use the graticule to help you draw an accurate plan diagram of **TSF** showing the correct proportions of the different tissues, without needing to calibrate the eyepiece graticule scale. [2]

[How to measure the thickness of the different tissues]

- **Align** eyepiece graticule along the length and/or breath of the different tissues and measure their thickness by counting the **number of eyepiece graticule units;**

[How to determine proportion and represent in drawing]

- Determine the *relative* proportion of each tissue by finding the ratio based on number of graticule units Or divide the length of each tissue by the diameter of the root;
- Use 1cm to represent 20 graticule units in the drawing;
  [2 max]

(ii) use the information that you have collected with the eyepiece graticule, make a plan drawing of **TSF** in the space provided below. [4]

Marking points [4m] – 1m each

1	**S**	• Size of drawing (50% of space or at least 7 cm in height) • Plus at least 3 lines
2	**L**	• Number of layers – 4 (Epidermis + cortical region + endodermis + xylem)
3	**P**	• Proportion of the stele (center cylinder) to the entire root (Stele is 1/6 (0.167) to 1/5 (0.2) of the whole root.)
4	**D**	• No cells • Solid, continuous lines

(b) You are provided with a plastic ruler. Use the plastic ruler to calibrate your eyepiece under **100x magnification**.

(i) Explain **why** this is a **less accurate** method compared to the use of stage micrometer. [2]
(Either one below)

[Idea of alignment problem]

- As the lines on the ruler are **thick**, there is difficulty in **aligning the eyepiece graticule** with the ruler for calibration as several eyepiece graticule units overlap one marking on the ruler Or difficult to decide where to start and end the reading of the eyepiece graticule;

- Compared to the stage micrometer which has thinner lines and the division superimpose accurately with the division on the eyepiece graticule;

[Uncertainty is larger with the ruler]

- Smallest division on ruler is 1mm whereas that of stage micrometer is 0.01mm (note this will depend on the stage micrometer given);
- Higher percentage error/ higher uncertainty with ruler;

(ii) Calculate the magnification of your drawing. Show your working clearly. [2]

- 100 eye piece divisions = 1mm on the ruler;

- Magnification = Drawing size/ Actual size + Correct calculation;

(Note: drawing size must be indicated on the plan drawing, otherwise = 0)

(c) Observe the central tissue in the root on **TSF**.
The cells in the central tissue are **not** identical.

Make a **large** drawing of this group of **four** cells.

Use **one** ruled label line and label to identify the cell wall of **one** cell. [4]

Marking points [4m]

1	**S**	• Size of drawing (50% of space: min 5cm combined) • **Quality of drawing**
2	**D (2m)**	Differences in the cells drawn a. Cell wall thickness – must be *obviously* different (note: cell wall must be drawn for **all** cells.) b. Shape – at least 2 cells must be angular – of which 1 cell must have 5 sides or more)
3	**L**	• Label 1 cell wall • 4 cells touching; without intercellular air spaces Do not award if label line criss-cross with other labels.

(d) Using high power, observe

- the cells that form the outermost layer (P) as well as
- the cells that are next to the central cavity of the section (Q).

(i) Prepare a table below to describe three structural differences between the cells found in P and Q. [3]

Any 3 features

Features	Epidermal cells/P	Parenchyma cells/Q
Shape	• Squarish/ rectangular/angular	• Roundish R: irregular circular shape
Size	• Smaller • All cells – similar sizes/ uniform in size	• Larger (about 5 to 6x larger) • Cells show a range of sizes/ not uniform in size
Cell wall thickness	• Unevenly thickened/ thicker cell wall on the outside	• Uniformly thin/ thinner cell wall
Special features/ Arrangement	• Tightly packed as one single row; • Absence of intercellular air spaces	• Loosely packed and more than one layers • Presence of intercellular air spaces between cells

(ii) **Based on your observations in (i)** above, provide an explanation for the increase in A when the stem is placed in a sucrose solution with a **higher water potential** than the cells. [3]

- Water will move from a higher water potential (sucrose solution) to a lower water potential (plant cells) by osmosis, causing cells to be turgid;

	Differences in cell wall thickness	Differences in cell size	Presence of intercellular air spaces/ multiple layers
[Identify feature]	• **thicker cell wall** in **P** restricts expansion of cells/ expand whereas/Or **thinner cell wall** in Q allows more expansion;	• **larger cell size** of **Q** allows more water to enter into cells resulting in greater increase in cell size compared to P;	• **intercellular air spaces -** Allows for expansion of cells in Q • Multiple layers of Q **–** the greater expansion of individual cells in Q collectively results in larger overall increase in the length of stem at the inner surface compared to outer surface or P

[Relate to differences in expansion] [Relate to increase in A]	• This leads to a greater increase in length of the inner region/ Cells Q – resulting in stem bending outwards; {Idea that Q expands more than P, resulting in the inner region of the stem increasing in length more than outer}
	R: Larger SA of Q because of its larger size. A larger cell has a smaller SA to volume ratio compared to a smaller cell. R: cuticle if cuticle is not one of the features in (i).

Question 3

(a) (i) Complete **Table 2.2** below. [2]

Type of penicillin	Diameter of decolourisation /mm	Area of decolourised zone around the well, πr^2 / mm^2	Antimicrobial activity against Mtb
P1	8	50.27 ~50	Lowest
P2	11	95.05~95	Highest
P3	10	78.55~79	High
P4	9	63.63~64	Moderate

@1m

1. Correct trend of diameter (A! within 10 minutes) and calculation of area to whole numbers (note that mm is smallest division on ruler, so round up to whole numbers);
2. Correct conclusion and wording about differential levels of microbial activity (P2>P3>P4>P1);

(ii) Identify the most effective of the four penicillins used and explain why. [2]

- P2 with the largest area of decolorisation indicates most bacteria death and thus the highest antimicrobial effect of the type of penicillin/ effectiveness of penicillin in destroying Mtb;
- by preventing formation/ weakening integrity of cell wall leading to lysis and cell death (AW);

(b) Design an experiment to determine the most effective concentrations of isoniazid when used together with 2% C10 to kill Mtb. [9]

Mark Scheme:

Independent variable:

1. States that independent variable is relative concentration of component antibiotics and uses uniformly-spaced concentrations

isoniazid/ C10 combinations / %	Volume of 100% isoniazid / ml	Volume of 20% C10 / ml	Volume of sterile distilled water / ml	Total volume of isoniazid/C10 cocktail / ml
*30/0	3.0	0.0	7.0	10.0
30/2	3.0	1.0	6.0	10.0
25/2	2.5	1.0	6.5	10.0
20/2	2.0	1.0	7.0	10.0
15/2	1.5	1.0	7.5	10.0
10/2	1.0	1.0	8.0	10.0
5/2	0.5	1.0	8.5	10.0

Dependent variable:

2. Area/ diameter of clearance around the well

Controlled variables:

3. Ref. to controlling temperature at 37°C with incubator oven
4. Identify and describe another variable to be controlled (e.g. volume of antibiotic sample, same dimensions of wells, duration of incubation, same concentration and volume of Mtb to plate, etc.)

Scientific Theory and Reasoning:

5. Explains that bacteria death is indicated by clear zone around well due to death of cells.

Method:

6. Shows how to perform a simple dilution to obtain the specified relative concentrations
7. How to use of ruler/ graph paper to measure (diameter – broadest part of well) and how to calculate area of clear circle around well
8. Describe how to determine the cocktail with most effective absolute concentrations of isoniazid used with 2% C10

Reliability:

9. Performs at least two more repeats with fresh reagents

Accuracy:

10. Repeating with decreased intervals of relative concentrations to obtain more data to achieve experimental aim

Control:

11. Perform a negative control using same volume of distilled water

Recording:

12. Shows how results are to be presented in the form of a table with IV and DV in appropriate column/rows

Risk/safety:

13. Refers to use of a biosafety cabinet in performing the procedure / isoniazid and C10 are skin irritants, wear goggles and gloves to prevent contact / isoniazid and C10 may cause allergic reactions, wear goggles and gloves to prevent contact and wash skin if contacted through spills.