HWA CHONG INSTITUTION
JC2 Preliminary Examinations
Higher 2

CANDIDATE NAME		CT GROUP	16S7___

CENTRE NUMBER					INDEX NUMBER				

BIOLOGY

9744/01

Paper 1 Multiple Choice Questions

21 September 2017

Additional Materials: Optical Mark Sheet

1 hour

INSTRUCTIONS TO CANDIDATES

1. Write your **name** and **CT group** in the spaces provided at the top of this cover page.
2. Fill in your particulars on the Optical Mark Sheet. Write your **NRIC number** and shade accordingly.
3. There are **thirty** 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 Optical Mark Sheet.
4. At the end of the paper, you are to submit **only** the Optical Mark Sheet.

INFORMATION FOR CANDIDATES

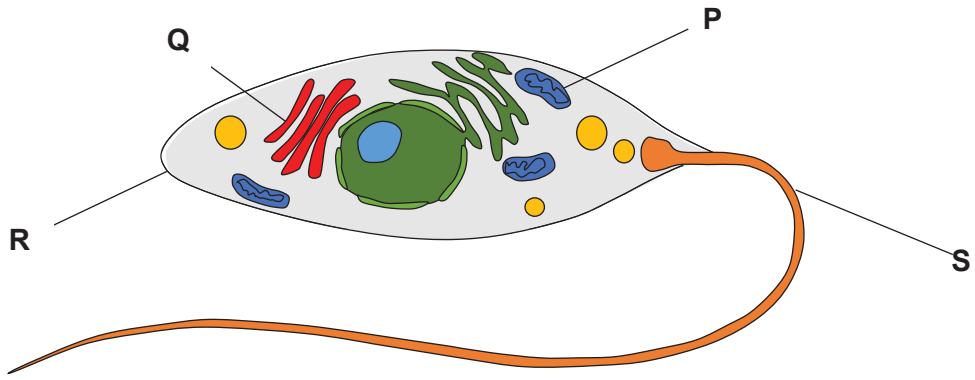
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

The used of an approved scientific calculator is expected, where appropriate.

This document consists of **24** printed pages.

1 The diagram shows a single-celled organism with structures **P** to **S** labelled.



Which statement(s) correctly describes the structures **P** to **S**?

1 Structure **P** is double membranous with infoldings called cisternae and functions in metabolism of glucose.

2 Structure **Q** is double membranous with flattened sacs called cristae and functions to modify and package products of the endoplasmic reticulum.

3 Structure **R** is composed of phospholipids, proteins and carbohydrates and functions to prevent cell lysis.

4 Structure **S** is composed of microtubules and provides cell motility.

A 3 only **B** 4 only **C** 1 and 4 **D** 2 and 3

2 Viruses are a major class of microorganisms, but they are not cells.

Which statement about viruses supports the view that viruses are not cells?

1 Viruses are very small in size.

2 Viruses are only able to replicate in a host cell.

3 Viruses have no metabolic activities of their own.

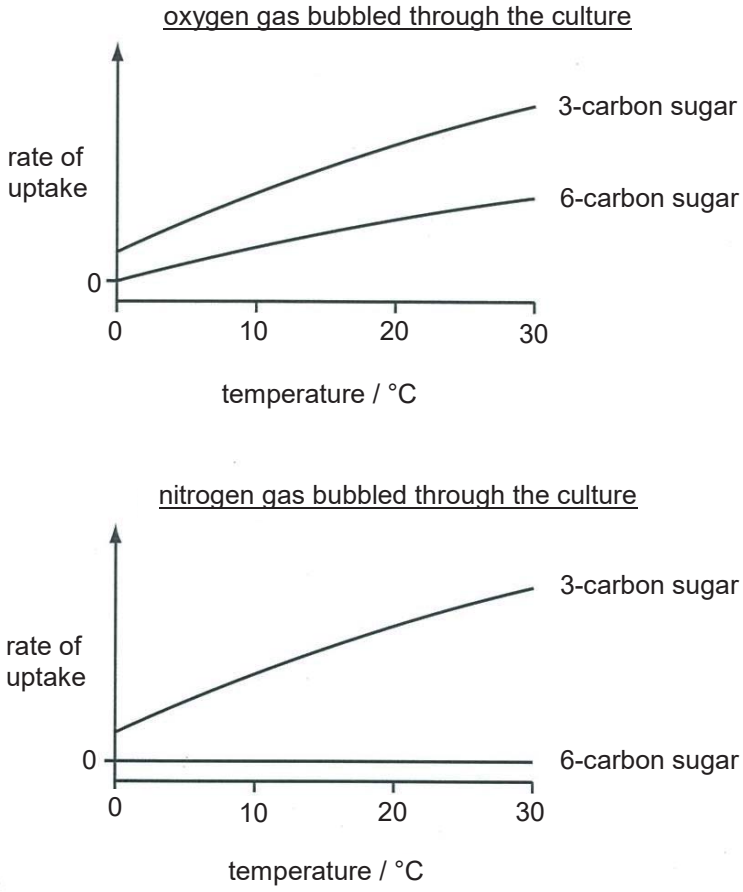
4 Viruses have protein capsids.

5 Viruses contain only a single form of nucleic acid.

6 Viruses can evolve by genetic recombination.

A 1, 2 and 3 **B** 1, 5 and 6 **C** 2, 3 and 5 **D** 3, 4 and 6

3 The graphs show the rate of uptake of sugars by a culture of animal cells under different conditions.



Which statements correctly describe the uptake of sugars by the animal cells?

1 3-carbon sugar passes through the phospholipid bilayer down a concentration gradient.

2 3-carbon sugar passes through channel proteins against a concentration gradient.

3 6-carbon sugar passes through carrier proteins against a concentration gradient.

4 6-carbon sugar passes through the phospholipid bilayer down a concentration gradient.

A 1 and 3 **B** 2 and 3 **C** 2 and 4 **D** 1 and 4

4 α- and β-amylase enzymes can break the α-1,4-glycosidic bonds of polysaccharides, but not the α-1,6-glycosidic bonds.

α-amylase acts randomly within polysaccharides and can produce glucose, maltose, trisaccharides and short, branched chains.

β-amylase acts at the ends of polysaccharides to remove successive maltose molecules.

Which statement about polysaccharide digestion is correct?

A Both α-amylase and β-amylase are required for the complete digestion of starch to produce only glucose molecules.

B Digestion of amylose by α-amylase will produce only branched molecules.

C Digestion of amylose using β-amylase will yield a higher proportion of disaccharides than digestion using α-amylase.

D Disaccharides can be produced from the digestion of cellulose using β-amylase, but not using α-amylase.

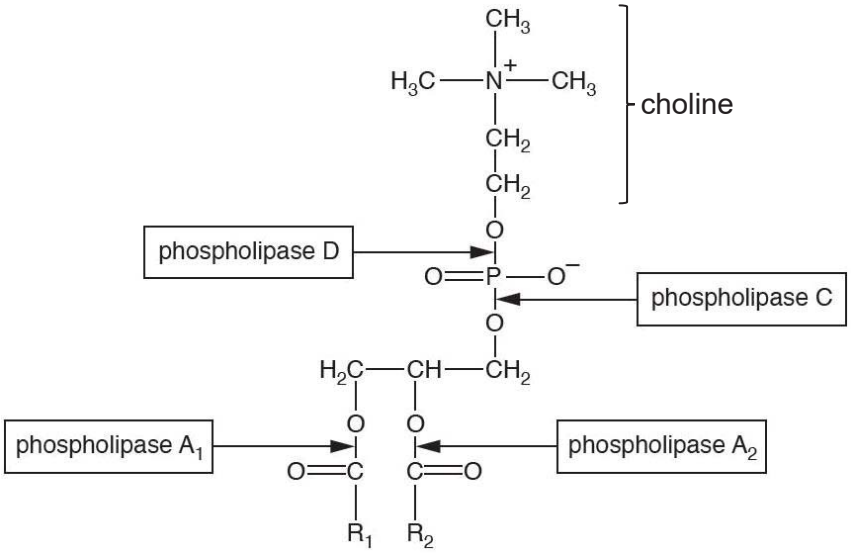
5 Phosphatidylcholines are phospholipids that have choline as part of the polar head section.

A high proportion of phospholipids in erythrocyte (red blood cell) membranes are phosphatidylcholines.

The table shows the results of an analysis to determine the four most abundant component fatty acids of human erythrocyte phosphatidylcholines.

fatty acid	molecular formula	
palmitic acid	$C_{16}H_{32}O_2$	$CH_3(CH_2)_{14}COOH$
linoleic acid	$C_{18}H_{32}O_2$	$CH_3(CH_2)_4(CH{=}CHCH_2)_2(CH_2)_6COOH$
oleic acid	$C_{18}H_{34}O_2$	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$
steric acid	$C_{18}H_{36}O_2$	$CH_3(CH_2)_{16}COOH$

The diagram shows a phosphatidylcholine. The site of action of four different phospholipases, A_1, A_2, C and D, are indicated.



In phosphatidylcholines,

- saturated fatty acids are more commonly found in position R_1 than unsaturated fatty acids, and
- unsaturated fatty acids are more commonly found in position R_2 than saturated fatty acids.

Which statement about enzyme action on isolated erythrocyte phosphatidylcholines is correct?

A The action of phospholipase A_1 is likely to yield a higher proportion of oleic acid than stearic acid.

B The action of phospholipase A_2 is likely to yield a higher proportion of linoleic acid than palmitic acid.

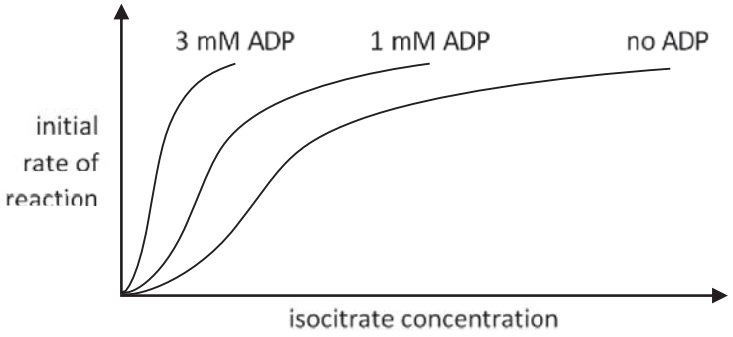
C The products of the combined action of phospholipases A_1, A_2 and D will be free fatty acids, glycerol and choline.

D The action of phospholipases A_1, A_2 and C will cause an increase in the pH of the reaction medium.

6 Isocitrate dehydrogenase catalyses the following reaction in the Krebs cycle:

$$\text{isocitrate} + NAD^+ \rightarrow \alpha\text{-ketoglutarate} + CO_2 + NADH$$

The curves in the graph are obtained when the initial rate of reaction is plotted against isocitrate concentration in the presence of various levels of ADP and excess NAD^+.



Which statement about this system is correct?

A ADP competes with isocitrate for the active site of isocitrate dehydrogenase.

B ADP binds to an allosteric site of isocitrate dehydrogenase and prevents binding of isocitrate to the active site.

C ADP binds to isocitrate and makes it easier for isocitrate to bind to the active site.

D ADP binds to an allosteric site of isocitrate dehydrogenase and makes it easier for isocitrate to bind to the active site.

7 Which is a correct statement about obtaining human embryonic stem cells for research?

A Removal of these cells is considered to be ethically acceptable as normal development of the embryo is not inhibited.

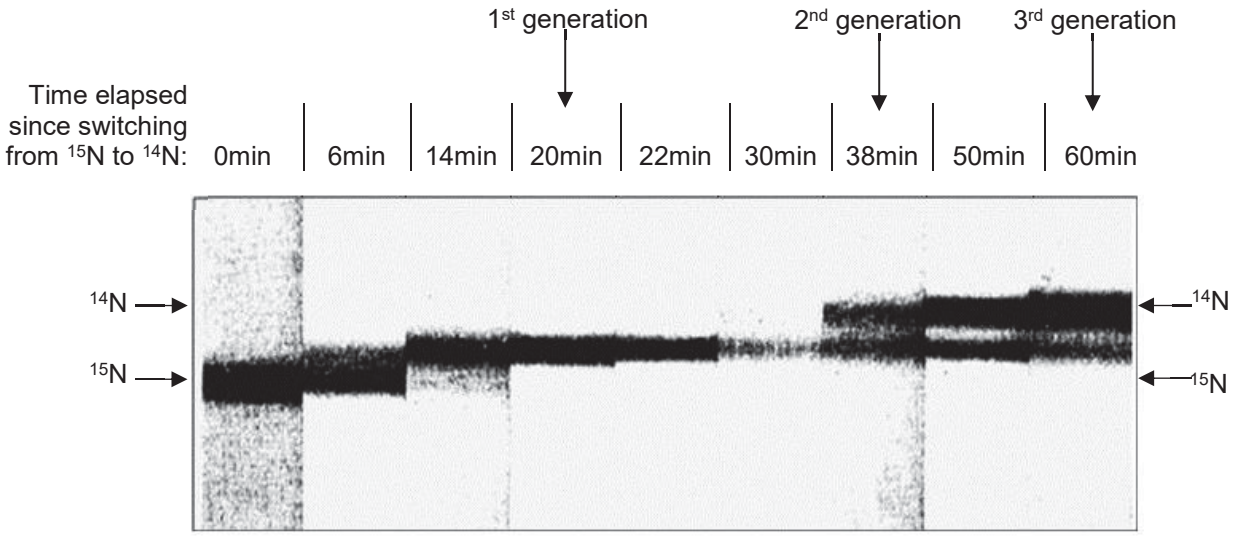
B The cells must be removed at an early stage of development from a region of the blastocyst known as the inner cell mass.

C The cells must be removed within a day following the successful fertilisation of the ovum by the sperm, and after checking for normal mitotic division.

D The region of the blastocyst from where the cells are removed is an area that develops at a later stage into the placenta.

8 In the classic paper that demonstrated the semi-conservative replication of DNA, scientists Meselson and Stahl began by showing that DNA itself will form a band when subjected to density gradient centrifugation.

Escherichia coli grown in ^{15}N DNA were switched to ^{14}N and then harvested at eight different time points. The DNA was centrifuged resulting in the banding pattern shown.



Which statements correctly explain the results?

1 At 20 min, the entire DNA of *E. coli* exists as hybrid with 100% ^{15}N DNA.

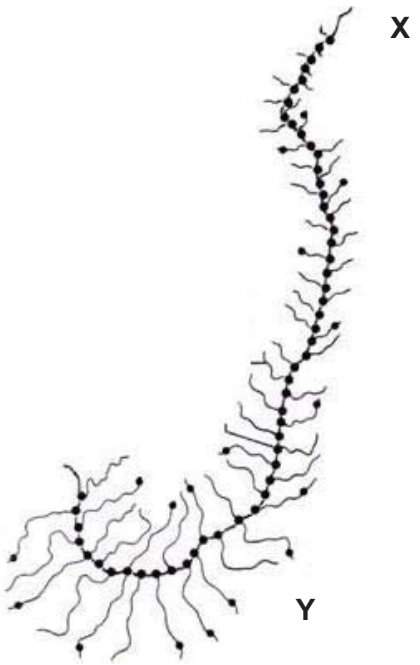
2 At 20 min, DNA of *E. coli* is 50% hybrid with 50% ^{15}N DNA.

3 At 38 min, there are two bands consisting of 50% hybrid DNA and 50% light DNA.

4 At 60 min, there is 25% hybrid DNA and 75% light DNA.

A 1 and 2 **B** 3 and 4 **C** 2, 3 and 4 **D** 1, 2, 3 and 4

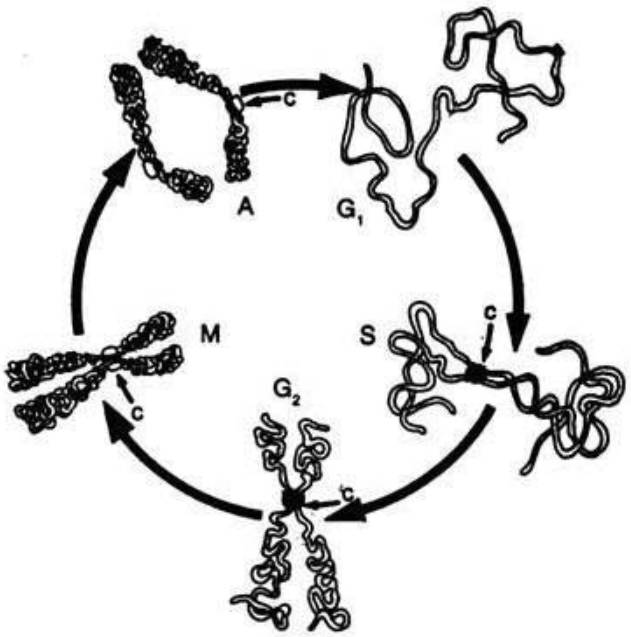
9 The diagram shows the rRNA gene undergoing transcription in the nucleolus of a cell with regions **X** and **Y** labelled.



Which row is correct?

	presence of nucleosomes	direction of transcription	presence of ribosomes
A	✓	**X** to **Y**	✗
B	✓	**Y** to **X**	✓
C	✗	**X** to **Y**	✗
D	✗	**Y** to **X**	✓

10 The morphology of chromosomes changes with the stages of cell cycle as shown in the diagram.



Which statements explain the changes in morphology of the chromosomes?

1 DNA replicates during S phase to produce an identical copy of itself in which the sister chromatids are joined together by two centromeres.

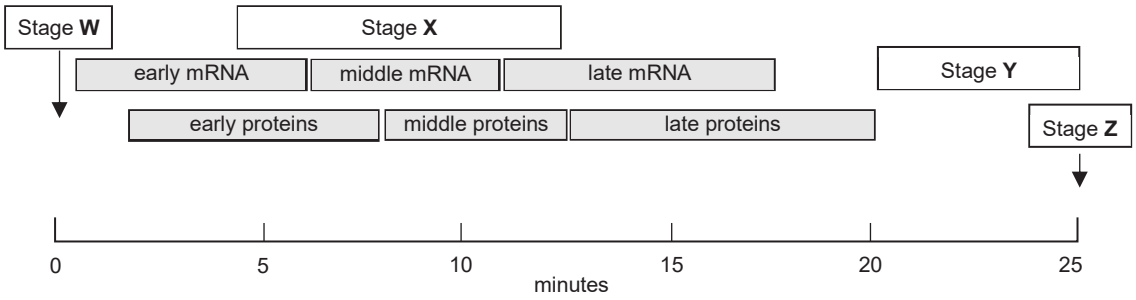
2 At G_2 phase, the centromere comprises many tandemly repeated DNA sequences that exist as heterochromatin.

3 Chromosomes at M phase is highly coiled and folded around histone-like scaffold proteins.

4 From anaphase to next G_1 phase, chromosomes have only one DNA molecule which coils around the histone core.

A 2 and 4 **B** 3 and 4 **C** 1, 2 and 3 **D** 1, 2, 3 and 4

11 The diagram shows the time course of events in a T4 phage infection.



Which statements correctly describe the events taking place in stages **W** to **Z?**

1 During Stage **W**, T4 phage tail fibres bind to specific molecules on the bacterial cell and the viral DNA penetrates into the cell via contraction of the tail sheath.

2 During Stage **X**, T4 phage replicates its own RNA genome.

3 From 13 minutes to 20 minutes, structural proteins including the head, tail, base plate and tail fibre proteins for Stage **Y** are synthesized.

4 From 13 minutes to 20 minutes, mRNA coding for enzymes required to liberate the mature phage particles in Stage **Z** are synthesized.

A 1 and 3 **B** 2 and 3 **C** 1, 2 and 4 **D** 2, 3 and 4

12 *Escherichia coli* cells are first grown in a medium containing glucose and all twenty amino acids. Subsequently, these cells are transferred to another medium for one hour, in which the only source of sugar is lactose and the only source of nitrogen is ammonium ions.

Compared with the cells grown in the first medium, which statements about the cells grown in the second medium are correct?

1 The *lac* repressor binds to the *lac* operator.

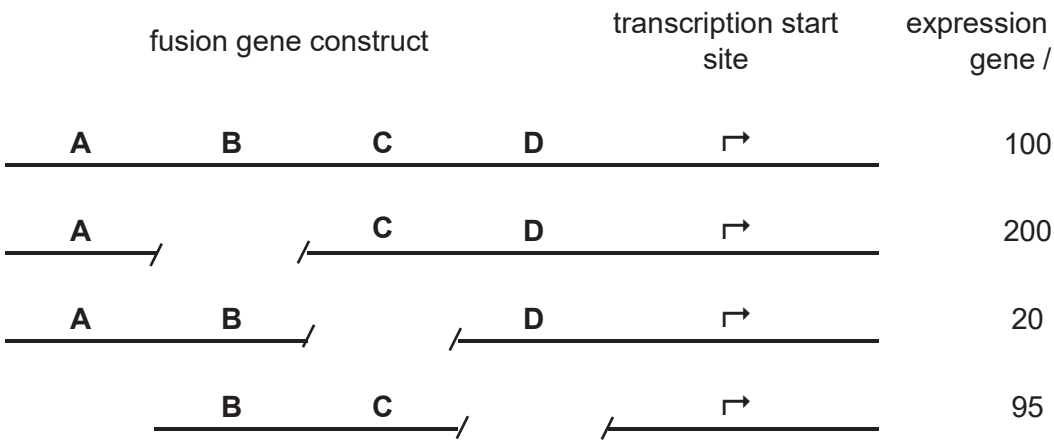
2 Catabolite-activator protein (CAP) binds to the CAP binding site.

3 The *trp* repressor binds to the *trp* operator.

4 RNA polymerase binds to the *trp* promoter.

A 1 and 3 only **B** 2 and 4 only **C** 1, 2 and 3 **D** 2, 3 and 4

13 To analyse the control elements of the human insulin gene, a researcher deleted different regions of the DNA upstream of its transcription start site *in vitro*. Each of the upstream regions was separately fused with the coding region of the *green fluorescent protein* (*GFP*) gene, forming different fusion gene constructs. These constructs were then separately introduced into human pancreatic cells. The following results were obtained.



Which region, **A**, **B**, **C** or **D**, binds a repressor protein?

14 The following is the DNA sequence on the template strand of a gene, from the 3' to 5' direction. The gene has 37 codons in total, and the table shows the first 7 codons.

codon	1	2	3	4	5	6	7
DNA	CAC	GTG	GAC	TGA	GGA	CTC	CTC

Three different gene mutations can occur and are described as follows:

1 insertion of two adenines in between codon 2 and 3

2 deletion of the thymine in codon 4

3 substitution of thymine for adenine in codon 6

Which row correctly identifies the possible effects of these gene mutations?

	frameshift mutation	premature ending of a polypeptide	polypeptide could be non-functional
A	1, 3	2 only	1, 2
B	2 only	2, 3	1, 2, 3
C	2, 3	1, 3	2, 3
D	1, 2	1 only	1, 2, 3

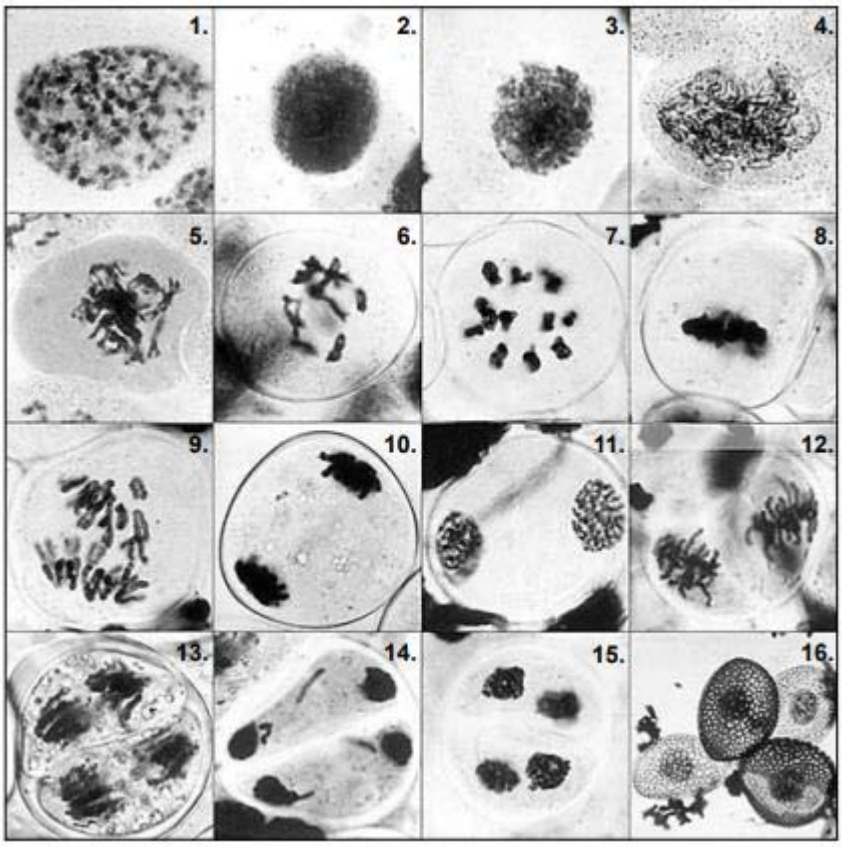
15 Mutations in either *BRCA1* or *BRCA2* genes are responsible for the majority of hereditary breast cancer in humans.

The proteins produced by the two genes migrate to the nucleus where they interact with other proteins, such as those produced by the tumour suppressor gene, *p53* and the DNA repair gene, *RAD51*.

Which combination of gene activity is most likely to result in breast cancer?

	gene		
	BRCA1 or *BRCA2*	*p53*	*RAD51*
A	encoding normal protein	encoding normal protein	encoding abnormal protein or no protein
B	encoding normal protein	encoding abnormal protein or no protein	encoding normal protein
C	encoding abnormal protein or no protein	encoding abnormal protein or no protein	encoding normal protein
D	encoding abnormal protein or no protein	encoding abnormal protein or no protein	encoding abnormal protein or no protein

16 The diagram shows a series of electronmicrographs depicting the different stages in meiosis, in the order in which they occur.



Which statements are **incorrect**?

1 The 11 bivalents line up along the equatorial plate in the stage shown in image 8.

2 During the stage shown in image 9, sister chromatids separate.

3 Cells after the stage shown in image 10 are haploid.

4 During the stage shown in image 11, DNA is replicated.

5 Homologous chromosomes pair up in the stage shown in image 12.

A 1 and 3

B 2 and 5

C 1, 2 and 4

D 2, 4 and 5

17 The table shows the results of a series of crosses in a species of small mammal.

coat colour phenotype		
male parent	female parent	offspring
dark grey	light grey	dark grey, light grey, albino
light grey	albino	light grey, white with black patches
dark grey	white with black patches	dark grey, light grey
light grey	dark grey	dark grey, light grey, white with black patches

What explains the inheritance of the range of phenotypes shown by these crosses?

A one gene with a pair of codominant alleles

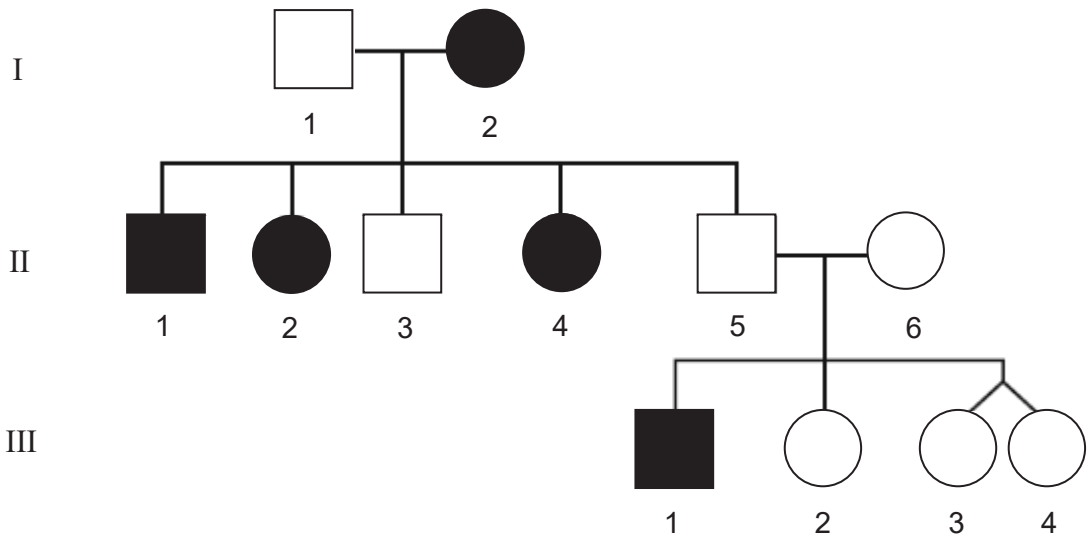
B one gene with multiple alleles

C one sex-linked gene with a dominant and recessive allele

D two genes, each with a dominant and recessive allele

Use the following information to answer **Questions 18** and **19**.

18 In a family, a genetic disorder occurs in some individuals as shown in the pedigree.



Individual III-2 marries a phenotypically normal male.

What is the probability that their first child will be affected with the genetic disorder?

A 1/4

B 1/8

C 1/12

D 1/16

19 Consider the identical twins, individuals III-3 and III-4. Neither individual has the genetic disorder. A study of many other traits expressed by these two individuals when they were aged 20 was carried out.

What would the likely findings of such a study reveal?

A All the traits are the same as the twins are genetically identical.

B Some of the traits are the same as the twins are genetically identical while some other traits are also different due to the influence of the environment.

C Some of the traits are the same when the twins have the same alleles while some other traits are also different when the twins have different alleles.

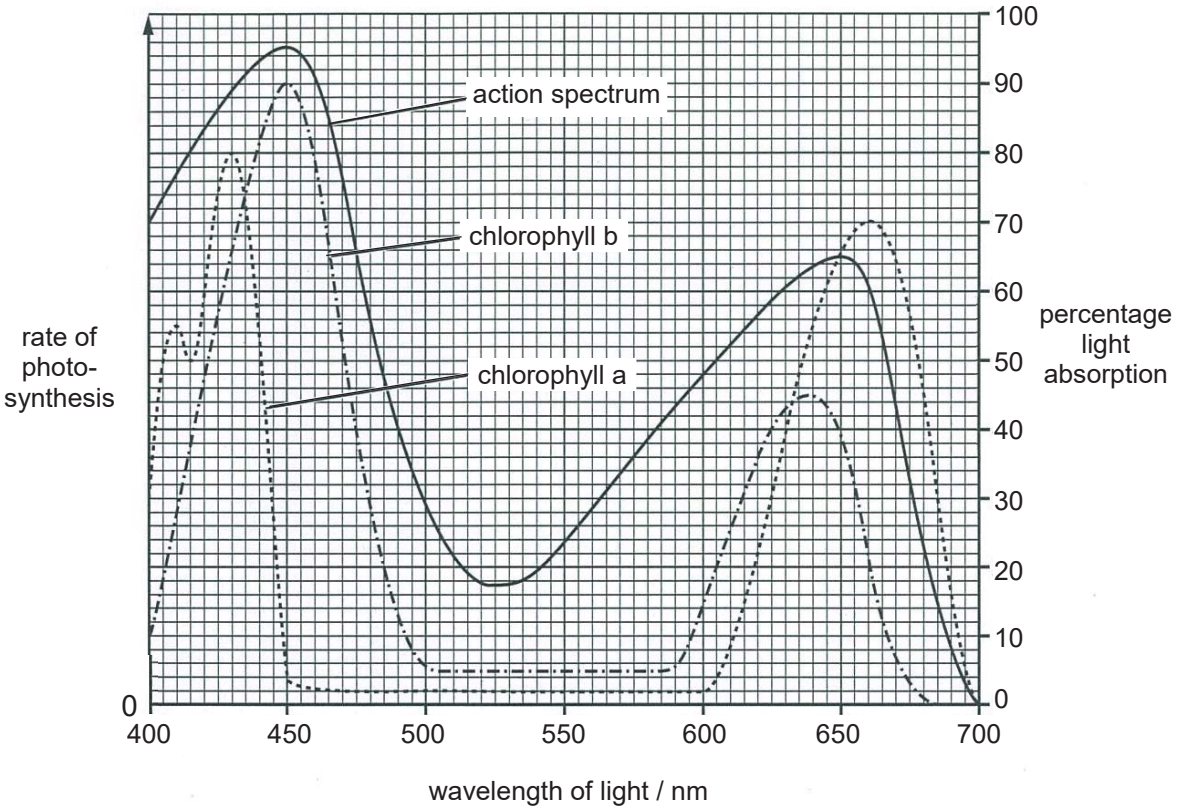
D All the traits are different due to the influence of the environment.

20 Duroc Jersey pigs are typically red, but a sandy variation is also seen. When two different varieties of true-breeding sandy pigs were crossed to each other, they produced F_1 offspring that were red. When these F_1 offspring were crossed to each other, they produced red, sandy and white pigs in a 9:6:1 phenotypic ratio.

Which row correctly shows the possible genotypes for each phenotype?

	red	sandy	white
A	AABB	AAbb	aaBB
B	AaBb	AaBB	aabb
C	Aabb	aaBB	aabb
D	AaBB	Aabb	aabb

21 The diagram shows the action spectrum and absorption spectra of chlorophylls a and chlorophyll b.



Which statements are correct?

1 Both chlorophyll a and b have little absorption in the range of wavelength which corresponds to green light.

2 Both chlorophyll a and b have higher absorption spectra peaks at the range of wavelength which corresponds to blue light as compared to that which corresponds to red light.

3 There is absence of an exact match between absorption and action spectra in the middle region due to presence of carotenoids and accessory pigments.

4 The action peaks correspond to the absorption peaks, where the rate of photosynthesis is the highest at the range of wavelength which corresponds to red light.

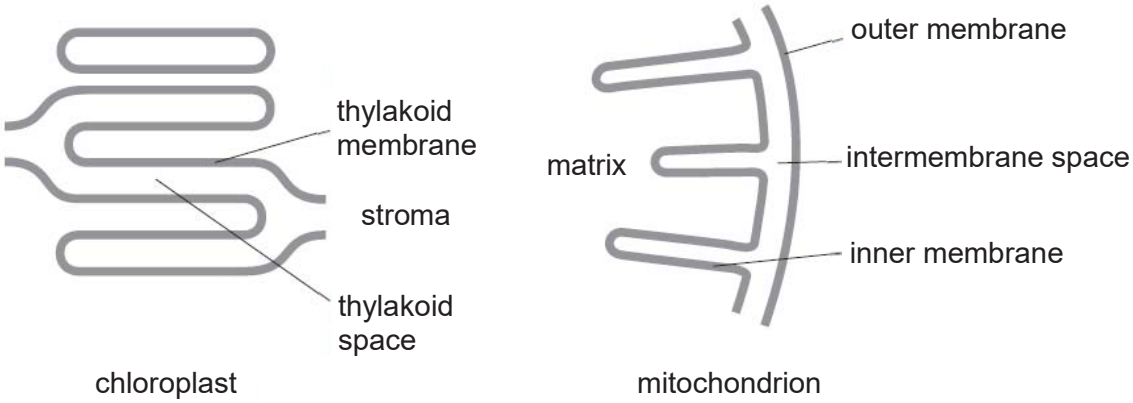
A 1 and 3

B 2 and 4

C 1, 2 and 3

D 2, 3 and 4

22 The diagram shows part of a chloroplast and part of a mitochondrion.

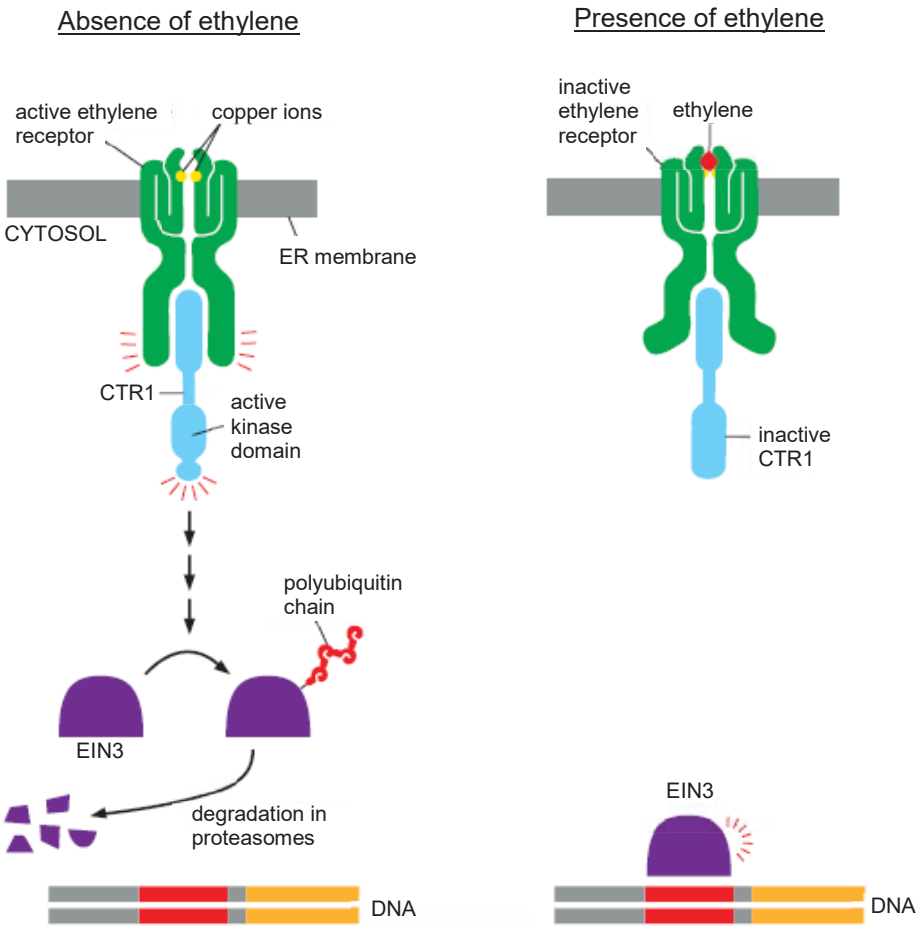


Which row correctly shows the mode and direction of proton movement and the location of ATP synthesis in these two organelles?

	proton movement			location of ATP synthesis	
	mode	direction			
		chloroplast	mitochondrion	chloroplast	mitochondrion
A	active transport	stroma to thylakoid membrane	matrix to inner membrane	stroma	matrix
	facilitated diffusion	thylakoid membrane to stroma	inner membrane to matrix		
B	active transport	thylakoid space to stroma	intermembrane space to matrix	thylakoid space	intermembrane space
	facilitated diffusion	stroma to thylakoid space	matrix to intermembrane space		
C	active transport	stroma to thylakoid space	matrix to intermembrane space	stroma	matrix
	facilitated diffusion	thylakoid space to stroma	intermembrane space to matrix		
D	active transport	stroma to thylakoid space	intermembrane space to matrix	stroma	intermembrane space
	facilitated diffusion	thylakoid space to stroma	matrix to intermembrane space		

23 Ethylene gas is a plant hormone that regulates plant growth, development and response to environmental stress. It is produced from leaves, roots, stems, flowers and especially ripened fruits.

Plants have various ethylene receptors, which are located in the endoplasmic reticulum (ER) and are all structurally related. The diagram shows the ethylene signalling pathway. Ethylene receptors are dimeric, transmembrane proteins, with a copper-containing ethylene-binding domain and a domain that interacts with a cytoplasmic protein called CTR1.



Which statements provide the most direct evidence that the ethylene gas signalling mechanism functions to mediate gene expression?

1 In the absence of ethylene, active CTR1 stimulates the ubiquitination and degradation in proteasomes of EIN3.

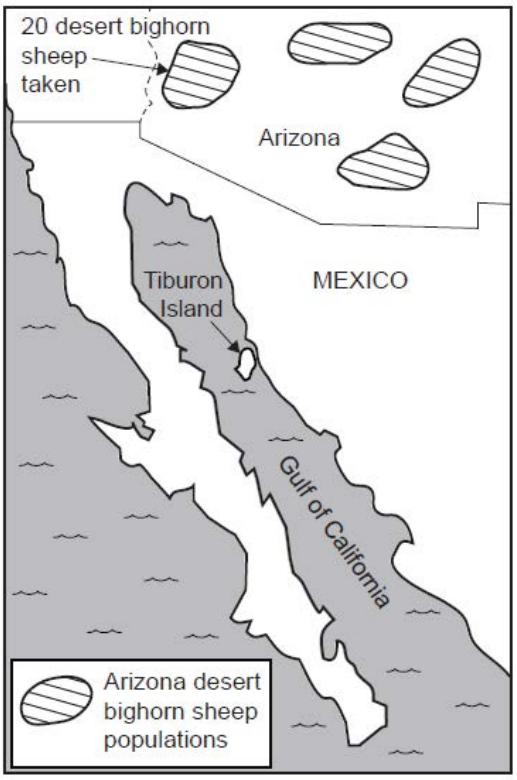
2 In the absence of ethylene, the active ethylene receptors halts transcription of ethylene-responsive genes through degradation of EIN3.

3 In the presence of ethylene, its binding inactivates the receptor, altering their conformation so that they no longer activate CTR1.

4 In the presence of ethylene, the EIN3 protein does not undergo selective degradation and can now activate the transcription of the large number of ethylene-responsive genes.

A 1 and 2 **B** 2 and 3 **C** 2 and 4 **D** 3 and 4

24 Tiburon is an isolated island off the coast of Mexico. Desert bighorn sheep became extinct on this island hundreds of years ago. In 1975, 20 desert bighorn sheep were taken from a population in the American state of Arizona as shown in the figure and were re-introduced to Tiburon Island. By 1999, the population of desert bighorn sheep on Tiburon Island had risen to 650.



Which statement about the 1999 population of desert bighorn sheep on Tiburon Island is correct?

A The gene pool of this population will be identical to the gene pool of the Arizona populations.

B This population is more homogenous with less genetic variation than the Arizona populations as it is an example of the founder effect.

C This population will have become a new species because the mutation rate on Tiburon Island will be much higher than in Arizona.

D Having been through a population bottleneck, the current population will now show increased genetic variation compared to the Arizona populations.

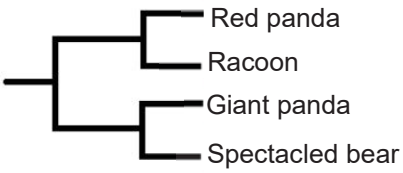
25 DNA-DNA hybridization has been used to study the evolutionary placement of red and giant pandas. A perfect match between two hybrid strands will yield the highest melting temperature (T_m) due to optimal hydrogen bonding between the bases while mismatches will lower the T_m leading to less than ideal hybridization.

The table shows the melting temperature of hybrid pairs of DNA (°C).

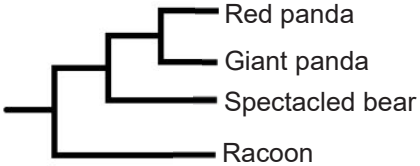
	Red panda	Raccoon	Giant panda	Spectacled bear
Red panda	80	68	52	44
Raccoon	-	82	53	42
Giant panda	-	-	83	75
Spectacled bear	-	-	-	81

Based on the results in the table, which phylogenetic tree would provide the most reasonable inference to the evolutionary relationships among these species?

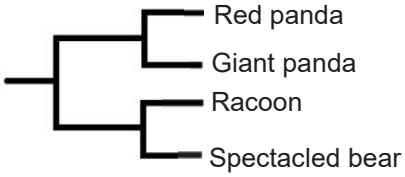
A



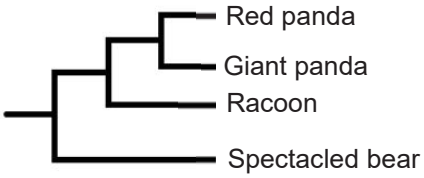
C



B



D



26 A study was carried out over a 12-year period on the rate of evolutionary change in the anole lizard populations found in a group of Caribbean islands.

It determined the average colouration pattern in a certain population changed from predominantly brown with green flecks to predominantly green with brown flecks.

This occurred during a prolonged pattern of above average annual rainfall between 1971 and 1983. During that time, there was an increase in the broad-leaved green plants.

Which effects might the introduction of a predator that hunts anoles using motion, rather than colour, to detect its prey have on the anole lizard population?

A A new mutation would emerge that introduced a grey colour to the anole population.

B The numbers of brown versus green anoles in the population would shift to a less balanced ratio over time.

C The number of green anoles in the population would increase further.

D The anole population would become highly endangered.

27 Read the following statement.

“At first, all giraffes had short necks because they all ate leaves close to the ground, but when all those leaves were gone, some giraffes started being born with long necks.”

Which statement would be most helpful in correcting this misconception?

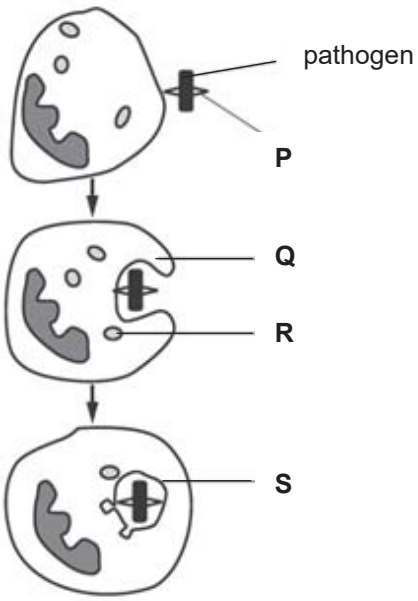
A Phenotypic variations occur through spontaneous mutations and are subsequently selected for or against.

B The phenotype for neck length changed in giraffes so that the species did not go extinct.

C Short-necked giraffes developed long necks in response to increased competition for food.

D When the environment changed, the struggle to exist created new mutations in the gene pool and natural selection acted on them.

28 The diagram shows the process of phagocytosis of a pathogen by a neutrophil.

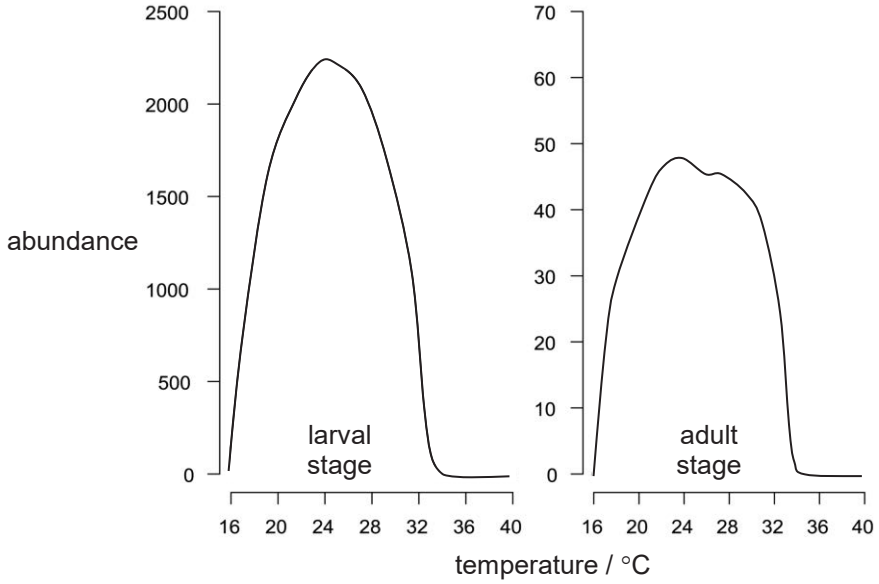


Which row is correct?

	P	Q	R	S	body's line of defence
A	antibiotic	extensions of cell wall	lysozyme	lysosome	innate immunity
B	antibiotic	extensions of cell membrane	phagosome	antigen-presenting cell	cell-mediated immune response
C	antigen	extensions of cell wall	antigen-presenting cell	lysozyme	humoral immune response
D	antigen	extensions of cell membrane	lysosome	phagosome	innate immunity

29 Malaria is caused by the protozoan parasite, *Plasmodium falciparum*. Female *Anopheles* mosquitoes pick up *P. falciparum* in a blood meal taken from an infectious person. *P. falciparum* then go through several developmental stages before they migrate to the mosquito salivary glands. Once in the salivary glands, the parasites can be transmitted to a susceptible human host when the mosquito takes another blood meal. The time spent developing in the mosquito is determined by temperature.

Both *Anopheles* and *P. falciparum* are sensitive to temperature. Because *Anopheles* mosquitoes are ectotherms, each stage in their life cycle (i.e. egg, larva, pupa and adult) is dependent on temperature, examples of which are illustrated in the following graphs.



Investigations into the effect of global warming on malaria transmission often focused on the blood meal-egg laying stage in adult females.

Which row shows the reason for and limitation of the use of female *Anopheles* mosquitoes?

	reason for the use	limitation of the use
A	Temperature-dependencies are not the same across the different developmental stages of the *Anopheles* mosquitoes.	Increased temperature increased larval mortality and decreased developmental speed.
B	*P. falciparum* is transmitted by adult females.	Optimum temperature for *P. falciparum* growth does not necessarily correspond to the vector's optimum temperature.
C	*P. falciparum* is transmitted by adult females.	Temperature-dependencies are not the same across the different developmental stages of the *Anopheles* mosquitoes.
D	Optimum temperature for *P. falciparum* growth does not necessarily correspond to the vector's optimum.	Increased temperature increased larval mortality and decreased developmental speed.

30 Many studies in recent years have investigated the effects of climate change on biodiversity.

Which statements about the impact on climate change on the level of biodiversity are correct?

1 At the population level, climate change is able to decrease genetic diversity due to mutation and directional selection.

2 At the community level, climate change has led to phenological shifts in flowering plants and insect pollinators, causing mismatches between plant and pollinator populations that lead to the extinctions of both the plant and the pollinator.

3 At the biome level, large portions of Amazonian rainforest in tropical South America could be replaced by tropical savannahs.

A 1 and 2 only **B** 1 and 3 only **C** 2 and 3 only **D** 1, 2 and 3

--END OF PAPER---

HWA CHONG INSTITUTION
JC2 Preliminary Examinations
Higher 2

CANDIDATE NAME		CT GROUP	16S ___
CENTRE NUMBER		INDEX NUMBER	

BIOLOGY

9744/02

Paper 2 Structured Questions

23 August 2017

No additional materials are required.

2 hours

INSTRUCTIONS TO CANDIDATES

There are **six** question booklets (**I** to **VI**) to this paper. Write your **name**, **CT group, Centre number** and **index number** in the spaces provided at the top of this cover page and on the lines provided at the top of the cover pages of Booklets **II**, **III**, **IV**, **V** and **VI**.

This paper contains **nine** structured questions. Answer **all** questions in the spaces provided on the question paper.

INFORMATION FOR CANDIDATES

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.

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

You are reminded of the need for good English and clear presentation in your answers.

For Examiners' Use	
1	/ 12
2	/ 11
3	/ 9
4	/ 10
5	/ 14
6	/ 12
7	/ 10
8	/ 13
9	/ 9
Total Mark	/ 100

This document consists of **28** printed pages and **8** blank pages.

BOOKLET I

QUESTION 1

The cell theory was developed in the 1830s. At the same time, it was proposed that living things arose spontaneously from non-living materials. This theory of "spontaneous generation" was later disproven, but the cell theory has stood the test of time to become widely accepted in the scientific community today.

(a) Outline the cell theory.

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..... [2]

Fig. 1.1 shows Louis Pasteur's famous swan neck flask experiment that disproved the spontaneous generation theory and supported the cell theory.

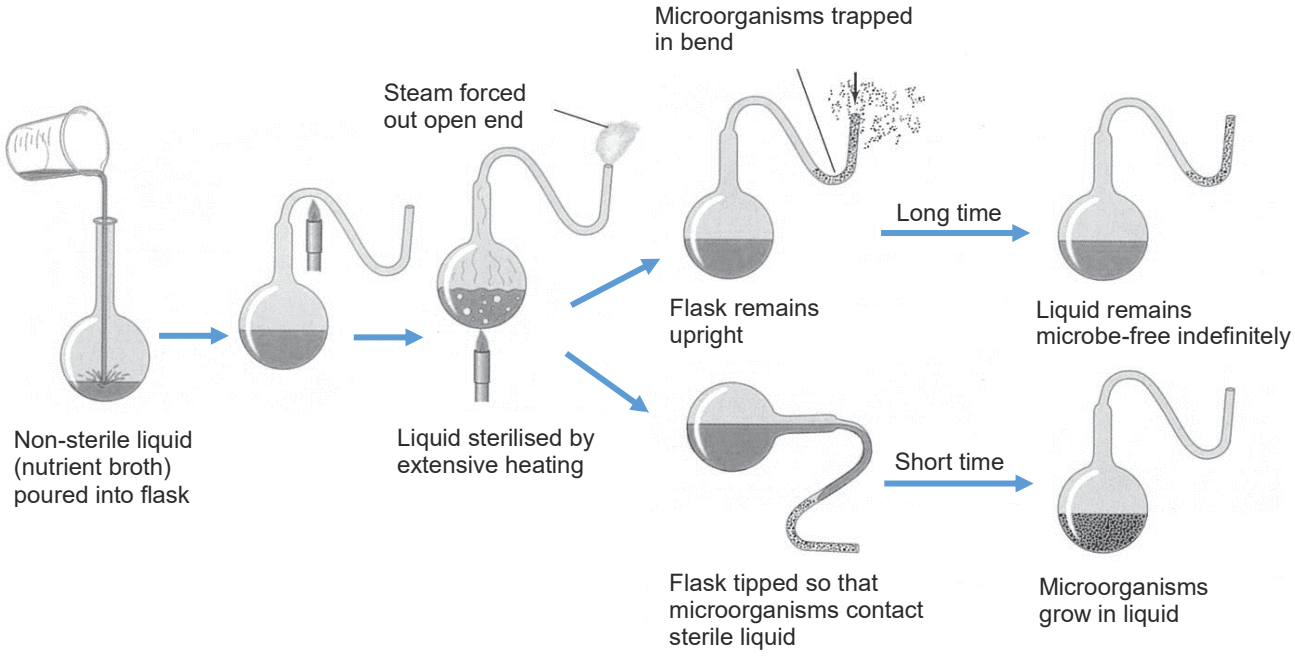

Fig. 1.1

(b)(i) With reference to Fig. 1.1, explain how Pasteur's experiment supports the cell theory.

.....

.....

.....

..... [2]

(ii) Suggest a reason for the universal acceptance of the cell theory in our world today.

.....

..... [1]

Pseudomonas syringae is a pathogen that can enter plants through wounds and cause disease in a wide variety of plants. Fig. 1.2 is an electronmicrograph of a cell belonging to the same domain as *P. syringae*.

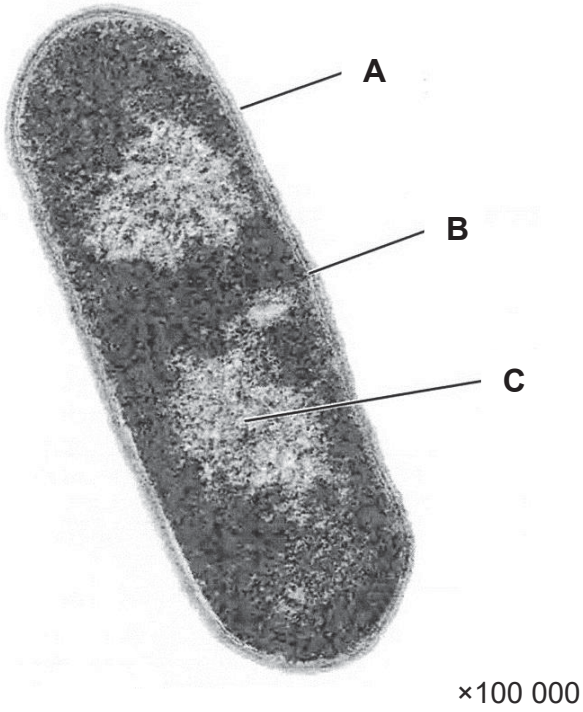

Fig. 1.2

(c)(i) State the name and chemical composition of the structures labelled **A** to **C**.

A .....

B .....

C ..... [3]

(ii) *P. syringae* colonises a host plant and obtains nutrients from the plant tissue. It can cause damage to the leaves of its host plant by secreting toxins and cell wall degrading enzymes, without causing harm to itself.

Explain why this is so.

.....

.....

.....

..... [2]

When two organisms live in close association with each other, the following are three different possible outcomes:

- parasitism occurs in the host-pathogen interaction between *P. syringae* and the host plant because the pathogen benefits while the host is damaged.
- mutualism occurs when both host and pathogen benefit.
- commensalism occurs when the pathogen benefits but the host neither gains nor loses.

Based on the endosymbiotic theory, mitochondria in eukaryotes originated from free-living oxygen-metabolising eubacteria that were engulfed by an ancestral eukaryotic cell, which was otherwise unable to use oxygen.

(d) State and explain which of the three types of interactions best describes the relationship between the ancestral eukaryotic cell and its endosymbiont.

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..... [2]

[Total: 12]

QUESTION 2

Fig. 2.1 is an electronmicrograph of a lymphocyte in the process of cell division during an immune response.

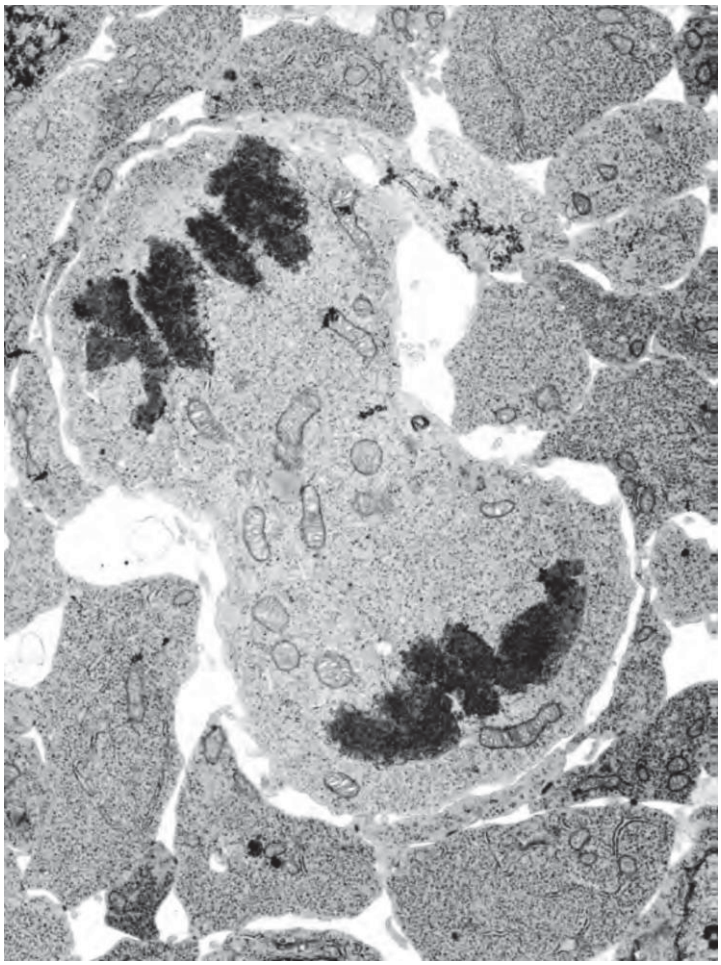

Fig. 2.1

(a) With reference to Fig. 2.1,

(i) name the stage of mitosis.

.....[1]

(ii) describe what is happening during this stage of mitosis.

.....

.....

.....

.....[2]

Stem cells from human bone marrow that are involved in blood cell formation are described as multipotent, rather than totipotent.

(b) Distinguish between multipotent cells and totipotent cells.

.....

.....

.....

..... [2]

Treatment of leukaemia using bone marrow transplants from donors with matching tissue types was first carried out in 1968. Treatment with adult stem cells extracted from the patient's bone marrow is a much more recent treatment. After removal of the stem cells, the remaining bone marrow cells and white blood cells in the patient, including the cancer cells, are killed. The stem cells are separated from the cancer cells in the extract. The remaining stem cells are returned to the patient's body. This procedure is still rarely used as it currently gives a greater risk of cancer in the future.

Several lines of research involving stem cells have shed some light on the causes of cancer. In some cases, the use of stem cells in treatment appears to increase the risk of cancer.

(c) Suggest why there might be a connection between the use of stem cells in treatment and cancer.

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..... [3]

In another line of research, scientists have discovered the formation of cybrids (cytoplasmic hybrid cells). Stem cells may be harvested from cybrids for research or medical purposes.

Fig. 2.2 shows the steps in the production of a cybrid. The DNA of such a cybrid is 99.6% human.

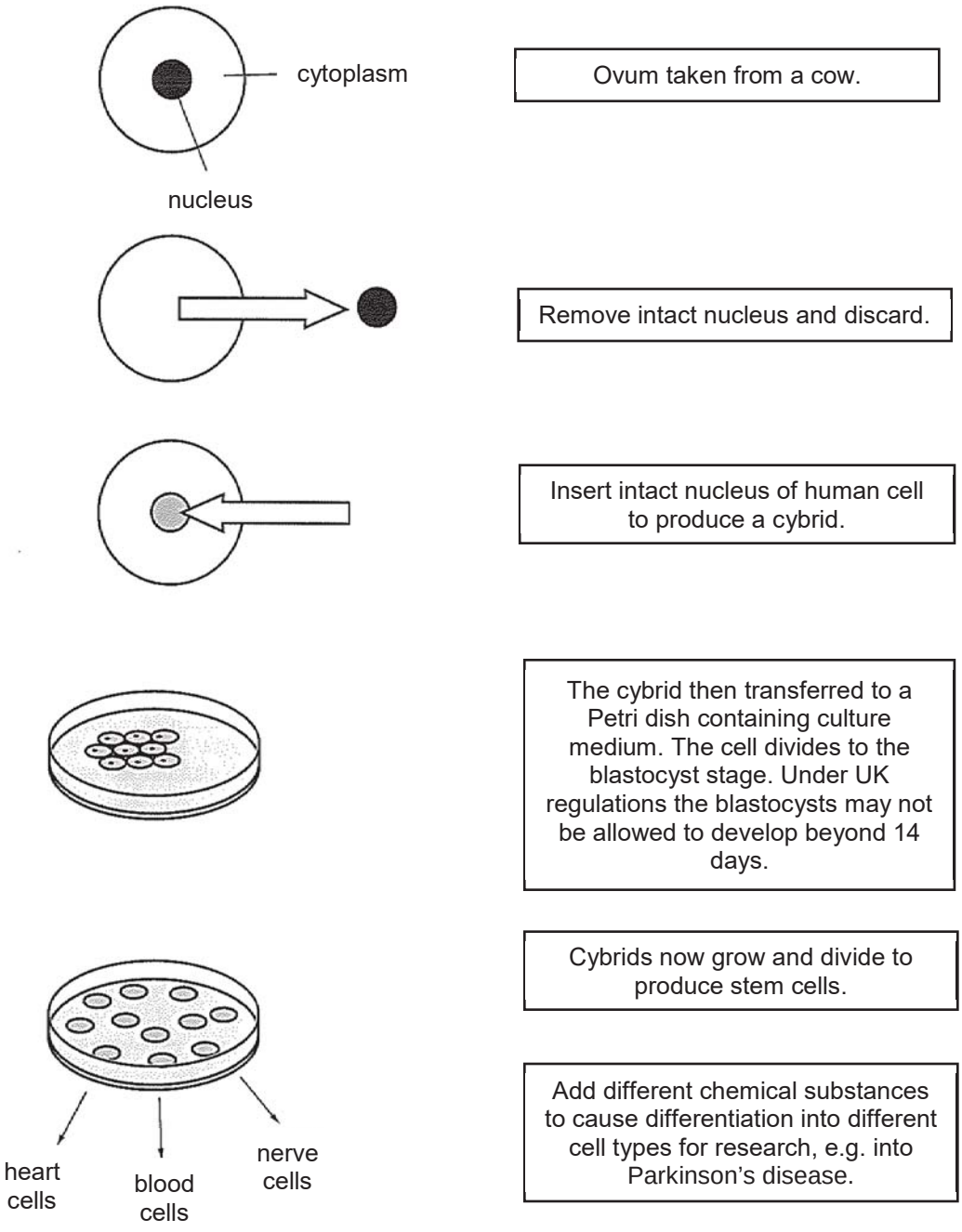

Fig. 2.2

(d) When the Human Fertilisation and Embryology Bill was considered by the UK Parliament in 2008, some people argued that it is unethical to allow the production of cybrids.

State whether you agree **or** disagree that this is unethical **and** explain why you reached this decision.

.....

.....

.....

.....

..... [3]

[Total: 11]

Candidate Name: _____ CT Group: 16S7 ____

BOOKLET II

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QUESTION 3

G-protein linked receptors (GPLRs) play a critical role in glucose homeostasis in mammals. Fig. 3.1 shows a GPLR on a section of the cell membrane of a liver cell.

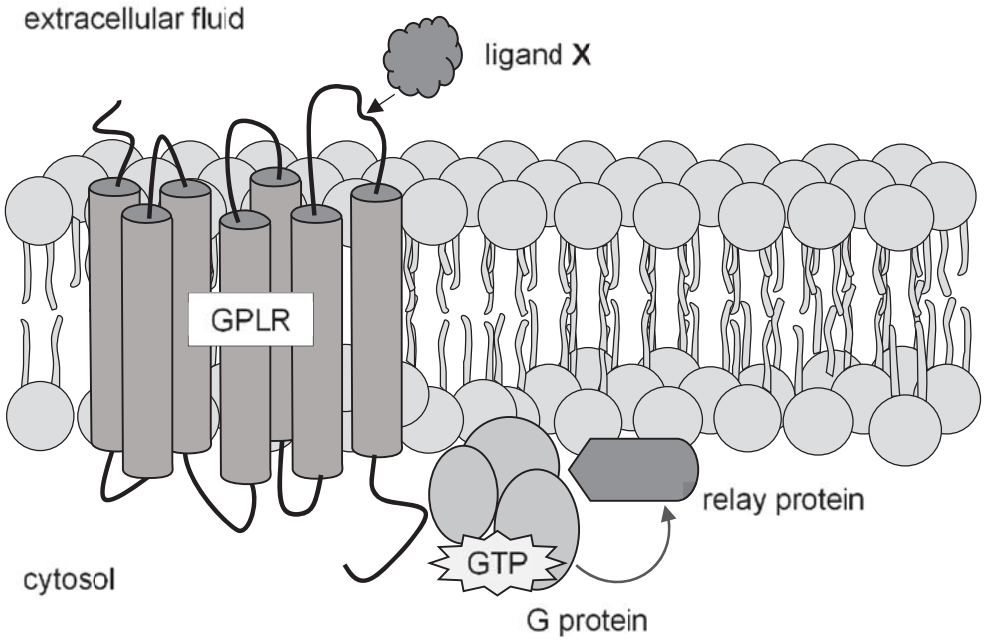

Fig. 3.1

(a)(i) State the identity of ligand **X**.

.....[1]

(ii) Explain why ligand **X** cannot diffuse directly into the liver cell to trigger a cellular response.

.....

.....

.....

.....[2]

(b) With reference to Fig. 3.1, describe how the structure of GPLR enables it to function as a membrane-bound receptor.

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.....[3]

If a mammal is in a fasting state, the ligand **X** binds to GPLR on liver cells to trigger the breakdown of stored glycogen into glucose that is released into the bloodstream. Fig. 3.2 shows part of the structure of the polymer glycogen.

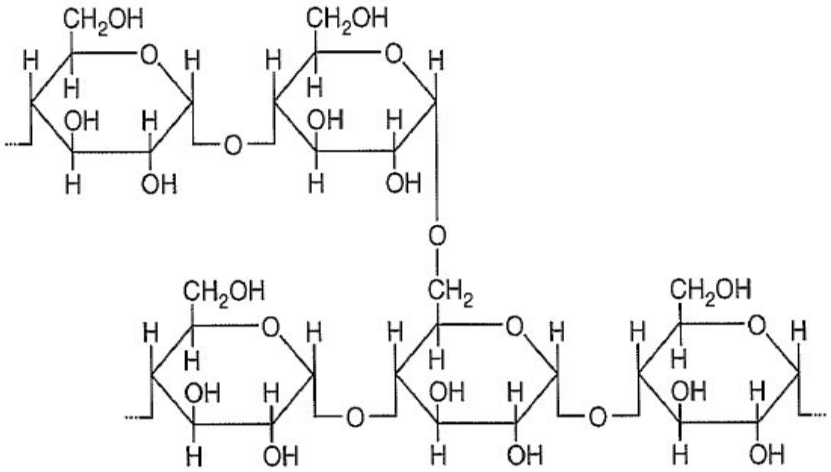

Fig. 3.2

(c) Explain how the structure of glycogen is adapted to its function as an efficient storage biomolecule.

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..... [3]

[Total: 9]

QUESTION 4

Semi-conservative DNA replication results in the formation of genetically identical DNA molecules. Fig. 4.1 shows a replication fork involved in DNA replication.

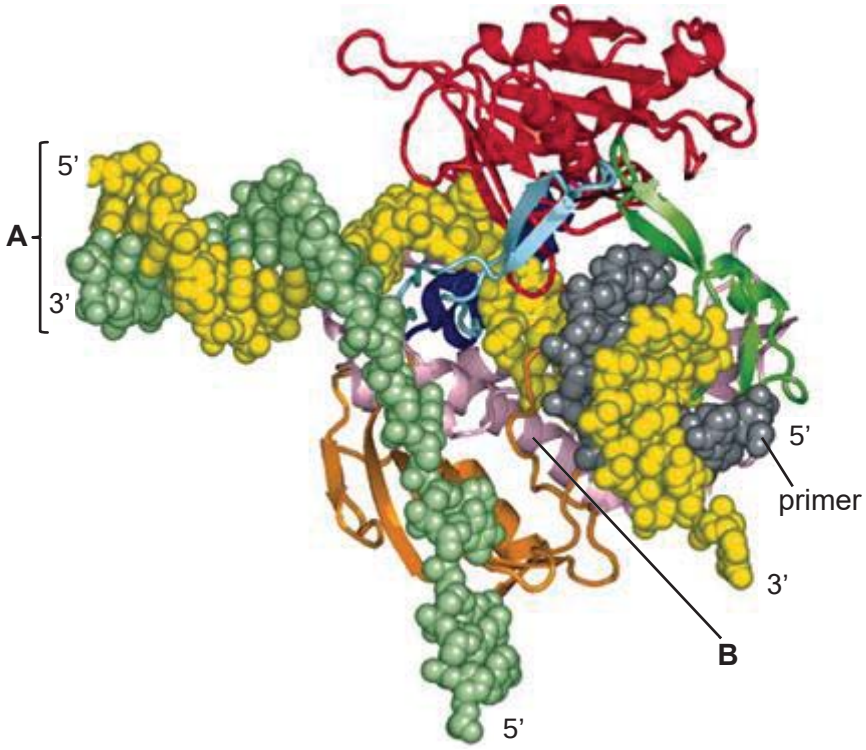

Fig. 4.1

(a) Describe two structural differences between helices **A** and **B**.

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.....

..... [2]

(b)(i) Describe how a primer strand is synthesised.

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..... [3]

(ii) With reference to Fig. 4.1, explain if the primer is priming the synthesis of the leading strand or lagging strand.

.....

.....

.....

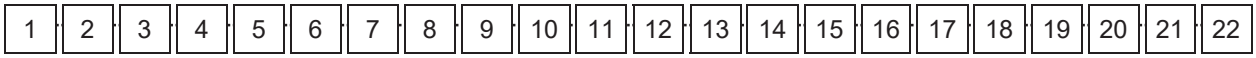
..... [2]

The gene encoding insulin receptor is located on chromosome 19 and contains 22 exons. There are two forms of the insulin receptor (IR) that differ by 12 amino acids. These two forms of the receptor are:

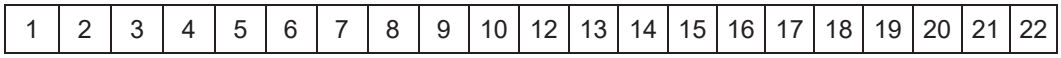
- IR-A, which binds insulin and insulin-like growth factor 2, and is expressed in the brain and ovary.
- IR-B, which binds only insulin, and is expressed in the skeletal muscle and liver.

Fig. 4.2 is a schematic diagram that illustrates the pre-mRNA sequence and the mRNA sequences for the two forms of IR.

IR pre-mRNA:



IR-A mRNA:



IR-B mRNA:

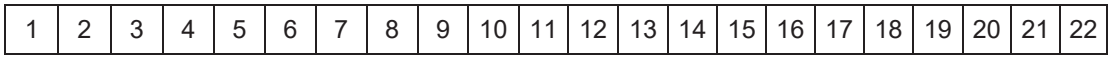


Fig. 4.2

(c) Explain the role of splicing in the structure and function of the two forms of IR.

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..... [3]

[Total: 10]

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Candidate Name: _____ CT Group: 16S7 ____

BOOKLET III

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QUESTION 5

A geneticist is studying the pattern of inheritance of glucose-6-phosphate dehydrogenase (G6PD) deficiency in a family, as shown in Fig 5.1.

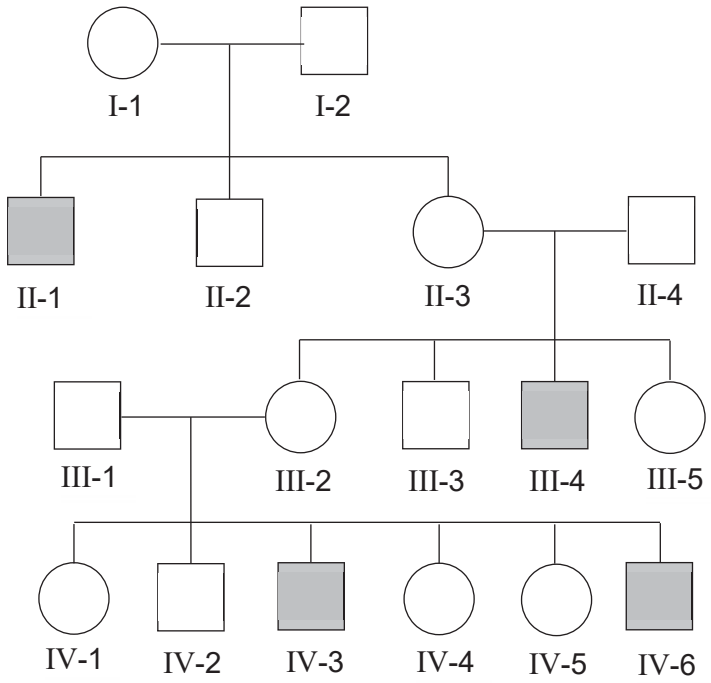

Fig. 5.1

(a) With reference to Fig. 5.1, predict and explain the most likely mode of inheritance of G6PD deficiency.

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..... [3]

Individual II-3 has blood group O and individual II-4 has blood group AB. The ABO gene locus is located on chromosome 9.

(b) Using suitable symbols, draw a genetic diagram to show the expected phenotypic ratio of the ABO blood group and G6PD production in offspring of II-3 and II-4.

[6]

The geneticist carried out another investigation on 200 couples where both partners have the blood group AB. The blood groups of their children are shown as follows:

99 children with blood group A
155 children with blood group AB
106 children with blood group B

The expected phenotypic ratio of a cross between a couple where both partners have the same blood group AB is 1 blood group A : 2 blood group AB : 1 blood group B.

The chi-squared (χ^2) test is used to determine if the results of this investigation are in accordance with the expected results. The formula for χ^2 and the table of probabilities are given as follows:

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

degrees of freedom	probability		
	0.10	0.05	0.01
1	2.71	3.84	6.64
2	4.69	5.99	9.21
3	6.25	7.82	11.35
4	7.78	9.49	13.28

(c)(i) Using the information provided, calculate the χ^2 value for the observed results. Show your working clearly.

[2]

(c)(ii) Deduce if the observed results follow the expected phenotypic ratio of 1 blood group A : 2 blood group AB : 1 blood group B.

Explain your answer.

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.....

..... [3]

[Total: 14]

Candidate Name: _____ CT Group: 16S7 ____

BOOKLET IV

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QUESTION 6

Fig. 6.1 shows the outer layers of two different bacteria **X** and **Y**.

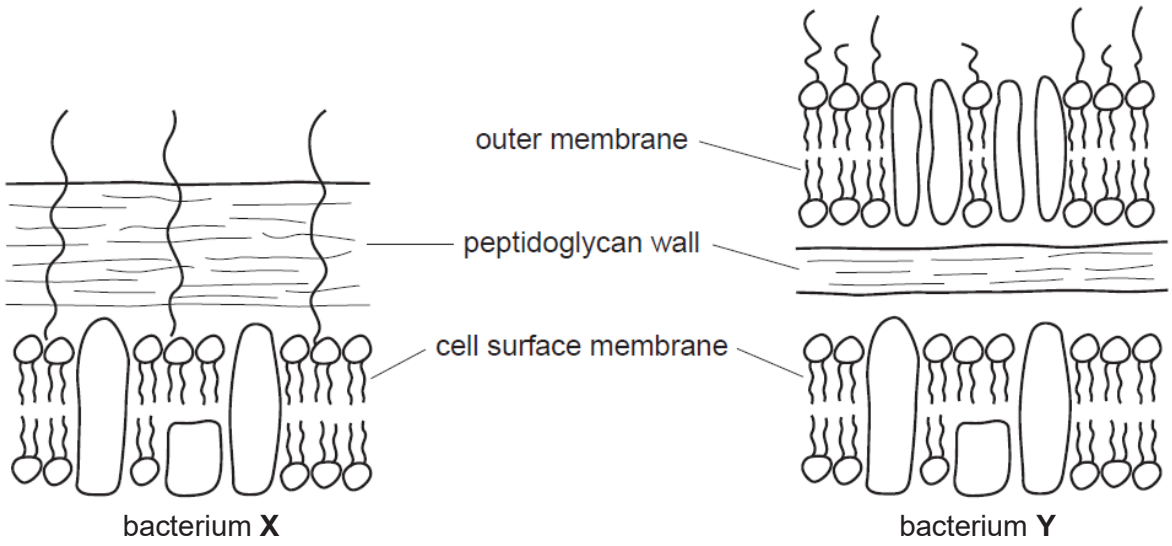

Fig. 6.1

(a) Describe how the outer layers of bacterium **Y** differs from those of bacterium **X**.

.....

.....

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..... [2]

Gram staining is a technique used to classify bacteria based on the structures of their outer layers. One of the two bacteria shown in Fig. 6.1 turns purple when stained with the Gram stain.

(b)(i) Identify the bacterium which turns purple when stained with the Gram stain.

..... [1]

(ii) Explain your answer to **(b)(i)**.

.....

.....

.....

..... [2]

Antibiotics such as penicillin are commonly used to treat bacterial infections. However, their effects on different bacteria may be different.

(c) Explain the different effects of penicillin on bacteria **X** and **Y**.

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..... [3]

The bacterium that causes cholera, *Vibrio cholerae*, releases a toxin. Fig 6.2 shows the mode of infection of *V. cholerae*.

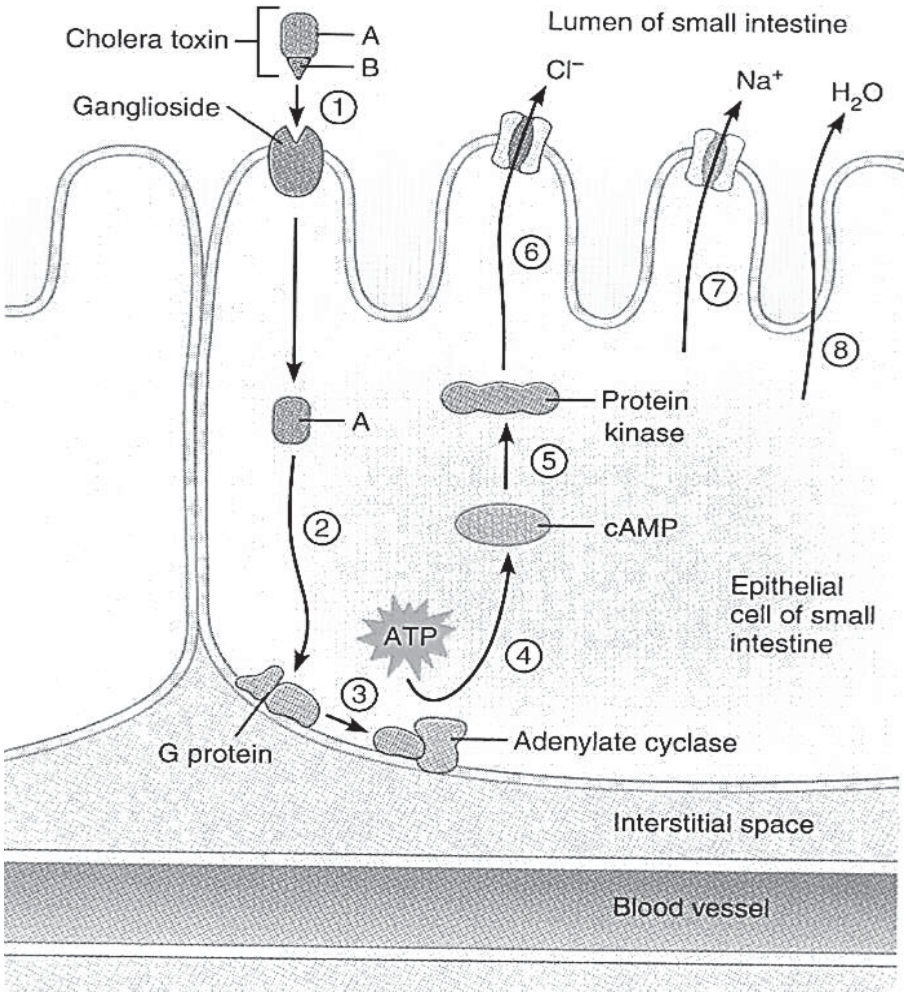

Fig. 6.2

(d) With reference to Fig. 6.2, describe and explain the mode of infection of *V. cholerae*.

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.....

..... [4]

[Total: 12]

Candidate Name: _____ CT Group: 16S7 ____

BOOKLET V

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QUESTION 7

Fig. 7.1 shows how influenza viruses attack the cells on the inside of the nose.

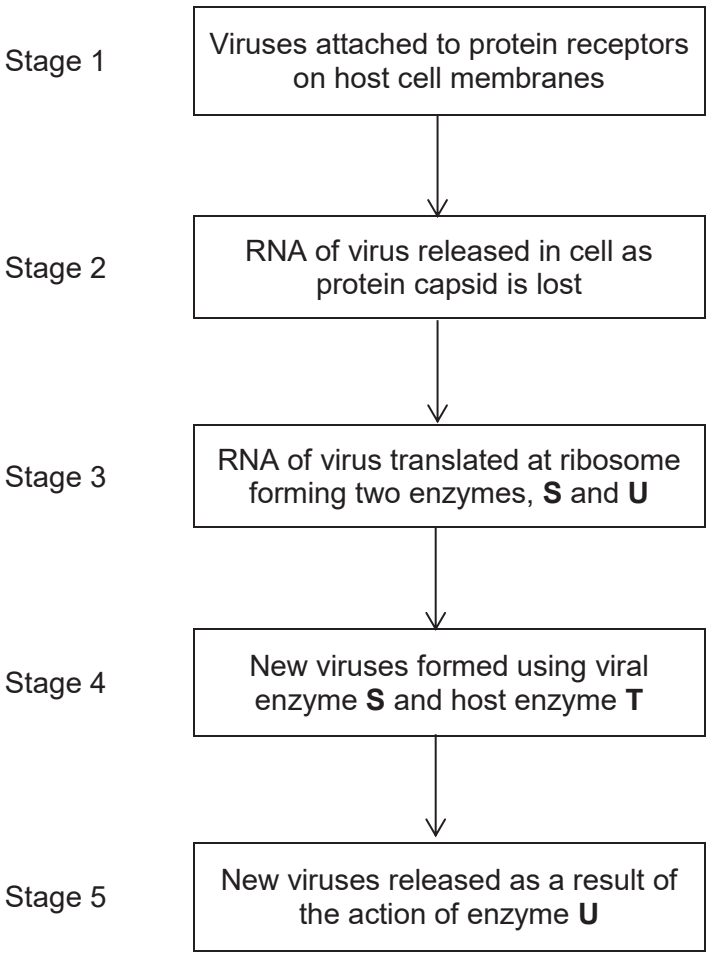

Fig. 7.1

(a) Explain why influenza viruses can only attack the cells on the inside of the nose.

.....

.....

.....

..... [2]

(b) Suggest why enzymes **S** and **T** are needed at Stage 4.

.....

.....

.....

..... [2]

(c) Suggest how enzyme **U** might catalyse the breakdown of the host cell membrane at Stage 5.

.....

.....

.....

..... [2]

When an organism is infected with two different strains of the influenza virus, different segments of single-stranded RNA can sometimes be transferred between the two strains, forming a new viral strain, as shown in Fig. 7.2.

In 1957, a new virus caused an influenza pandemic, known as the Asian influenza, in human populations.

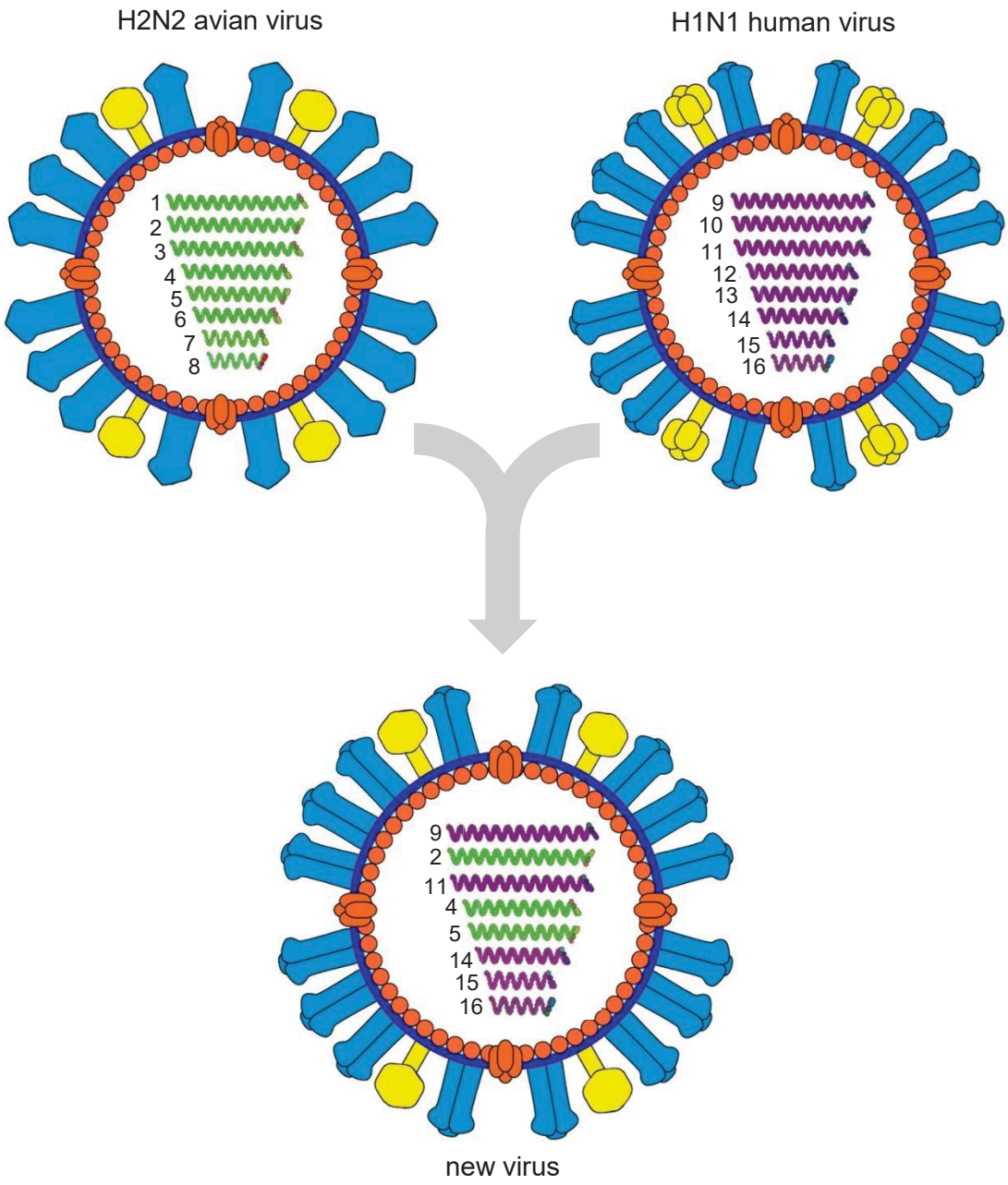

Fig. 7.2

(d) Most people in 1957 were susceptible to influenza caused by the new virus.

Explain why.

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..... [4]

[Total: 10]

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Candidate Name: _____ CT Group: 16S7 ____

BOOKLET VI

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QUESTION 8

Biologists have identified about 1.8 million species of extant (currently living) organisms and estimate that several million more remain to be discovered. In the 18th century, Carolus Linnaeus developed a system for biological classification.

(a) Define *biological classification*.

.....

.....

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..... [2]

The genetic code is the information encoded within the mRNA sequence that is translated into proteins by living cells. The codon table is shown in Fig. 8.1.

First position	Second position: U		Second position: C		Second position: A		Second position: G		Third position
U	UUU	Phe (F)	UCU	Ser (S)	UAU	Tyr (Y)	UGU	Cys (C)	U
	UUC		UCC		UAC		UGC		C
	UUA	Leu (L)	UCA		UAA	**STOP**	UGA	**STOP**	A
	UUG		UCG		UAG		UGG	Trp (W)	G
C	CUU	Leu (L)	CCU	Pro (P)	CAU	His (H)	CGU	Arg (R)	U
	CUC		CCC		CAC		CGC		C
	CUA		CCA		CAA	Gln (Q)	CGA		A
	CUG		CCG		CAG		CGG		G
A	AUU	Ile (I)	ACU	Thr (T)	AAU	Asn (N)	AGU	Ser (S)	U
	AUC		ACC		AAC		AGC		C
	AUA		ACA		AAA	Lys (K)	AGA	Arg (R)	A
	AUG	**Met (M)**	ACG		AAG		AGG		G
G	GUU	Val (V)	GCU	Ala (A)	GAU	Asp (D)	GGU	Gly (G)	U
	GUC		GCC		GAC		GGC		C
	GUA		GCA		GAA	Glu (E)	GGA		A
	GUG		GCG		GAG		GGG		G

Fig. 8.1

The first part of the cytochrome b protein sequence alignment of mold fungus (*Neurospora*), horse (*Equus*), human (*Homo*), corn (*Zea*) and rice (*Oryza*) is shown in Fig. 8.2 using the amino acids as a one letter code.

```
Neurospora      AIGTVILILMMATAFLGYVLPYGQMSLWGATVITNLISAIPWIGQDIVEFIWGGFSVNNA
Equus           NIGIILLFTVMATAFMGYVLPWGQMSFWGATVITNLLSAIPYIGTTLVEWIWGGFSVDKA
Homo            NIGIILLLATMATAFMGYVLPWGQMSFWGATVITNLLSAIPYIGTDLVQWIWGGYSVDSP
Zea             CLGVVIFLLMIVTAFIGYVPPWGQMSFWGATVITSLASAIPVVGDTIVTWLWGGFSVDNA
Oryza           CLGVVIFLLMIVTAFIGYVPPWGQMSFWGATVITSLASAIPVVGDTIVTWLWGGFSVDNA
                 :* ::::  :.***:*** *:****:*******.* **** :*  :* ::***:**:.
```

Fig. 8.2

(b)(i) Explain how multiple sequence alignment can be used in biological classification of the five genera of organisms.

[3]

(ii) Identify the longest amino acid sequence where there are no differences amongst the five genera.

[1]

(iii) Suggest, with a reason, whether the DNA coding for the amino acid sequence identified in **(b)(ii)** must be identical for the five genera.

[2]

International agreement limits the hunting of whales. Only the meat of the Minke, Fin and Humpback whales from Southern Hemisphere populations is allowed to be sold on the domestic market in Japan.

Scientists obtained five samples of food that were being sold as "whale meat" in a Japanese market place. In this study, the gene for cytochrome b at the mitochondrial DNA was used for sequence alignment to obtain a cladogram of these organisms.

The scientists identified the species and probable geographic origin of the meat using genetic analysis. The results were used to construct the cladogram in Fig. 8.3.

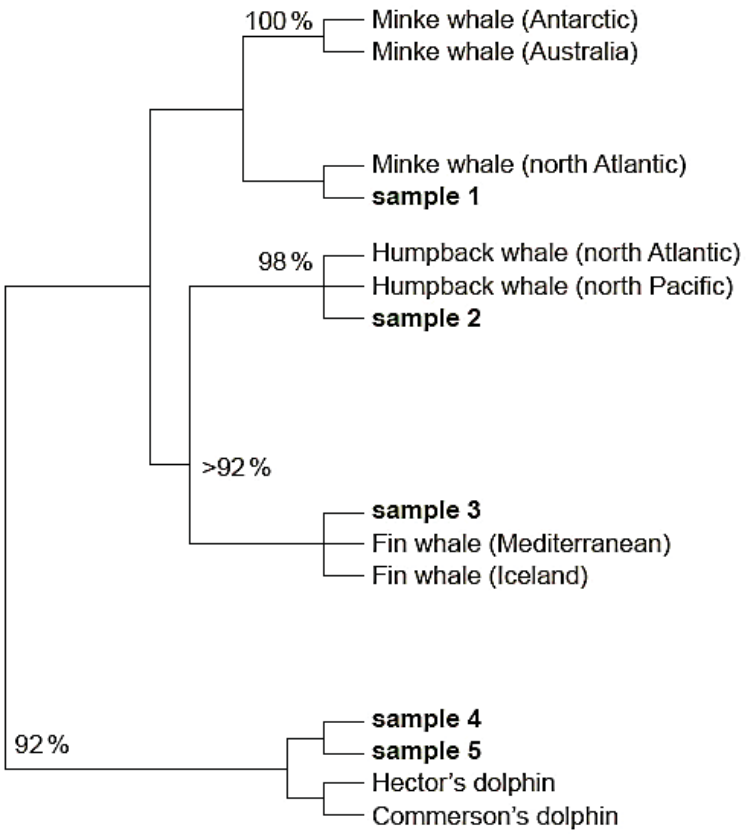

Fig. 8.3

(c) Describe what a cladogram represents.

.....

.....

.....

.....

.....

..... [3]

(d) State a reason each for illegal sale of the respective meat samples in Japan:

(i) sample 1

.....

..... [1]

(ii) sample 4

.....

..... [1]

[Total: 13]

QUESTION 9

The poison ivy plant, *Toxicodendron radicans,* when handled or damaged, releases an oily substance, known as urushiol, onto the outside of its roots, stems, leaves and fruits.

On first skin contact with urushiol, a person will not notice any ill effects, but if the person is sensitive to urushiol, second and subsequent contacts will cause poison ivy rash. This is an itchy, often painful, red rash that can become blistered.

On contact with human skin, urushiol diffuses through to the deeper skin layers, where it stimulates a series of changes.

- It enters skin cells, known as keratinocytes, and immune system cells, known as Langerhans cells, and is oxidised to quinones.
- Quinones become attached to the exterior surface of cell surface membrane proteins of the two cell types, forming complexes known as haptens.
- The Langerhans cells presenting the haptens migrate to nearby lymph nodes, where T-cells are located.
- The keratinocytes presenting the haptens are induced to produce and release cytokines.

The keratinocytes presenting the haptens have a short life span.

These events are summarised in Fig. 9.1.

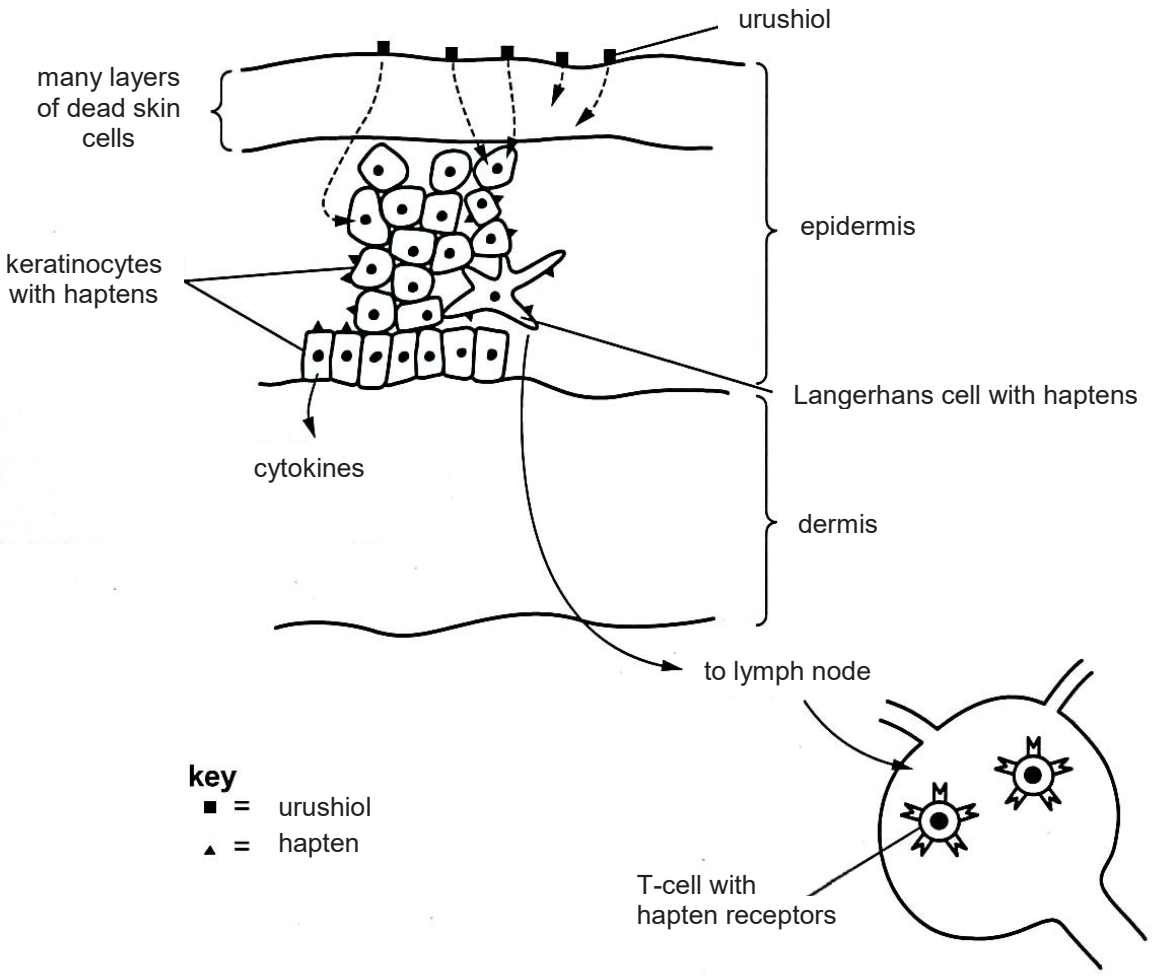

Fig. 9.1

(a) Outline **one** possible mechanism by which urushiol could enter the keratinocytes and Langerhans cells.

[2]

(b) Poison ivy rash occurs as a result of destruction, by an immune system response, of keratinocytes displaying haptens. Langerhans cells, T-cells and macrophages, but not B-cells, are involved in this immune response.

(i) Describe and explain the events that are likely to occur during an immune response to bring about poison ivy rash.

[6]

(ii) Suggest **one** reason why some people are not sensitive to skin contact with urushiol.

[1]

[Total: 9]

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HWA CHONG INSTITUTION
JC2 Preliminary Examinations
Higher 2

CANDIDATE NAME		CT GROUP	16S7 ___

CENTRE NUMBER					INDEX NUMBER				

BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

13 September 2017

No Additional Materials are required.

2 hours

INSTRUCTIONS TO CANDIDATES

There are **four** question booklets (**I** to **IV**) to this paper. Write your **name**, **CT group**, **Centre number** and **index number** in the spaces provided at the top of this cover page, and your **name** and **CT group** on the lines provided at the top of the cover page of Booklets **II, III and IV**.

SECTION A

This section contains **three** structured questions. Answer **all** parts in the spaces provided on the question paper.

SECTION B

This section contains **two** free-response questions. Answer **any one** question. Your answer must be in continuous prose, where appropriate.

INFORMATION FOR CANDIDATES

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.

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

You are reminded of the need for good English and clear presentation in your answers.

For Examiners' Use	
1	**/ 25**
2	**/ 10**
3	**/ 15**
4 or **5**	**/ 25**
Final Mark	**/ 75**

This document consists of **19** printed pages and **5** blank pages.

BOOKLET I

SECTION A

QUESTION 1

Plants harvest light energy from the sun for photosynthesis, producing biomass that is used as food. Such biomass can also be used as 'biofuels', which include wood, ethanol, biodiesel and biogas. Biofuels offer plant-based solutions to the Earth's growing energy problems.

Oats and wheat, commonly grown in temperate regions, are C3 plants. Most plants are C3 plants and are so-called because their first photosynthetic product is a three carbon compound.

Corn, sorghum and sugarcane are C4 plants. They are common food crops of tropical regions.

The enzyme ribulose bisphosphate carboxylase oxygenase (rubisco) catalyses the fixation of carbon dioxide in the Calvin cycle and is used by both C3 and C4 plants. Each molecule of rubisco is made up of eight large polypeptides and eight small polypeptides. Fig. 1.1 shows a side view of the molecule.

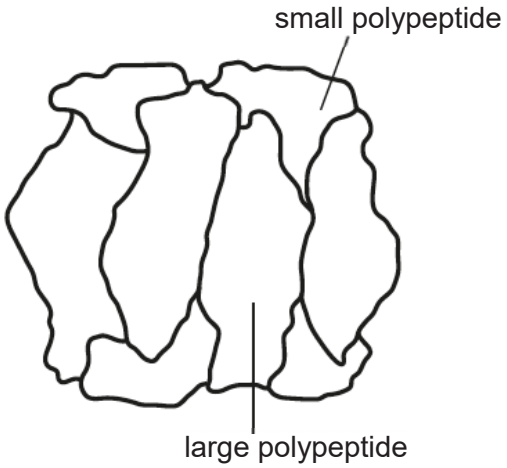

Fig. 1.1

(a) (i) State why rubisco is said to have quaternary structure.

.....

..... [1]

(ii) Explain what makes a molecule such as rubisco soluble.

.....

.....

.....

..... [2]

(b) In the absence of light, rubisco changes shape from an active form to an inactive form.

Explain why rubisco does **not** need to be in an active form in the absence of light.

[3]

(c) The active sites of rubisco accept ribulose bisphosphate (RuBP) and **either** carbon dioxide **or** oxygen and can catalyse the two reactions shown:

either

RuBP + CO_2 → unstable intermediate compound → 2GP (PGA)

or

RuBP + $2O_2$ → unstable intermediate compound → GP (PGA) + $2CO_2$

Explain the consequences to the plant of the reaction involving oxygen.

[3]

Fig. 1.2 shows the temperatures and carbon dioxide concentrations at which growth of C3 or C4 plants are favoured, based on the yield of photosynthesis.

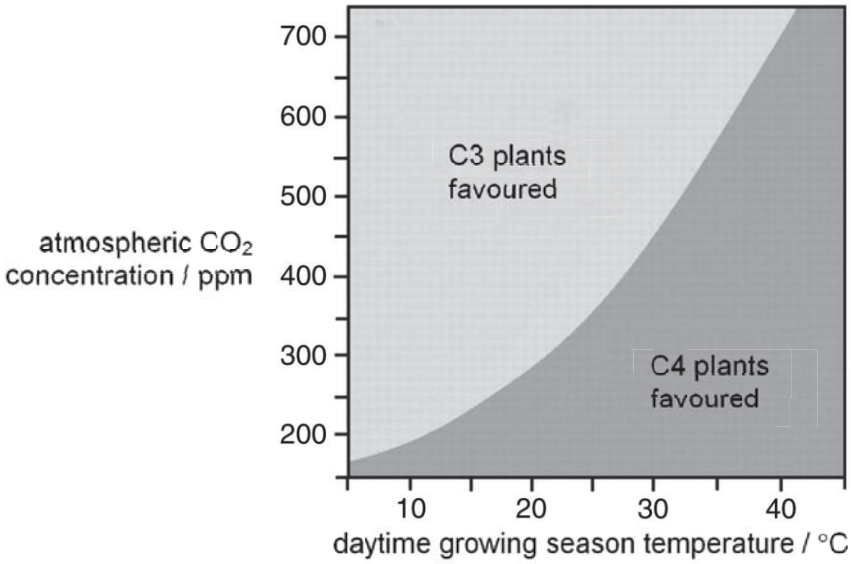

Fig. 1.2

The annual mean carbon dioxide concentration measured at Mauna Loa Baseline Atmospheric Observatory, Hawaii, has increased over the last 50 years to 404.21 ppm in 2016.

(d) With reference to Fig. 1.2, predict whether C3 or C4 plants are favoured in the context of global warming in the tropics. Explain how these plants are better adapted physiologically.

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..... [5]

Biofuels have been around as long as cars have. At the start of the 20th century, Henry Ford planned to fuel his Model Ts with ethanol, and early diesel engines were shown to run on peanut oil.

Discoveries of huge petroleum deposits kept petrol and diesel cheap for decades, however, and biofuels were largely forgotten. With the recent rise in oil prices, along with growing concern about global warming caused by carbon dioxide emissions, biofuels have been regaining popularity.

Corn is a crop grown in the 'Corn Belt' of the United States Midwest for food and biofuel.

Fig. 1.3 shows the industrial process of manufacturing ethanol from corn starch. Ethanol can be mixed with petrol to make gasohol.

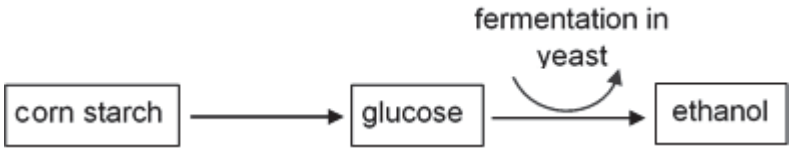

Fig. 1.3

(e) (i) Describe how yeast converts glucose to ethanol.

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..... [2]

(ii) Explain why it may be better in the long term to use ethanol made from corn starch, rather than petrol, as a fuel for cars.

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..... [2]

Transport in Britain accounted for 21% of all greenhouse gas emissions in 2007. In order to reduce greenhouse gas emissions, the UK Government has set a target of 10% of transport energy to come from sustainable sources by 2020. Biofuels, including biodiesel, are expected to provide a significant part of this 10%.

Reliance on biofuels is controversial for the following reasons:

- Some carbon dioxide is still released because energy is used during the production (cultivation, harvesting, processing) and distribution of biofuels.
- Large areas of land may need to be taken out of food production to grow the crops. It is estimated that all such land in the UK would only meet about 10% of its total diesel needs.
- The change in land use, such as from tropical rainforest to palm plantation, may release large amounts of carbon dioxide.

Table 1.1 is an assessment of the carbon dioxide released during the cultivation, processing and distribution of plant-derived biodiesel as well as the annual emissions from any change of land use, assuming these are spread over 20 years. In Britain all diesel, now must include 3.3% biodiesel. As Table 1.1 shows, there is a wide range of sources.

Table 1.1

crop	country	grams carbon dioxide equivalent released / MJ biodiesel produced			
		emissions due to change of land use			emissions from cultivation, processing and distribution
		existing crop land	grassland	forest	
oilseed rape	UK	0	154	583	79
soy	Brazil	0	683	2466	71
soy	USA	0	122	1127	53
palm	Indonesia	0	127	224	41
palm	Malaysia	0	57	176	41

(f) (i) With reference to Table 1.1, suggest the source of biodiesel chosen by an oil company if reduction of greenhouse gas emissions were the sole criterion.

.....[1]

(ii) Explain your answer to **(f)(i)**.

.....

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.....[2]

(g) Identify **two** criteria, apart from cost, that should also be considered in choosing a source of biodiesel. Explain the significance of each criterion.

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[4]

[Total: 25]

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Candidate Name: _____ CT Group: 16S7 ____

BOOKLET II

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QUESTION 2

Li-Fraumeni syndrome is a rare disorder that greatly increases the risk of developing several types of cancer, particularly in children and young adults.

In a pedigree study by a genetic counsellor, it was suggested that Li-Fraumeni syndrome runs in Jane's family. Jane provided a sample of blood to conduct DNA analysis on the *p53* gene. Fig. 2.1 shows her DNA with *p53* gene amplified using PCR and digested with a restriction endonuclease at the mutated site.

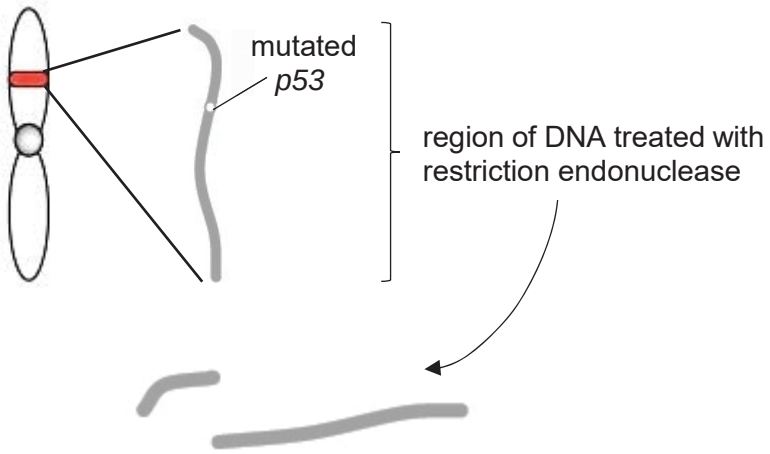

Fig. 2.1

The pre-digested samples were separated by gel electrophoresis and stained. Fig. 2.2 shows the DNA profiles obtained from an unrelated normal individual, Jane and tumour tissue from a family member suffering from breast cancer.

Key
Lane 1: DNA markers
Lane 2: Unrelated normal individual
Lane 3: Jane
Lane 4: Jane's family member with cancer

Fig. 2.2

(a) Outline how gel electrophoresis separates DNA fragments.

[4]

(b) With reference to Fig. 2.1 and 2.2, explain the DNA profile of Jane.

[3]

(c) With reference to development of cancer as a multi-step process, describe how Jane might develop breast cancer.

[3]

[Total: 10]

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Candidate Name: _____ CT Group: 16S7 ____

BOOKLET III

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QUESTION 3

The total number of antibody specificities available to an individual is known as the antibody repertoire. In humans, the antibody repertoire is at least 10^{11}.

Fig. 3.1 is a schematic diagram of the production of a heavy chain polypeptide for an antibody. At the top is the chromosomal arrangement found in an immature B cell, at the bottom is shown the heavy chain polypeptide.

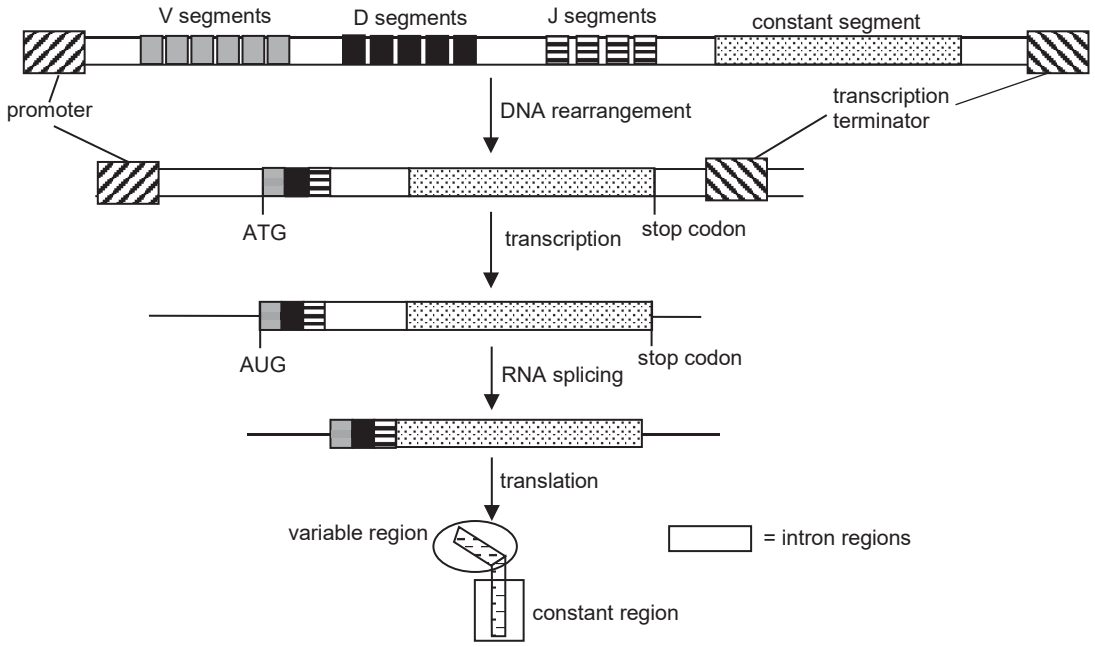

Fig. 3.1

(a) With reference to Fig. 3.1, explain how somatic recombination during B cell development results in the formation of millions of different antibody molecules.

[4]

Whooping cough is a disease that is particularly serious in young children. Whooping cough is caused by the bacterium *Bordetella pertussis*. Children may be vaccinated against whooping cough.

In an investigation, a group of rats was vaccinated. Sixty days later, these rats were infected with *B. pertussis*. In this investigation, the levels of antibodies raised against antigen X and antigen Y in the blood of the rats were measured. Fig. 3.2 shows the mean levels of anti-X antibodies and anti-Y antibodies.

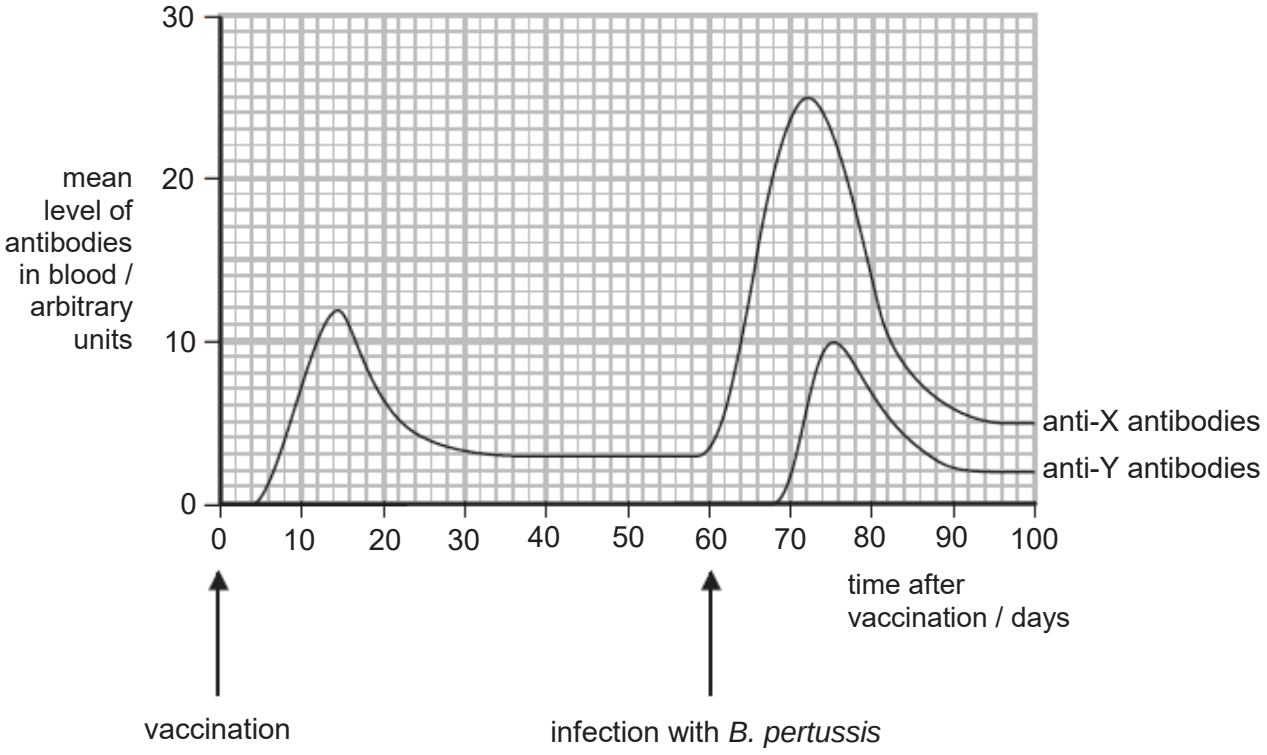

Fig. 3.2

(b) (i) Compare the increase in mean level of anti-X antibodies after vaccination and after infection with *B. pertussis*.

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..... [2]

(ii) Explain the changes in mean level of anti-X antibodies after infection with *B. pertussis*.

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..... [2]

(c) (i) Suggest why anti-Y antibodies were not present in the blood of these rats until after infection with *B. pertussis*.

.....

..... [1]

(ii) Place a tick in the box next to the term that describes the type of immunity that results in the production of anti-Y antibodies. [1]

- ☐ artificial active
- ☐ artificial passive
- ☐ natural active
- ☐ natural passive

Early in the immune response to antigen X, B cells express immunoglobulin M (IgM). Later, in the response to the same antigen, class switching allows for the formation of IgG.

(d) Explain how class switching allows for formation of IgG.

.....

.....

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.....

..... [3]

(e) Comment on the reliability of the data shown in Fig. 3.2.

.....

.....

.....

..... [2]

[Total: 15]

--- END OF SECTION A ---

Candidate Name: _____ **CT Group: 16S7 ____**

BOOKLET IV

4 or 5

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SECTION B

Answer **one** question in this section.

Write your answers on the lined paper provided at the end of this Question Paper.

Your answer should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answer must be in continuous prose, where appropriate.

You answer must be set out in parts **(a)**, **(b)** etc., as indicated in the question.

QUESTION 4

(a) Describe and explain gene mutation and chromosomal aberration. Using a suitable named example, explain how chromosomal aberration can result in a diseased phenotype in humans. [13]

(b) The genotype of an organism is not always directly expressed in the phenotype. Gene expression and the resultant phenotype are often modified through the interaction between an individual's particular genotype and the environment.

Discuss how the genotype of an organism is linked to its phenotype and using suitable named examples, explain how the environment may affect the phenotype of an organism. [12]

[Total: 25]

QUESTION 5

(a) Using a named example each, describe and explain directional and disruptive selection. Suggest, with reasons, which of these two forms of natural selection might contribute to the emergence and subsequent development of a new species. [13]

(b) The fossil record reveals that the evolutionary history of life on Earth has been episodic, with long, relatively stable periods punctuated by brief, cataclysmic ones. During these upheavals, macroevolutionary events occur where new species are formed through adaptive radiation and others die out in great numbers through mass extinctions.

Discuss mechanisms that trigger adaptive radiation and mass extinctions, and explain how microevolution can be linked to these macroevolutionary events. [12]

[Total: 25]

--- END OF SECTION B ---

--- END OF PAPER---

Preparation list for 2017 JC2 H2 Biology Prelim Paper 4 -- Practical 2017

Question 1

Apparatus/Reagents/Chemicals	Quantity per student
Potato extract, labelled **T**, at room temperature	30 cm^3
1.0% amylase solution in a container, labelled **E**, at room temperature	10 cm^3
1.0% starch solution in a container, labelled **S**, at room temperature	30 cm^3
1 $moldm^{-3}$ sulfuric acid in a container, labelled **A**, at room temperature	20 cm^3
0.1% potassium manganate (VII) solution in a container, labelled **P**, at room temperature	20 cm^3
Iodine solution in container with a dropping pipette or means to remove it, labelled **iodine**, at room temperature	15 cm^3
10 cm^3 syringe with the means to wash them out	1
3 cm^3 or 5 cm^3 syringes with the means to wash them out	2
Spatula	1
Dropping pipettes	2
Glass microscope slides	1
Coverslips	2
Sieve	1
Beaker or container, capacity sufficient to hold approximately 100 cm^3 solution	2
Test tubes, small	6
Test tube rack to hold 6 test tubes	1
Glass rod	1
Mounting needle	1
Spotting tile or white tile	1
15 cm ruler	1
Paper towels	5
Glass marker pen	1
Stopwatch	1
Suitable eye protection	1

Question 1

It is advisable to wear suitable eye protection when handling chemicals.

Preparation of solutions

(i) **T**, potato extract
This is prepared by juicing well washed potatoes.
T must be prepared immediately before the examination.

(ii) **E**, 1.0% amylase solution
This prepared by putting 1 g of amylase powder into a beaker and making up to 100 cm^3 with distilled water and mixing well.
E must be prepared immediately before the examination.

(iii) **S**, 1.0% starch solution
This is prepared by putting 1 g of starch into 25 cm^3 of warm distilled water in a beaker and mixing to a paste, making up to 100 cm^3 with boiling distilled water, Mix well and allow to cool.

(iv) **A**, 1.0 $moldm^{-3}$ sulfuric acid
This is prepared from (98%) sulfuric acid, by adding 5 cm^3 of this sulfuric acid to 500 cm^3 of distilled water and making up to 1 dm^3 with distilled water.
This is an exothermic reaction, **add acid to water**.

(v) **P**, 0.1% potassium manganate (VII) solution
This is prepared by putting 1.0 g of potassium manganate (VII) into a beaker and making up to 100 cm^3 with distilled water. This is to make a 1.0% solution.
Then put 10 cm^3 of this 1.0% solution into a beaker and make up to 100 cm^3 with distilled water.
This solution must be made up immediately before the start of the examination and kept out of sunlight.

(vi) **iodine**, iodine solution (0.1 $moldm^{-3}$)
This is prepared by putting 8 g of potassium iodide into a beaker. Moisten the potassium iodide with a few drops of water. Add 2.54 g of iodine to the potassium iodide and stir well. Make up to 100 cm^3 adding small volumes of distilled water and stir well. Continue to stir until the iodine has dissolved.
This solution must be made up immediately before the start of the examination and kept out of sunlight.

Question 2

Each candidate must have sole, uninterrupted use of a microscope for 1 hour 15 minutes only.

Apparatus	Quantity per student
Stage micrometer with divisions down to 0.1mm or 0.01mm	at least 1 between 2
Prepared slide of Leaf of Rosemary (TS), labelled **S1**	at least 1 between 2

HWA CHONG INSTITUTION
JC2 Preliminary Examinations
Higher 2

CANDIDATE NAME		CT GROUP	16S ___
CENTRE NUMBER		INDEX NUMBER	

BIOLOGY

9744/04

Paper 4 Practical

28 August 2017

No additional materials are required.

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES

There are **three** question booklets (**I** to **III**) to this paper. Write your **name**, **CT group, Centre number** and **index number** in the spaces provided at the top of this cover page and on the lines provided at the top of the cover pages of Booklets **II and III**.

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

Shift
Laboratory

INFORMATION FOR CANDIDATES

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.

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

You are reminded of the need for good English and clear presentation in your answers.

For Examiners' Use	
1	/ 25
2	/ 16
3	/ 14
Total Mark	/ 55

This document consists of **16** printed pages and **4** blank pages.

QUESTION 1

Many plants store starch in specific organs such as the bases of stems (e.g. potato tubers) or in roots before and during a dormant period. This provides the energy for growth the following year.

You are to investigate the activity of the enzyme starch phosphorylase on an extract of potato, *Solanum tuberosum*. The breakdown of stored starch within cells is catalysed by starch phosphorylase:

$$\text{starch} + \text{phosphate} \rightarrow \text{glucose phosphate}$$

You are provided with 30 cm^3 of potato extract, **T**. Pieces of potato tuber were chopped, mixed with a small volume of water and ground up in order to obtain **T**.

1 Stir **T** with a glass rod and filter it by pouring into a 100 cm^3 beaker through the sieve. Place the sieve on top of the opening of the beaker to allow the filtration process to complete.

2 Using a small plastic spoon, obtain a spoonful of the filtration residue from the sieve and place it into another 100 cm^3 beaker. Re-suspend the residue (termed as re-suspended **T**) in 30 cm^3 of distilled water. Ensure that you stir thoroughly.

3 Using a clean plastic pipette, remove a small sample from the re-suspended **T** and place it on the white tile. Test the sample for starch and record your result below. **Using a paper towel, wipe away the sample from the white tile.**

Colour of extract on adding iodine solution: ..... [1]

Different plant species manufacture distinctive starch grains, morphologically varying in size and shape. Each individual starch grain is composed of growth rings called lamellae and a central core called hilum.

4 Using the same plastic pipette from step **3**, place a few drops of re-suspended **T** on a clean glass slide. Carefully lower a coverslip over the glass slide. You are to ensure there are no air bubbles present. Now examine the mounted glass slide under the light microscope for the presence of starch grains.

Make a large labelled detailed drawing, in the space below, of two adjacent starch grains.

[4]

5 The potato extract was prepared by crushing and filtering some storage tissue.
Explain the result obtained in step **3** when iodine solution was added to the re-suspended **T**.

.....

..... [1]

You are required to investigate the progress of this enzyme-catalysed reaction by **both**

- testing for the disappearance of starch, and
- testing for the appearance of glucose phosphate by finding the time taken for the decolourisation of potassium manganate(VII) solution.

To test for the production of glucose phosphate, the change in the colour of potassium manganate(VII) solution is:

purple $\rightarrow$ colourless

where the formation of a colourless solution indicates end-point.

You are provided with:

labelled	contents	hazard	volume / cm^3
E	starch phosphorylase	harmful irritant	10
S	starch solution	none	40
A	sulfuric acid	irritant	20
P	potassium manganate (VII) solution	harmful	20

You are advised to wear suitable eye protection, especially when using the starch phosphorylase solution, **E** and the sulfuric acid, **A**. If **either E** or **A** come into contact with your skin, wash off with cold water. **P** may stain your skin.

Proceed as follows:

6 Label the test-tubes with the sampling times of your choice. You should **not** sample for longer than 15 minutes.

7 Dispense 2.5 cm^3 of **A** into each test-tube. Add 1 cm^3 of **P** into each test-tube and gently shake to mix with **A**.

Read step **8** to step **12** and note that the stopwatch should not be stopped until you have the last end-point recorded. *The reaction will start as soon as* **E** *is added to* **S**.

8 Dispense 30 cm^3 of **S** into a plastic vial. Add 4 cm^3 of **E** into the plastic vial containing **S**. Immediately stir the mixture in the beaker and start the timer.

9 At each of your sampling times,

- test for the disappearance of starch as described in step **3**, and
- test for the appearance of glucose phosphate by removing 3 cm^3 of the mixture and putting it into the appropriately labelled test-tube, mixing well.

10 Record, in **(a)** below, the time shown on the stopwatch when the colourless end-point is reached (**raw** result). Do **not** stop the stopwatch.

11 Repeat step **9** for each of the times decided in step **6** until you have recorded the end-point for the last sample, removed at 15 minutes.

12 Calculate the time taken to reach **each** end-point (**processed** results).

(a) Prepare the space below to record your results for

- the test for starch,
- the **raw** results for the appearance of glucose phosphate, and
- your **processed** results for the appearance of glucose phosphate.

[5]

(b) Account for the results obtained in **(a)**.

.....

.....

.....

.....

.....

..... [3]

(c) Identify **one** limitation of this investigation and suggest a way in which the experiment can be improved to give more accurate and reliable results.

.....

.....

.....

..... [2]

(d) This procedure investigated the progress of the hydrolysis of starch by starch phosphorylase. To modify this procedure for investigating a different variable, the time for the hydrolysis would be standardised.

Consider how you could modify this procedure to investigate the effect of **pH** on the activity of starch phosphorylase.

Describe how the independent variable, **pH**, could be investigated.

.....

.....

.....

.....

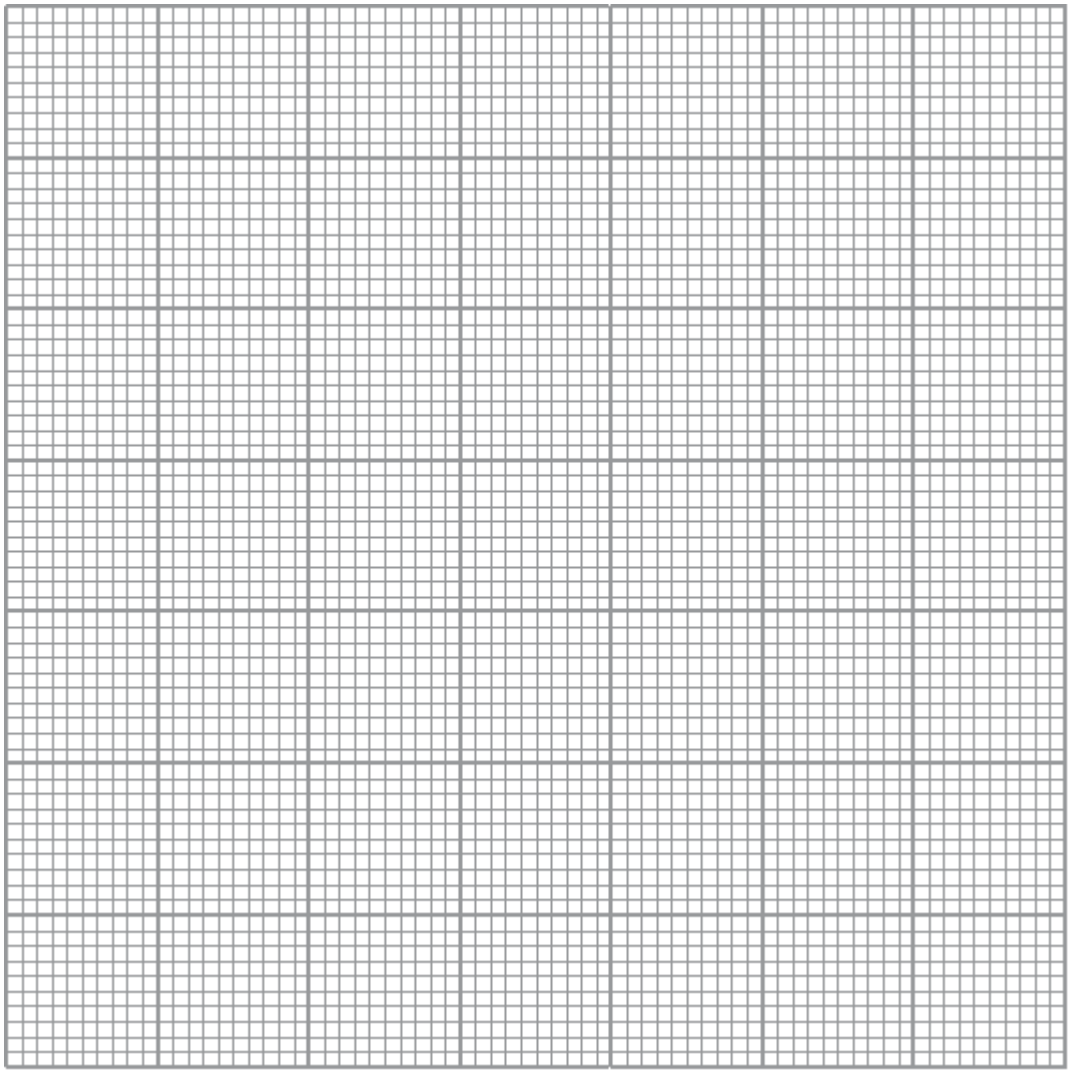
..... [3]

(e) A student investigated the effect of starch concentration on the initial rate of reaction of starch phosphorylase. Table 1.1 shows the results for this investigation.

Table 1.1

percentage concentration of starch	initial rate of reaction of starch phosphorylase / arbitrary units
0.00	0
0.05	100
1.25	215
1.75	285
2.50	340
3.25	340

(i) Use the grid provided to plot a graph of the data shown in Table 1.1.



[4]

(ii) Use the graph to estimate the Michaelis-Menten constant (K_m).
Show your working on the graph and in the space below.

K_m = ... [2]

[Total: 25]

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Candidate Name: _____ CT Group: 16S7 ____

BOOKLET II

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QUESTION 2

During this question you will require access to a microscope, slide **S1** and a stage micrometer.

Leaves require carbon dioxide and water for photosynthesis. For carbon dioxide to enter, the stomata on the surface of leaves must be open. However, the plant must not lose too much water. The plant must strike a balance between conserving water and bringing in sufficient amounts of carbon dioxide for photosynthesis.

S1 is a slide of a stained transverse section through a xerophytic plant leaf, which is adapted to conserve water.

You are not expected to be familiar with this specimen.

(a)(i) Examine the slide under the low-power objective lens of your microscope.
Observe the cells found immediately below the upper epidermis in the shaded area shown in Fig. 2.1.

Fig. 2.1

Select one group of **four** cells found immediately below the upper epidermis. Examine this group of cells under the high-power objective lens. Each cell in the group should touch two of the other cells and at least one cell should be capable of making starch.

Make a large labelled detailed drawing, in the space below, of this group of **four** cells.

[5]

(ii) Examine slide **S1** under the low-power objective lens of your microscope again. Make a large plan drawing of the part of the leaf indicated by the shaded area in Fig. 2.1.

On your drawing, use **one** ruled label line and label to identify one feature that adapts the plant to living in a dry habitat.

Annotate this label to explain **how** the feature you have identified adapts this plant to living in a dry habitat.

[3]

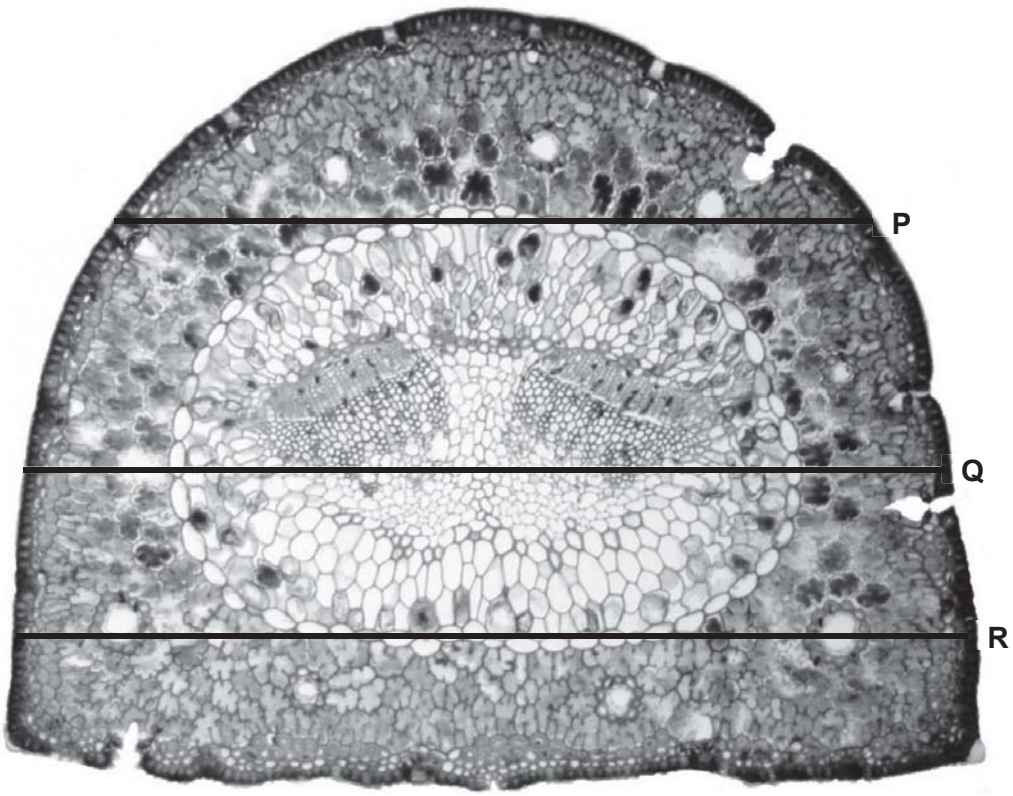
(iii) Using the eyepiece graticule fitted in the eyepiece lens of your microscope, and the stage micrometer, find the actual width, in μm, of the leaf.

Show the measurements that you made and your working.

width of leaf = ... μm [2]

(b) Fig. 2.2 is a photomicrograph of a stained transverse section through a leaf of a different xerophytic plant species.

You are not expected to be familiar with this specimen.



Magnification × 175

Fig. 2.2

Use the magnification and the lines in Fig. 2.2 to find the actual width of the leaf, in μm, at positions labelled **P**, **Q**, and **R**.

Show the measurement that you made and your working for the width at position **Q**.

P ..... μm, **Q** ..... μm, **R** ..... μm [2]

(c) Leaves of xerophytic plants have morphological adaptations that facilitate conservation of water.

A student hypothesises that xerophytic plants have narrower leaves than mesophytic plants, which grow in areas where water is more readily available. The student measured the width of 30 leaves from a mesophytic plant species, **X**, and that of 30 leaves from a xerophytic plant species, **Y**.

(i) State how narrower leaves allow xerophytic plants to conserve water.

.....

..... [1]

A summary of the student's results is shown in Table 2.1.

Table 2.1

plant species	width of leaves / μm		
	mean, $\bar{x}$	standard deviation, s	$\bar{x} \pm 2s$
X	1012.5	186.1	1012.5 ± 372.2
Y	562.0	14.8	562.0 ± 29.6

(ii) Comment on what these results show and explain if the results support the student's hypothesis.

.....

.....

.....

.....

.....

..... [3]

[Total: 16]

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Candidate Name: _____ CT Group: 16S7 ____

BOOKLET III

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QUESTION 3

The rate of respiration of an organism is an indication of its demand for energy. Respiration rate may be measured by means of a respirometer.

A student used a respirometer to compare the rate of respiration amongst three organisms
- single-celled green algae, immobilised in sodium alginate beads,
- germinating seeds, and
- insect larvae.

After putting the single-celled green algae, immobilised in sodium alginate beads, into the air-filled container and attaching the graduated tube, the respirometer was lowered into a water trough as shown in Fig. 3.1. The green algae respired and water moved into the graduated tube. The procedure was repeated for the other two organisms.

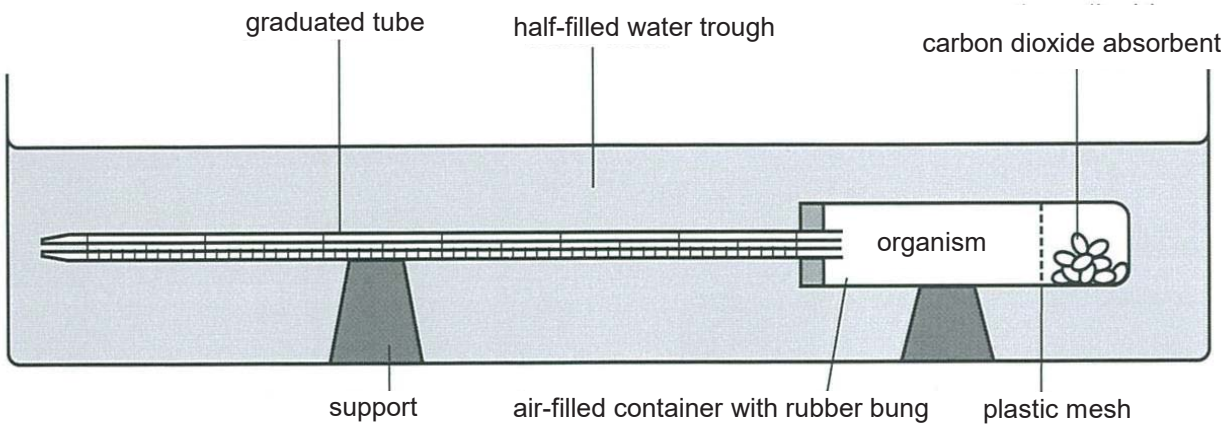


Fig. 3.1

Using this information and your own knowledge, design an experiment to compare the rates of respiration of single-celled green algae, germinating seeds and insect larvae.

You must use:
- single-celled green algae, immobilised in sodium alginate
- germinating seeds
- insect larvae
- half-filled water trough
- carbon dioxide absorbent
- air-filled container with rubber bung
- graduated tube
- weighing balance

You may select from the following apparatus:
- normal laboratory glassware, e.g. boiling tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.
- thermometer
- petroleum jelly
- stopwatch
- marker
- white card

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it,
- 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 reliable as possible,
- show how you will record your results and the proposed layout of results tables and graphs,
- use the correct technical and scientific terms,
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[Total: 14]

--- END OF PAPER---

HWA CHONG INSTITUTION
JC2 Preliminary Examinations
9744 H2 Biology Paper 1 Answer

Question	Answer
1	B
2	C
3	A
4	C
5	B
6	D
7	B
8	B
9	C
10	A
11	A
12	B
13	B
14	D
15	D

Question	Answer
16	D
17	B
18	C
19	B
20	D
21	C
22	C
23	C
24	B
25	A
26	D
27	A
28	D
29	B
30	C

HWA CHONG INSTITUTION (COLLEGE SECTION)
2017 JC2 9744 H2 BIOLOGY
PRELIMINARY EXAMINATIONS PAPER 2 MARK SCHEME

STRUCTURED QUESTIONS

Question 1

(a)(i) Outline the cell theory. [max 2]

any two:
1. living organisms composed of cells
2. cells form most basic unit of life
3. cells arise from other cells

(a)(ii) With reference to Figure 1.1, explain how Pasteur's experiment supports the cell theory. [2]

1. description of what happens to the nutrient broth (ref to stimulus)
2. shows that cells must come from pre-existing cells

(a)(iii) Suggest a reason for the universal acceptance of the cell theory in our world today. [1]

any one:
1. tested / scrutinized by other scientists
2. reproducible
3. overwhelmingly supported by scientific community

(b)(i) State the name and chemical composition of the stuctures labelled **A** to **C**. [3]

	name	chemical composition
A	1a. cell wall	1b. peptidoglycan
B	2a. cell membrane	2b. phospholipids and proteins
C	3a. nucleoid	3b. DNA

(c) *P. syringae* can cause disease in the leaves of its host plant by secreting toxins and cell wall degrading enzymes, without causing harm to itself. Explain why this is so. [2]

1. ref to toxins affect the functioning of membranous organelles
2. ref to different composition of cell wall
3. ref to specific 3D conformation of enzymes

(d) State and explain which of the three types of interactions best describes the relationship involved in the endosymbiotic theory. [2]

1. mutualism
2. prokaryote produces ATP, host cell provides shelter / nutrients

[Total: 12]

Question 2

(a) With reference to Fig. 3.1,

(i) name the stage of mitosis shown. [1]

(late) anaphase

(ii) describe what is happening during this stage of mitosis. [2]

1. centromere divide, forming daughter chromosomes
2. migrate to poles, centromere leading
3. pulled by kinetochore microtubules

(b) Distinguish between multipotent cells and totipotent cells. [max 2]

1. multipotent more specialized
2. multipotent cells cannot give rise to organs but totipotent cells can
3. correct example of multipotent cell and totipotent cell

(c) Suggest why there might be a connection between the use of stem cells in treatment and cancer. [max 3]

1. stem cells may undergo uncontrolled cell division
2. telomerase active
3. risk of developing tumour where stem cells implanted
4. ref to exposure to carcinogens
5. appropriate ref in context to cancer critical genes

(d) State whether you agree **or** disagree that this is unethical **and** explain why you reached this decision. [3]

A1 agree
A2 human animal hybrid would not happen in nature
A3 ref to disrespect for human life
A4 few examples of success in medical applications
A5 may lead to abuse in future
A6 possibility of unforeseen consequences
A7 unnecessary / there are alternative techniques

D1 disagree
D2 the amount of non-human DNA is negligible
D3 protocol limits keeping 'embryo' to 14 days
D4 more ethical alternative to ESC
D5 provides more stem cells than possible from ESC
D6 can relieve human suffering
D7 idea of rejection at implantation

[Total: 11]

Question 3

(a)(i) State the identity of ligand **X**. [1]

glucagon

(a)(ii) Explain why ligand **X** cannot diffuse directly into the liver cell to trigger a cellular response. [2]

1. Ref to: glucagon as a large and hydrophilic molecule
2. Ref to: hydrophobic core of cell membrane

(b) With reference to Fig. 3.1, describe how the structure of GPLR enables it to function as a membrane-bound receptor. [3]

1. Hydrophilic amino acid residues on inter-helical loops are soluble in aqueous medium
2. Hydrophobic amino acid residues on transmembrane helices enable embedding of GPLR within cell membrane
3. Ref. to specific 3D conformation of binding sites

(c) Explain how the structure of glycogen is adapted to its function as an efficient storage biomolecule. [3]

Any three:
1. Ref. to α(1,4) glycosidic bonds that result in coiling
2. Ref. to α(1,6) glycosidic bonds that result in branching
3. Ref. to glycogen having several hundreds to thousands of glucose monomers
4. Ref. to anomeric carbon being involved in glycosidic bond formation
5. Ref. to glycosidic bonds being easily hydrolysed to release glucose monomers

[Total: 9]

Question 4

(a) Describe two structural differences between helices **A** and **B**. [2]

1. Ref to: double-stranded vs single-stranded
2. Ref to: deoxyribonucleotides vs made of amino acids
3. Ref to: phosphodiester bonds vs peptide bonds
4. Ref to: Hydrogen bonds formed between complementary bases vs hydrogen bonds formed between NH and CO groups

(b)(i) Describe how a primer strand is synthesised. [3]

1. Ref to: DNA template
2. Ribonucleotides form complementary base pairs with the DNA template
3. Ref to: formation of phosphodiester bonds.
4. Ref to: synthesis in the 5' to 3' direction

(b)(ii) With reference to Fig. 4.1, explain if the primer is priming the synthesis of the leading strand or lagging strand. [2]

Leading strand is synthesised towards the replication fork

(c) Explain the role of splicing in the structure and function of the two forms of IR. [3]

1. Ref to. different combinations of exons,
2. Ref to. different amino acid sequences and different specific 3D conformation of binding sites
3. Ref to. specific ligands IR-A and IR-B can bind, to different degrees / with different efficacy

[Total: 10]

Question 5

(a) With reference to Fig. 5.1, predict and explain the most likely mode of inheritance of G6PD deficiency. [3]

1. sex-linked recessive
2. all affected individuals in the family are males, indicating that males display disease phenotype more often than females as males are hemizygous
   OR
   approximately half of the sons of carrier females are affected, as every son has a 50% chance of receiving the X chromosome with recessive allele
3. unaffected parents can produce affected offspring such as II-1 / III-4 / IV-3 / IV-6, indicating that the mothers must have a dominant allele to mask the effect of the recessive allele
   OR
   if fathers are not affected, daughters will not be affected but may be carrier, as they will receive the X chromosome with dominant allele from their father

(b) Using suitable symbols, draw a genetic diagram to show the expected phenotypic ratio of the ABO blood group and G6PD production in offspring of II-3 and II-4. [6]

Let **D** be the dominant allele for production of G6PD
d be recessive allele for no production of G6PD
$\mathbf{I^A}$ be the (codominant) allele for production of A antigen
$\mathbf{I^B}$ be the (codominant) allele for production of B antigen
$\mathbf{I^O}$ be the recessive allele for no production of antigen

	II-4		II-3
Parental phenotypes:	No G6PD deficiency, Blood group AB	x	No G6PD deficiency, Blood Group O
Parental genotypes :	$X^DYI^AI^B$	x	$X^DX^dI^OI^O$
Parental gametes :	X^DI^A X^DI^B YI^A YI^B		X^DI^O X^dI^O

Random fertilization (as shown in the Punnett Square)

		male gametes			
		X^DI^A	X^DI^B	YI^A	YI^B
female gametes	X^DI^O	$X^DX^DI^AI^O$	$X^DX^DI^BI^O$	$X^DYI^AI^O$	$X^DYI^BI^O$
	X^dI^O	$X^DX^dI^AI^O$	$X^DX^dI^BI^O$	$X^dYI^AI^O$	$X^dYI^BI^O$

expected genotypic ratio	2 ($1X^DX^DI^AI^O$ + $1X^DX^dI^AI^O$) :	2 ($1X^DX^dI^BI^O$ + $1X^DX^dI^BI^O$) :	$1X^dYI^AI^O$:	$1X^DYI^BI^O$:	1 $X^dYI^AI^O$:	$1X^dYI^BI^O$
expected phenotypic ratio	2 normal, blood group A female :	2 normal, blood group B female :	1 normal, blood group A male :	1 normal, blood group B male :	1 G6PD deficient, blood group A male :	1 G6PD deficient, blood group B male

(c)(i) Using the information provided, calculate the χ^2 value for the observed results. Show your working clearly. [2]

$$\chi^2_{cal} = \frac{(99-90)^2}{90} + \frac{(155-180)^2}{180} + \frac{(106-90)^2}{90}$$

$$= 7.22$$

(c)(ii) Deduce if the observed results follow the expected phenotypic ratio of 1 blood group A: 2 blood group AB: 1 blood group B.

Explain your answer. [3]

1. No
2. Since $\chi^2_{calculated}$ (= 7.22) > $\chi^2_{critical}$ (= 5.99)
3. there is less than 5% probability that there is difference between observed and expected results is due to chance alone, indicating that the deviation is significant

[Total: 14]

Question 6

(a) Describe how the outer layers of bacterium **Y** differs from those of bacterium **X**. [2]

1. Y has an outer membrane / channel proteins which is / are absent in X
2. Y has a thinner peptidoglycan wall compared to X
3. X has the peptidoglycan wall exposed on the surface while Y has an outer membrane exposed on the surface / AW describing location of peptidoglycan wall

(b)(i) Identify the bacterium which turns purple when stained with the Gram stain. [1]

X

(b)(ii) Explain your answer to **(b)(i)**. [2]

1. Bacterium X is Gram positive as it has a thicker peptidoglycan wall
2. which helps to retain / trap crystal violet dye / prevent crystal violet dye from being washed away when alcohol is added, thus staining peptidoglycan wall blue / purple

(c) Explain the different effects of penicillin on bacteria **X** and **Y**. [3]

1. Penicillin is able to reach the peptidoglycan wall of X
2. where it binds and blocks transpeptidases, preventing formation of the cross-links between NAM residues in the transpeptidation step in cell wall synthesis in X
3. while the outer membrane of Y stops penicillin getting through to reach the peptidoglycan wall, thus penicillin exerts no effect on Y

(d) With reference to Fig. 6.2, describe and explain mode of infection of *V. cholerae*. [4]

1. The B subunit of cholera toxin binds to ganglioside receptor on the surface of the epithelial cells of the small intestine, enabling entry of cholera toxin subunit A via receptor-mediated endocytosis into the cell
2. Cholera toxin subunit A binds to and activates the G protein, resulting in one of the G protein subunits to dissociate and bind to adenylate cyclase, activating it
3. Activated adenylate cyclase generates high levels of intracellular cAMP from ATP, which activates the protein kinase
4. stimulating secretion of chloride ions, with associated sodium ions and water secretion, resulting in acute diarrhoea

[Total = 12]

Question 7

(a) Explain why influenza viruses can only attack the cells on the inside of the nose. [2]

1. Specific glycoproteins haemagglutinin on the viral membrane
2. They recognise and bind to sialic acid containing receptors on the membrane of the nose

(b) Suggest why enzymes **S** and **T** are needed at Stage 4. [2]

1. To synthesise (-) viral RNA using (+) sense RNAs as templates to be packaged into new viral particles as their nucleic acid using replicase / RNA-dependent RNA polymerase
2. For amino acids to bind to tRNA using host aminoacyl tRNA synthetases
3. For peptide bond formation between amino acids using host peptidyl transferase

(c) Suggest how enzyme **U** might catalyse the breakdown of the host cell membrane at Stage 5. [2]

1. Neuraminidase is a hydrolytic enzyme that breaks glycosidic bonds
2. The active site binds to and cleaves sialic acid residues on the receptor

(d) Most people in 1957 were susceptible to influenza caused by the new virus. Explain why. [4]

1. Antigenic shift
2. A sudden change in the antigenicity of a virus due to reassortment combination of the segmented virus genome with another genome of a different antigenic type
3. New viral strain has RNA segments 2, 4 and 5 from H2N2 avian virus and segments 9, 11, 14, 15 and 16 from H1N1 human virus
4. New combination of RNA segments causes the virus to change its 3D conformation of HA and/or NA
5. New 3D conformation of the new virus binds more effectively to receptors on the cells of lungs and airways of humans
6. New 3D conformation of the new virus cannot be recognised by antibodies / memory cells / B cells

[Total: 10]

Question 8

(a) Define *biological classification*. [2]

1. Organizing / arranging into groups of organisms / species
2. Ref to shared / morphological, characteristics / similarities / traits

(b)(i) Explain how multiple sequence alignment can be used in biological classification of the five genera of organisms. [4]

1. The DNA / amino acid sequence of a sample from the tissue of an organism of each genus
2. The aligned sequences of all five genera are homologous
3. The percentage similarity of sequences used to, estimate / establish, evolutionary relationship
4. The greater the degree of homology in the sequences, the more closely related the species are

(b)(ii) Identify the longest amino acid sequence where there are no differences amongst the five genera. [1]

WGATVIT

(b)(iii) Suggest, with a reason, whether the DNA coding for the amino acid sequence identified in **(b)(ii)** must be identical for the five genera. [2]

1. No
2. Degeneracy of the genetic code

(c) Describe what a cladogram represents. [4]

1. A type of phylogenetic tree
2. Inferred by shared derived characters
3. Shows the presence of clades
4. Ref to Fig. 8.3 to illustrate examples of clades for example

(d) State a reason each for illegal sale of the respective meat samples in Japan:

(i) Sample 1 [1]

It is from a North Atlantic population of whales

(ii) Sample 4 [1]

It is from a species that is not in the same clade as the, Minke / Humpback / Fin, whales

[Total: 15]

Question 9

(a) Outline **one** possible mechanism by which urushiol could enter the keratinocytes and Langerhans cells. [2]

1. endocytosis
2. (further detail) e.g. membrane invaginates

OR

1. diffusion
2. (further detail) e.g. across phospholipid bilayer across hydrophobic core of the cell membrane

(b)(i) Describe and explain the events that are likely to occur during an immune response to bring about poison ivy rash. [max 6]

1. Langerhans cell / keratinocyte / macrophage, as antigen-presenting cell
2. Ref to T-cells recognition through binding with complementary receptors
3. Activation of T-cells
4. Proliferation / mitosis of activated T-cells
5. T memory cell formation
6. Description of T-cytotoxic cell action
7. Explanation of faster response for second and subsequent contacts
8. T-helper cells secrete cytokine to stimulate, T-cytotoxic cell response/macrophages

(b)(ii) Suggest **one** reason why some people are not sensitive to skin contact with urushiol. [1]

Any one:

1. immunocompromised / described
2. may not have, specific T-cells / T-cells with, quinone / hapten, receptors
3. may have T-cells but low in number and not come across APC
4. may need several doses to build up sufficient numbers of T-cells
5. inability of cells to convert urushiol

[Total: 9]

SECTION A

Question 1

(a)(i) State why rubisco is said to have quaternary structure. [1]

Ref to: more than one polypeptide

(a)(ii) Explain what makes a molecule such as rubisco soluble. [1]

1. Ref to: globular protein
2. Ref to: hydrophilic / polar / charged amino acid residues at the surface of the molecule
3. Ref to: hydrophobic / non-polar / non-charged amino acid residues at the inside of the molecule
4. Ref to: hydrogen bonds with water (molecules)

(b) Explain why rubisco does not need to be in an active form in the absence of light. [3]

1. Ref to: no light dependent reaction and no light independent reaction
2. Ref to: no ATP / reduced NADP
3. Ref to: no need to fix CO_2

(c) Explain the consequences to the plant of the reaction involving oxygen. [2]

1. Ref to: no CO_2 being fixed
2. Ref to: no (new) PGA / GP being made
3. Ref to: no (new) TP / glucose being made
4. Ref to: no (new) RuBP being (re)generated
5. Ref to: ATP used in making RuBP being wasted
6. Calvin cycle / light independent reaction / Photosynthesis decreased

(d) With reference to Fig. 1.2, predict whether C3 or C4 plants are favoured in the context of global warming in the tropics. Explain how these plants are better adapted physiologically. [4]

1. Ref to: C4 plants being favoured over C3 plants at high temperatures above 26 °C
2. Ref to: Plants closing their stomata, resulting in reduced CO_2 diffusion into the leaf
3. Ref to: risk of O_2 competing with CO_2 for rubisco in C3 plants / AW
4. Ref to: less CO_2 fixed, resulting in lower yield of C3 plants / AW

(e)(i) Describe how yeast converts glucose to ethanol. [2]

1. Ref to: anaerobic conditions
2. Ref to: pyruvate forming ethanal
3. Ref to: reduction of ethanal

(e)(ii) Explain why it may be better in the long term to use ethanol made from corn starch, rather than petrol, as a fuel for cars. [2]

1. Ref to: corn as renewable resource
2. Ref to: uptake of CO_2 by corn in photosynthesis
3. AVP

(f)(i) With reference to Table 1.1, suggest the source of biodiesel chosen by an oil company if reduction of greenhouse gas emissions were the sole criterion. [1]

palm oil from Malaysia

(f)(ii) Explain your answer to **(f)(i)**. [2]

1. Ref to: lowest emission due to change of land use and from cultivation, processing and distribution
2. Cite appropriate values

(g) Identify two criteria, apart from cost, that should also be considered in choosing a source of biodiesel. Explain the significance of each criterion. [4]

1. Ref to: impact on environment / wildlife / biodiversity
2. Ref to: impact on food supply
3. Ref to: loss of carbon sink / carbon dioxide emission
4. Ref to: ownership of land
5. AVP

[Total: 25]

Question 2

(a) Outline how gel electrophoresis separates DNA fragments. [4]

1. Gel electrophoresis separates a mixture of DNA fragments on the basis of size / molecular weight
2. Negatively-charged DNA fragments are loaded into wells at negatively-charged electrode, migrate towards the positively-charged electrode under application of an direct current
3. Size of the pores in the gel matrix act as a molecular "sieve" to resist / retard the movement of the molecules
4. Smaller / shorter DNA fragments are less impeded by the pores than longer ones and migrate faster and further forming a series of discrete size-fractionated bands

(b) With reference to Fig. 2.1 and 2.2, explain the DNA profile of Jane. [3]

1. Jane's is a heterozygous / carrier with 1 normal allele and 1 mutant allele on the homologous chromosomes
2. Restriction digestion of the normal allele generates 1 fragment that has moved least from the cathode and digestion of the mutant allele generates 2 fragments that have moved further from the cathode
3. Due to the presence of restriction site caused by gene mutation of *p53* in the mutant allele

(c) With reference to development of cancer as a multi-step process, describe how Jane might develop breast cancer. [3]

1. There is an accumulation of mutations in a single cell lineage, ref. to *BRCA 1 and BRCA* gene mutations
2. Activation of telomerase resulting in lengthening of telomeres, thus evading apoptosis / replicative cell senescence
3. Angiogenesis resulting in formation of new blood vessels, supplying nutrients and oxygen and removing toxic waste products
4. Cancer cells acquired ability to invade to directly migrate and penetrate into neighbouring tissues leading to metastasis

[Total: 10]

Question 3

(a) With reference to Fig. 3.1, explain how somatic recombination during B cell development results in the formation of millions of different antibody molecules. [4]

1. Ref to process by which different segments of V, D, J ligated to form gene encoding different variable regions in heavy chain of the antibody
2. Ref to idea that only 1 segment from each is chosen
3. Ref to idea that remaining gene segments removed
4. Ref to number of gene segments in context of question
5. Ref to different mRNA sequences leading to different amino acid sequences, and subsequently different specific 3D conformation of variable region

(b)(i) Compare the increase in mean level of anti-X antibodies after vaccination and after infection with *B. pertussis*. [2]

Any two:

1. Ref to levels of antibody rise earlier after infection
2. Ref to levels of antibody rise faster after infection
3. Ref to levels of antibody rise higher after infection
4. credit comparative manipulation of data

(b)(ii) Explain the changes in mean level of anti-X antibodies after infection with *B. pertussis*. [2]

1. Ref to secondary immune response
2. Ref to memory cells / immunological memory
3. Ref to idea that (on infection / second exposure) memory cells are activated / stimulated

(c)(i) Suggest why anti-Y antibodies were not present in the blood of these rats until after infection with *B. pertussis*. [1]

Any one:

1. Ref to idea that antibodies will only be present if antigen present
2. Ref to idea that antigen Y is not present in vaccine
3. Ref to vaccination failed to stimulate immune response

(c)(ii) Place a tick in the box next to the term that describes the type of immunity that results in the production of anti-Y antibodies. [1]

Natural active

(d) Explain how class switching allows for formation of IgG. [3]

1. Ref to one constant region gene segment from IgM is replaced with another of a different segment from IgG
2. Ref to gene segment coding for constant region of IgG is ligated with other exons
3. Ref to somatic recombination in activated B cells

(e) Comment on the reliability of the data shown in Fig. 3.2. [2]

Any two:

1. Ref to no indication of number of rats used
2. Ref to no data points indicated
3. Ref to no error bars (on graph) / no indication of variability
4. Ref to idea that no indication of experimental details / control group
5. Ref to idea that mean has been used therefore there must have been some repeats carried out

[Total: 15]

SECTION B

Question 4

(a) Describe and explain gene mutation and chromosomal aberration. Using a suitable named example, explain how chromosomal aberration can result in a diseased phenotype in humans. [13]

1. Ref. to gene mutation as a change in one or a few bases in the DNA sequence of one gene
2. Ref. to base substitution
3. and effects
4. Ref. to base addition or deletion
5. and effects
6. Ref. to chromosomal aberration as a change in the structure of a chromosome
7. Ref. to chromosomal deletion, duplication, inversion, translocation
8. and effects
9. Ref. to chromosomal aberration as a change in the number of chromosomes
10. Ref. to aneuploidy and polyploidy
11. and effects
12. Ref. to relevant named example, e.g. Down syndrome
13. and link to chromosomal aberration

(b) Discuss how the genotype of an organism is linked to its phenotype and using suitable named examples, explain how the environment may affect the phenotype of an organism.[12]

1. Ref. to genotype as the genetic makeup
2. Ref. to phenotype as a measurable or distinctive character
3. Ref. to how genotype dictates phenotype
4. Ref. to dominant and recessive alleles
5. and their effects in phenotypes
6. Ref. to role of environment on phenotype
7. Ref. to relevant named example 1
8. e.g. temperature on coat / fur colour in Himalayan rabbits
9. and how phenotype is affected
10. Ref. to relevant named example 2
11. e.g. diet on differentiation in honey bees
12. and how phenotype is affected

[Total: 25]

Question 5

(a) Using a named example each, describe and explain directional and disruptive selection. Suggest, with reasons, which of these two forms of natural selection might contribute to the emergence and subsequent development of a new species. [13]

Directional selection

1. Ref to a correct named example
2. Ref to idea of this form of selection favouring one extreme phenotype and eliminating the other extreme phenotype in the population
3. Correct identification of selection pressure
4. Correct sketch of distribution graph with appropriate labelled axes

Disruptive selection

5. Ref to any correct named example
6. Ref to idea of this form of selection eliminating intermediate phenotypes and favouring extreme phenotypes
7. Correct identification of selection pressure

8. Correct sketch of distribution graph with appropriately labelled axes

Emergence and development of new species (speciation)

9. Disruptive selection
10. The possibility that the gene pool of one population may become split into two distinct gene pools over time / disruptive selection would result in two distinct populations
11. Ref to presence of geographical barrier / isolation
12. Ref to generation of reproductive isolating mechanisms

(b) The fossil record reveals that the evolutionary history of life on Earth has been episodic, with long, relatively stable periods punctuated by brief, cataclysmic ones. During these upheavals, macroevolutionary events occur where new species form through adaptive radiation and others died out in great numbers through mass extinctions.

Discuss mechanisms that trigger adaptive radiation and mass extinctions, and explain how microevolution can be linked to these macroevolutionary events. [12]

Mechanisms that trigger adaptive radiation

1. Ref to availability of new resources through ecological opportunities
2. Ref to an original colonizing group encountered no competitor and diversified
3. Ref to adaptations that can make the organisms better adapted for the habitat they occupy
4. Ref to succeeding generations diversify into new species

Mechanisms that trigger mass extinctions

5. Major changes in climate could have adversely affected those plants and animals
6. Ref to changes in the environment due to catastrophes
7. Ref to natural / biological factors
8. Ref to some animals / plants unable to adapt

Linking microevolution to the macroevolutionary events

9. Ref to defining microevolution
10. Ref to defining macroevolution
11. Ref to mechanisms / processes that bring about microevolution like natural selection, mutation, genetic drift and gene flow
12. Ref to mass extinctions create new ecological opportunities that can be exploited by surviving organisms to evolve
13. Ref to difference in scale for microevolution and macroevolution
14. Ref to macroevolution occurring as a result of microevolution

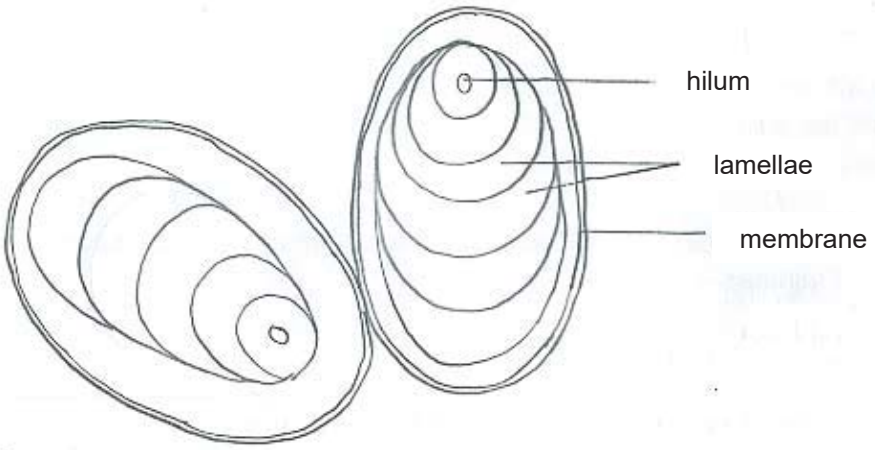
[Total: 25]

Question 1

3 Colour of extract on adding iodine solution [1]
blue-black

4 Make a large labelled detailed drawing of two adjacent starch grains. [4]

High power / detailed drawing of 2 adjacent starch grains from potato, *Solanum tuberosum* (whole mount, 400x)



1. Drawing quality that includes clear continuous lines with no shading
2. Draw 2 adjacent starch grains
3. Correct shape of starch grains
4. Correct drawing of lamellae and hilum
5. All 3 correct labels: membrane, lamellae, hilum

5 Explain the result obtained in step **3** when iodine solution was added to the re-suspended **T**. [1]

1. crushing ruptures potato cells / cell walls / releases starch grains
   OR
2. starch grains / amyloplasts are too large to pass through sieve and remain in residue / re-suspended T thus turning iodine solution blue-black.

12 Calculate the time taken to reach **each** end-point (**processed** results).

(a) Prepare the space below to record your results for:

- the test for starch
- the **raw** results for the appearance of glucose
- your **processed** results for the appearance of glucose. [5]

time / min A: s	test for starch	test for glucose	
		time shown on stopwatch when end-point is reached	time taken to reach end-point / s
3	blue-black	4 min 17 s	77
6	blue-black	6 min 54 s	54
9	blue-black	9 min 50 s	50
12	blue-black	12 min 32 s	32
15	yellowish-brown	15 min 30 s	30

1. correct choice of equal time intervals which must span entire 15 min
2. correct column headings and units: time / min, test for starch, time shown on stopwatch, time taken to reach end-point / s
3. appropriate colours recorded for starch test for at least four times;
4. correct pattern of results for glucose test – time taken to reach end-point decreases with increasing time
5. processed times recorded as whole seconds

(b) Account for the results obtained in **(a)**. [3]

1. as time increases, a greater proportion of / more starch is broken down by starch phosphorylase into glucose phosphate
2. resulting in an increase in glucose phosphate concentration which leads to a shorter time taken to decolourise the potassium manganate (VII) solution / reach the colourless end-point
3. until all starch is broken down into glucose phosphate at the end of 15 minutes which leads to the iodine solution remaining yellowish-brown / negative results for starch test, indicating absence of starch

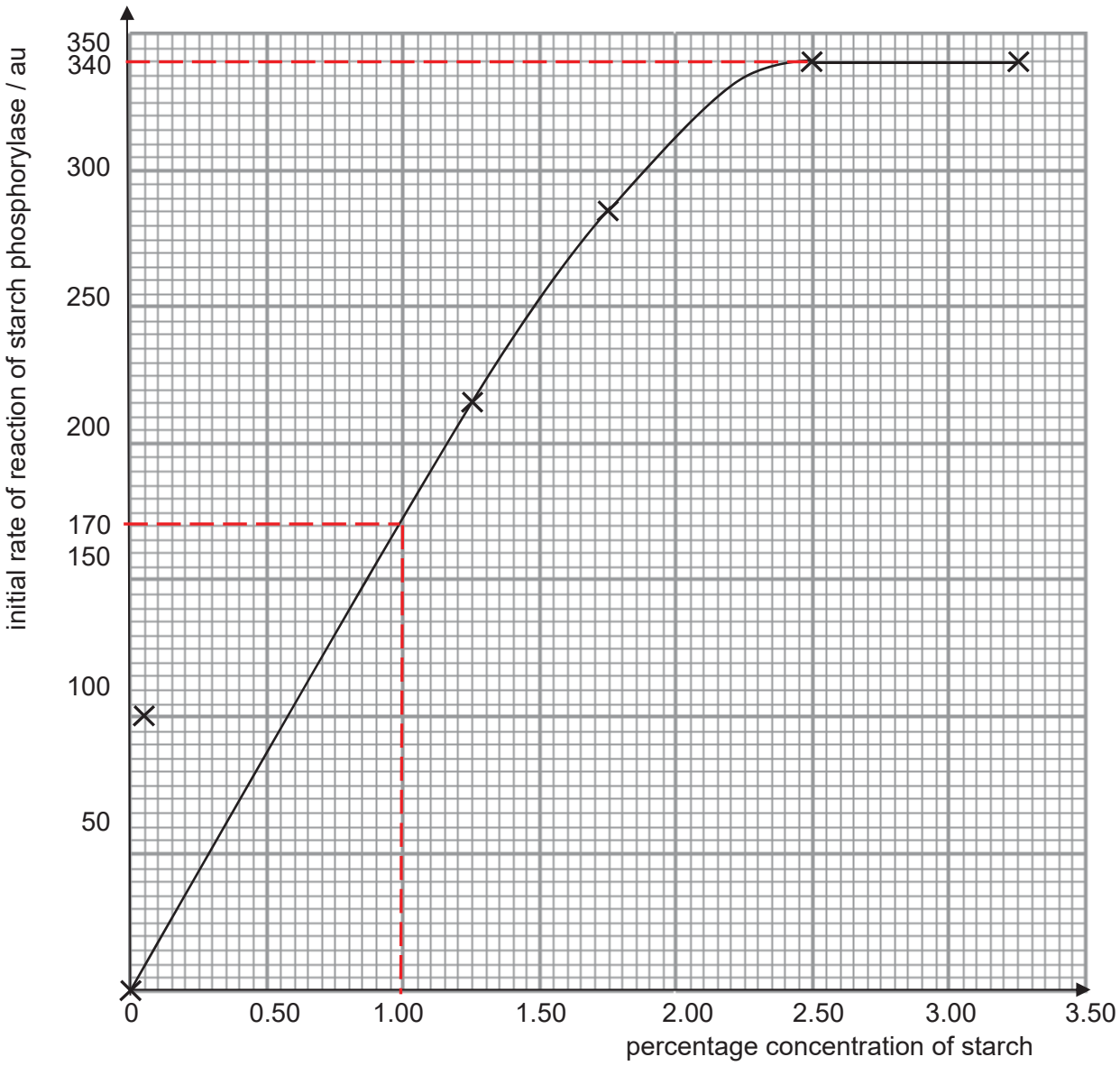
(c) Identify **one** limitation of this investigation and suggest a way in which the experiment can be improved to give more accurate and reliable results. [2]

Limitation	Method to overcome limitation
L1. Use of naked eye to observe colour of achromic point / end-point OR visual comparison is subjective, resulting in inaccurate determination of colour of achromic point / end-point	M1. Use a colourimeter / spectrophotometer to determine colour intensity of reaction mixture
L2. Use of dropper / plastic pipette to withdraw reaction mixture OR different size / volume of drops of iodine solution / reaction mixture could contribute to differences in colour intensity for starch test	M2. Use a micropipette to withdraw a fixed precise volume of iodine solution / reaction mixture
L3. The contents of tubes were mixed manually OR rigour of manual shaking may be inconsistent, leading to inconsistent mixing of the tubes contents	M3. Use a mechanical shaker / vortex to mix the contents of tubes thoroughly to ensure a homogenous mixture;

(d) Consider how you could modify this procedure to investigate the effect of **pH** on the activity of amylase. Describe how the independent variable, **pH**, could be investigated. [3]

1. at least five pH with stated values
2. use of buffers;
3. remove sample after set time / example of time and test with iodine and idea of looking for a colour change / test with potassium manganate (VII) and time taken to decolourise

(e)(i) Use the grid provided to plot a graph of the data shown in Table 1.1. [4]



1. correct choice of axes with independent variable (percentage concentration of starch) on x-axis
2. both axes correctly labelled including units
3. axes scaled appropriately so that graph takes up at least 50% of the grid and divisions are equidistant
4. Correctly plotted points and points joined by appropriate line of best fit (curve) as required by the data, showing plateau from 2.50% starch onwards, with no extrapolation beyond extreme measured data

(ii) Use the graph to estimate the Michaelis-Menten constant (K_m).
Show your working on the graph and in the space below. [2]

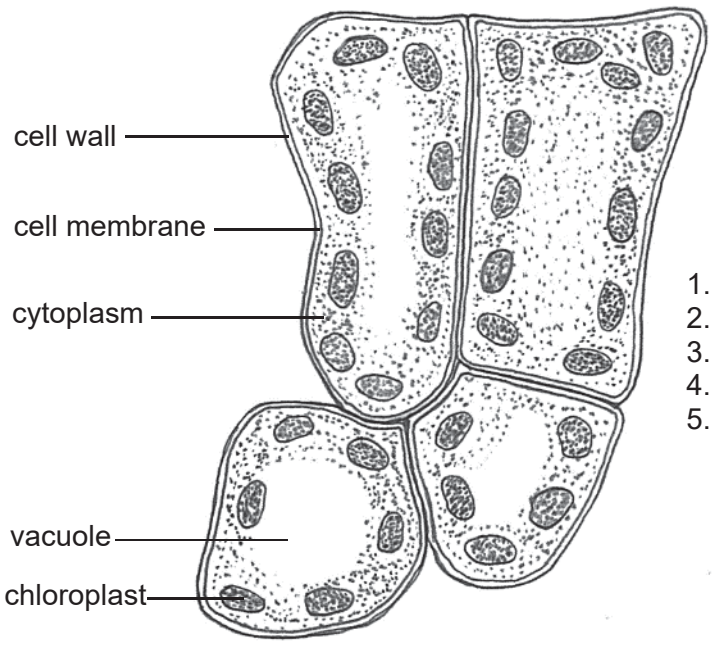
1. shows on the graph V_{max} line at top of curve to the y-axis from the maximum rate of reaction
2. shows on the graph how K_m is read off at half V_{max}
3. correct answer for K_m from graph with correct units

[Total: 25]

Question 2

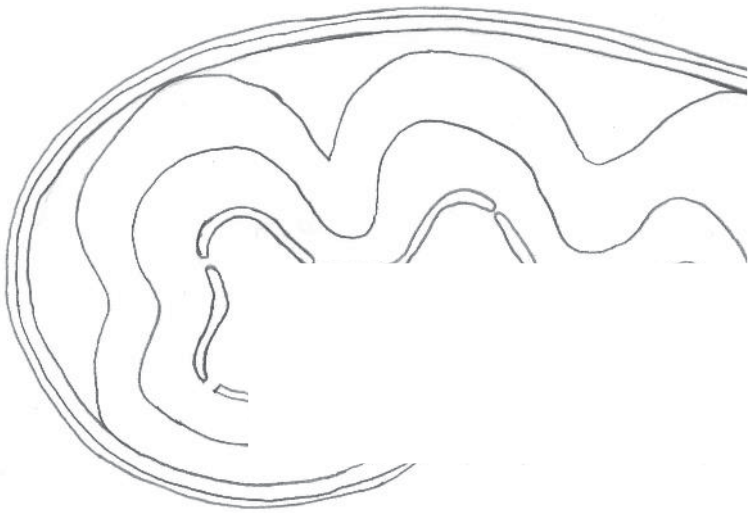
(a)(i) Make a detailed, labelled drawing in the space below of this group of four cells. [5]

Detailed drawing of four cells found immediately below the upper epidermis (t.s., ×400)



1. Accurate title
2. Quality of drawing
3. Position of cells
4. Shape and proportion of cells
5. Correct labels

(ii) Examine slide **S1** under the low-power objective lens of your microscope again. Make a large, plan drawing of the part of the leaf indicated by the shaded area in Fig. 2.1.
On your diagram, use **one** ruled label line and label to identify one feature that adapts the plant to living in a dry habitat.
Annotate this label to explain **how** the feature you have identified adapts this plant to living in a dry habitat. [3]



1. Correct number and proportion of layers
2. Curving of lamina
3. Correct label and annotation

(iii) Using the eyepiece graticule fitted in the eyepiece lens of your microscope, and the stage micrometer, find the actual width, in μm, of the leaf.

Show the measurements that you made and your working. [2]

1. Divide stage micrometer measurement by number of eyepiece graticule divisions
2. Measure width of leaf in eyepiece graticule divisions
3. Correct working and final answer in μm

(b) Show the measurement that you made and your working for the width at position **Q**. [2]

P 577 μm, **Q** 697 μm, **R** 726 μm

1. Measure width of leaf
2. Divide by 175 and multiply by 1000
3. Correct answer to appropriate degree of accuracy

(c) (i) State how narrower leaves allow xerophytic plants to conserve water. [1]

Narrower leaves presents a lower surface area

(ii) Comment on what these results show and explain if the results support the student's hypothesis.

[3]

1. Leaves of xerophytic plant species Y (562.0 μm) are significantly narrower than those of mesophytic plant species X (1012.5 μm)
2. Range of width of leaves of plant species X is not overlapping with that of plant species Y
3. Ref. to larger standard deviation as a larger spread of values around the mean width for leaves of plant species X compared with those of plant species Y.

[Total: 16]

Question 3

1. Ref to different organisms have different rates of respiration
2. ATP is synthesised with the production of carbon dioxide and water
3. Higher rate of respiration, the more oxygen consumed per unit time
4. Measure about 5 g of each organisms
5. Using a respirometer, measure the distance moved by the meniscus in a fixed time
6. Use petroleum jelly to seal between the graduated tube and the airtight container
7. Incubate respirometer in the water trough for 5 min
8. Setup equilibrate at room temperature for 1 minute
9. Repeat experiment for the other two organisms
10. Measure distance moved by meniscus
11. Calculate rate of respiration
12. Carbon dioxide absorbent corrosive / irritant, wear gloves and goggles to protect oneself.
13. AVP

[Total: 16]